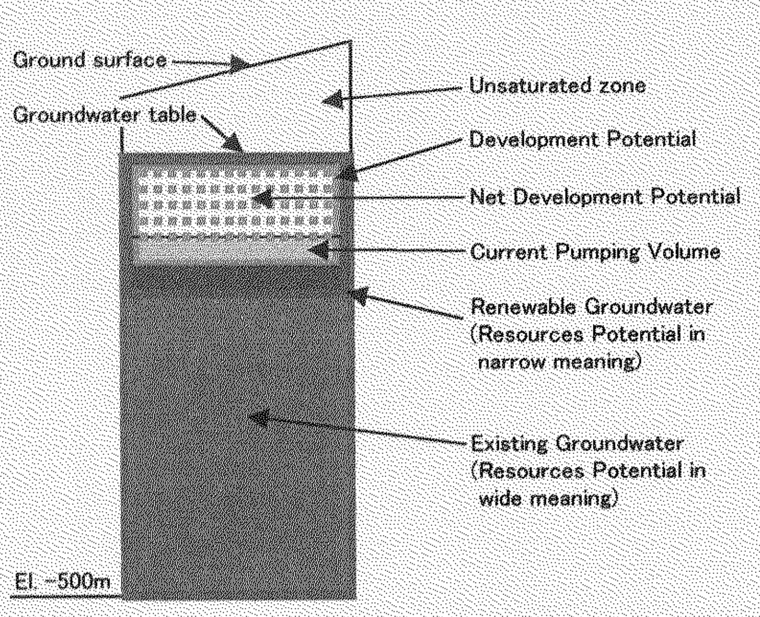
4.3. Groundwater Resources Development Potential

4.3.1. Resources Potential and Resources Development Potential

In the case of groundwater system, a water resources potential has two meanings. One is the total volume of existing groundwater contained in a certain basin or area, and it is a quite huge volume because the total thickness of all aquifers sums up to around 1,300m and they have rather high effective porosity (Strativity). Another is theoretically available groundwater volume every year, in other words it is a renewable groundwater and almost same meaning of the total of yearly net recharge and groundwater inflow at a certain basin. Both of the groundwater volumes are estimated through SSM simulation study as explained so far.

Figure 4.3.1 CONCEPT OF GROUNDWATER POTENTIAL



On the other hand, a groundwater resources development potential has rather restricted meaning that the groundwater volume which can be developed safely for long years, in other words it is water volume available for a sustainable groundwater development. The groundwater resources development potential also has two categories: the total development potential and the volume excludes the groundwater volume already utilized for every purpose. These concepts of groundwater potentials are simply illustrated in Figure 4.3.1.

4.3.2. Groundwater Resources Development Potential

Groundwater resources potential is rather easily estimated through SSM simulation, as explained in the previous section (Chapter 4.1). However, the groundwater resources development potential is not directly calculated from the simulation but it needs farther consideration. In this section, the groundwater resources development potentials are examined separately: in the cases of sub-basins in inland and at coastal, and the offshore submarine springs.

(1) Groundwater resources development potentials in inland and coastal sub-basins

Inland sub-basins mean sub-basins those are not directly contacted with the Mediterranean Sea, and the most of sub-basins in SSM are included in this category. Because of steep inclination of the

Lebanon Mountain Range, these sub-basins have enough high elevation to avoid a seawater intrusion by pumping, and the groundwater development potential can be estimated from the net recharge volume and existing groundwater withdrawal.

While, coastal sub-basins contact with the sea directly and any groundwater developments in these basins have a risk of seawater intrusion every time. When considering groundwater development potential in these coastal sub-basins, the potential estimated from yearly recharge amount and the potential which does not cause seawater intrusion should be compared. And, in the case of Lebanon, every coastal sub-basin has enough high groundwater inflow because of the steep topography, and therefore, the potential estimated from yearly recharge is usually smaller than the later, and it means the former is the safety side estimation. Thus, the groundwater development potential shall be estimated from yearly recharge amount.

In Lebanon, groundwater in a certain basin easily moves out or in to/from the other basin beyond the boundary, so that the net recharge volume cannot be accounted directly as a safety pumping rate for long period because the pumping causes a new groundwater movement and it may influence to any spring yield in or out of the basin. It is rather difficult to estimate exactly the safety-pumping rate in this meaning but in the Study it is set as 1/3 of the net yearly recharge volume tentatively. The groundwater development potential, and the net development potential (development potential – current groundwater withdrawal), are shown in Table 4.3.1, all together. As shown in the table, some of the basins; the Bared, Abou Ali, Ibrahim, Damour, and so on, are already in over-pumping supposed by the result of SSM simulation.

The current discharges from these basins shall be counted as the minus potentials for the consideration on net groundwater resources development potential. Table 4.3.1 presents the net groundwater development potential by river basin basis, and some sub-basins, even though in such deficit river basins, may have any net development potential depending upon the condition. Such situation at each sub-basin can be evaluated from the data attached in ANNEX (4-1-1).

Table 4.3.1. (10 Years Average)*1 (Unit: 1000m3)

Basin		Groundwater Resources Development Potential						Monthly Average*5		Development Potential
		Recharge	Spring Out	Net*2 Recharge	Total Development Potential*3	Existing Withdrawal	Net Development Potential*4	Wet Month Average	Dry Month Average	
Kebir	All basin	118,751	38	118,713	39,571	20,932	18,639	1,864	1,243	Medium(9)
Ostuene	All basin	45,749	10,331	35,418	11,806	30,510	−18,704	−1,247	−1,870	OverPump
Akkar	All basin	44,278	8,728	35,550	11,850	18,303	−6,453	−430	−645	OverPump
Bared	All basin	112,912	111,835	1,077	359	13,657	−13,657	−910	−1,366	OverPump
Abou Ali	All basin	187,479	159,877	27,602	9,201	20,512	−20,512	−1,367	−2,051	OverPump
Jouz	All basin	69,852	9,983	59,869	19,956	16,272	3,684	368	246	
Ibrahim	All basin	149,276	282,647	−133,371	0	16,545	−16,545	−1.103	−1,655	OverPump
Kelb	All basin	69,512	106,203	−36,691	0	3,392	−3,392	−226	−339	OverPump
Beirut	All basin	118,119	28,427	89,692	29,897	3,964	25,933	2,593	1,729	Medium(6)
Damouar	All basin	66,285	84,472	−18,187	0	3,582	−3,582	−239	−358	OverPump
Awali	All basin	96,449	100,908	−4,459	0	3,268	−3,268	−218	−327	OverPump
Saintaniq	All basin	68,946	1,844	67,102	22,367	7,857	14,510	1.451	967	Fair(12)
Zahrani	All basin	48,119	7,346	40,773	13,591	3,680	9,911	991	661	Fair(14)
Abou Assouad	All basin	63,388	1,107	62,281	20,760	5,470	15,290	1,529	1,019	Fair(11)
Litani Upper	All basin	494,748	0	494,748	164,916	8,596	156,320	15,632	10,421	High(2)
Litani Middle	All basin	252,369	85,811	166,558	55,519	12,164	43,355	4.336	2,890	High(5)
Litani Lower	All basin	184,628	0	162,894	54,298	4,173	50,125	5,013	3,342	High(4)
Assi	All basin	683,505	73,595	609,910	203,303	11,052	192,251	19,225	12,817	High(1)
Hasbani	All basin	204,071	5,857	198,214	66,071	6,584	59,488	5,949	3,966	High(3)
Main Rivers Total	**Total**	**3,078,434**	**1,079,009**	**1,977,693**	**503,032**	**189,753**	**303,719**	**53,210**	**30,689**	
Oliant	All basin	17,384	0	17,384	5,795	15,151	−9,356	−624	−936	OverPump
Abda	All basin	18,386	0	18,386	6,129	4,355	1,774	177	118	Poor
Minie	All basin	18,424	0	18,424	6,141	6,859	−718	−48	−72	OverPump
Chekka	All basin	79,962	11,912	68,050	22,683	2,012	20,671	2,067	1,378	Medium(8)
Batrouan	All basin	90,479	0	90,479	30,160	6,423	23,737	2,374	1,582	Medium(7)
Jounie	All basin	36,319	0	36,319	12,106	1,734	10,372	1,037	691	Fair(13)
Aaramoun	All basin	62,964	0	62,964	20,988	3,837	17,151	1,715	1,143	Medium(10)
Barja	All basin	15,414	0	15,414	5,138	1,236	3,902	390	260	
Sarafand	All basin	47,574	0	47,574	15,858	14,808	1,050	105	70	Poor
Sour	All basin	218,128	46,095	132,599	44,200	36,342	7,858	786	524	Fair(15)
Yammoune	Individual	99,062	68,016	31,046	10,349	6,300	4,049	405	270	
K. Kaouk	Individual	38,687	17,010	21,677	7,226	211	7,015	701	468	
Non-River Total	**Total**	**742,783**	**143,033**	**560,316**	**186,772**	**99,268**	**87,504**	**9,086**	5,498	
GRAND TOTAL	**Total**	**3,821,217**	**1,222,042**	**2,538,009**	**689,804**	**289,021**	**391,223**	**62,296**	**36,187**	

*1: Results of SSM Simulation for current 10 years.
*2: Net Recharge is "Recharge − Spring-Out".
*3: Total Development Potential is "Net Recharge/3".
*4: Net Development Potential is "Total Development Potential − Exist Withdrawal".
*5: Monthly Average is assumed monthly development potential as:
60% of yearly potential is available in wet 6 months, and
40% of yearly potential is available in dry 6 months.

(2) Groundwater resources development potential at offshore

Because of the hydrogeological characteristics of Lebanon, there are many submarine springs along the coastal line or offshore. Spring water was recharged in the inland sub-basins and runs down through mainly confined aquifers and finally flow out to the sea bottom because its piezometric head is higher than the depth of the sea (refer to Figure 2.4.6, at previous Chapter). The studies on submarine springs by AUB or NCRS said a huge amount of fresh water springs out from the bottom of the sea. One of them, the study report on submarine springs by AUB, submitted to IDRC, Ottawa, Canada, February 2000, said the total annual discharge from all the springs (but only in Chekka Bay) may exceed 700 MCM.

Although the exact location or yield of each submarine spring is unknown, the maximum limit of the submarine spring water development can be estimated through SSM simulation. The maximum fresh water volume flowing out from those submarine springs must be less than the total groundwater volume that flows out to the sea, supposedly actually spring out volume is only certain percent of the total flow-out amount though.

Table 4.3.2 shows the groundwater flow-out to the sea from all of coastal sub-basins, and the flow-out to the out of the country through the Assi and the Hasbani, as well as a part of the Litani sub-basin (by SSM simulation on 1996). As shown in the Table, a huge amount of groundwater, around 1,800 MCM/year, is flowing out to the sea every year, and it is roughly 24% of the yearly precipitation volume. Beside the coastal basins, some considerable amount of groundwater is flowing out to the other countries: to Syria from the north of Bekaa Plain and to Israel from the downstream of the Hasbani. Total of the groundwater flow-out to outside of the country is estimated as 955 MCM at 1996, which year has nearly average rainfall within the latest 10 years (but somewhat higher than the average).

Table 4.3.2 SUMMARY OF GROUNDWATER FLOWOUT IN CURRENT CONDITION (Unit: 1000m³)

Flow-out to Sea	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Kebir	4,258	4,262	4,702	4,604	4,488	3,928	3,722	3,459	3,218	3,438	3,688	4,070	47,836
Ostuene	7,140	7,216	7,406	7,061	6,240	5,254	5,073	4,861	4,732	5,468	6,419	6,820	73,689
Akkar	4,592	4,398	4,393	4,157	3,746	3,322	3,322	3,261	3,175	3,685	4,101	4,277	46,428
Bared	2,249	2,319	2,646	2,308	2,013	1,735	1,685	1,619	1,555	1,760	1,951	2,083	23,930
Abou Ali	10,333	10,707	11,373	11,075	10,442	9,152	8,627	7,934	7,152	7,507	8,476	9,208	111,985
Jouz	2,989	2,798	2,998	2,915	3,000	2,888	2,967	2,951	2,840	2,925	2,852	2,945	35,047
Ibrahim	16	15	17	16	17	16	16	16	15	16	15	16	191
Kelb	1,279	1,215	1,328	1,272	1,299	1,241	1,270	1,261	1,213	1,249	1,217	1,261	15,108
Beirut	1,425	1,458	1,557	1,527	1,382	1,141	1,017	896	798	860	1,069	1,175	14,304
Damouar	1,727	1,641	1,775	1,732	1,779	1,699	1,728	1,699	1,622	1,667	1,634	1,698	20,400
Awali	5,827	5,651	6,203	6,115	6,035	5,535	5,468	5,261	4,942	5,095	5,219	5,431	66,780
Saintariq	892	974	1,072	1,060	908	659	501	367	289	297	525	631	8,153
Zahrani	3,864	3,663	3,937	3,841	3,935	3,760	3,838	3,793	3,630	3,733	3,671	3,798	45,461
Abou Assouad	3,609	3,659	3,974	3,993	3,984	3,638	3,549	3,358	3,084	3,080	3,223	3,359	42,508
Litani	55,994	49,376	53,592	50,813	49,482	47,403	48,884	48,760	47,156	51,280	51,130	51,488	605,337
Rivers Total	106,174	99,350	106,974	102,488	98,747	91,372	91,666	89,492	85,401	92,040	95,191	98,262	1,157,157
Chant	216	278	323	349	320	245	187	121	63	52	110	149	2,413
Abda	1,733	1,702	1,636	1,506	1,170	872	794	740	740	1,057	1,417	1,530	14,898
Mnie	474	600	692	707	592	398	245	105	12	44	214	354	4,438
Chekka	5,026	4,828	5,136	4,972	5,040	4,800	4,891	4,823	4,603	4,740	4,712	4,912	58,484
Batrouan	11,324	11,132	11,400	11,080	9,674	7,988	7,277	6,632	6,026	6,512	8,559	8,690	106,275
Jounie	14,866	14,198	15,020	14,756	14,065	12,704	12,464	11,945	11,179	11,729	12,850	13,009	158,785
Aeramoun	3,286	3,355	3,631	3,648	3,508	3,106	2,946	2,709	2,425	2,429	2,741	2,824	36,608
Barja	3,729	3,649	3,964	3,944	3,913	3,580	3,508	3,344	3,112	3,186	3,306	3,451	42,687
Sarafand	4,466	4,377	4,738	4,681	4,731	4,419	4,411	4,269	4,013	4,077	4,111	4,292	52,584
Sour	15,072	14,619	15,443	15,079	14,885	13,765	13,764	13,425	12,715	13,016	13,808	14,143	169,533
Non River Total	60,193	58,738	61,983	60,722	57,897	51,857	50,487	48,113	44,889	46,841	51,626	53,354	646,700
GRAND TOTAL	166,367	158,088	168,958	163,210	156,644	143,229	142,152	137,605	130,290	138,882	146,817	151,616	1,803,857

Flow-out to Outside		Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
to Syria	(Assi)	56,721	53,490	57,847	55,811	57,309	54,940	56,361	56,046	53,982	55,602	54,021	56,030	668,160
to Israel	(Hasbani)	20,934	19,691	21,254	20,532	21,133	20,335	20,930	20,864	20,128	20,753	20,094	20,769	247,415
	(Litani)	3,343	3,145	3,367	3,270	3,368	3,245	3,338	3,323	3,202	3,300	3,216	3,319	39,434
subtotal to Israel														286,849
TOTAL		80,997	76,325	82,468	79,613	81,810	78,519	80,629	80,233	77,311	78,655	77,331	80,118	955,010

(3) Conclusion

As discussed so far, a huge amount of rain water infiltrated into the ground, partly returned back to the surface though, flows down through the country and finally pours into the sea or goes out from the country to the north and south. On the course of groundwater movement, around 700 MCM of groundwater (in both inland and coastal sub-basins) shall be available for development. However, in this amount, already around 400 MCM/year of groundwater is withdrew and utilized, so that remaining around 400 MCM/year of groundwater shall be available for future development scheme (the net groundwater resources development potential).

Besides the groundwater movement in the land, also a huge amount of groundwater pours into the sea uselessly. SSM calculated out as high as 1,800 MCM/year (estimated in 1996) of groundwater is losing in the sea. This huge amount of groundwater shall be available to develop in future if any kind of proper development schemes is applied, such as an underground dam scheme at inshore or offshore submarine spring development. Groundwater flowing out to the neighboring countries is also another large amount of groundwater loss. However, the report does not describe on the issue.

CHAPTER 5

WATER DEMAND

CHAPTER 5 WATER DEMAND

5.1 Domestic and Industrial Water Demand

5.1.1 Current Situation

(1) Category of Water Demand

For the purpose of water demand estimation in this study, water demand is categorized as shown in Figure 5.1-1, based on observations of water uses in Lebanon:

- Residential demand is divided into outdoor and indoor demands, as households in the rural area use water for outdoor purposes such as keeping domestic animal or irrigating home garden.
- Indoor demand is estimated by urban and rural by adopting different per capita consumption because life style or water use behavior is different between in the urban and rural area.
- Non-residential demand is comprised of commercial and administrable uses. For estimating future demand, category of tourism use is added because a rapid growth of tourism is anticipated by the Ministry of Tourism.
- While water demand is estimated, leakage should not be included in the water demands for private sources (wells or tanker) due to no distribution networks.

Total Domestic and Industrial Water Demand							
Domestic						Industrial	Leakage
Residential			Non-Residential				
Indoor		Outdoor	Commercial and Administration (C&A)	Tourism (Hotel) only for future projection			
Urban	Rural						

⇩

Category by public and private supply

Total Domestic and Industrial Water Demand				
Public Supply (Network)			Private Supply (Wells)	
Domestic	Industrial	Leakage	Domestic	Industrial

Figure 5.1-1 Composition of Water Demand

(2) Criteria for Current Water Demand Estimation

Several previous studies and reports have addressed the issues of water consumption and demand. Their study results and observations are summarized in Annex. Considering these results and observations, basic criteria for estimation of the current water demand are set up as follows.

(a) Residential consumption (indoor)

The majority of systems currently operate on a suppressed supply basis and there are few, if any, operating flow meters. There are no available records from which typical per capita consumption rate of existing water usage can be estimated. Based on the figures in previous studies and evaluation made above, to estimate the current water demand, the study uses the following rates for the current per capita consumption.

Urban	130 l/c/d
Rural	100 l/c/d
Greater Beirut:	140 l/c/d

(b) Residential consumption (outdoor)

Outdoor consumption 25 l/c/d; this is applied only for rural population.

(c) Non-residential consumption

Non-residential consumption is a function of intensity of commercial activity. Considering observations of non-residential consumption in the previous studies shown in Annex and intensity of commercial activity by Caza, following percentages of indoor residential consumption are used for non-residential consumption by urban and rural area, classified into 4 categories.

Table 5.1-1 Non-residential Water Consumption

Category	Intensive of C&A activity	Non-residential consumption (Percentage of indoor consumption)		Caza
		Urban	Rural	
S	Beirut city	35%	2%	Beirut City
A	High	15%	2%	Tripoli, GBA North, GBA South, Kesrwan, Saida City, Sour, Zahle
B	Medium	10%	2%	Koura, Batroun, Jbeil, Metn, Baabda
C	Low	5%	2%	Remaining Cazas

(d) Industrial consumption

Unit water consumption per industrial establishment was calculated for Kesrwan Coastal Area in the following table. It is estimated to be 8.7 and 2.0 m^3/day per establishment in summer in industrial zones and in no industrial zones, respectively. The average is 6.7 m^3/day for the Caza.

Table 5.1-2 Water Consumption of Establishment

	Water consumption (m^3/establishment/day)	
	Winter	Summer
Zouk Mosbeh industrial zone	8.30	8.7
Other Area	1.50	2.0
Average	6.20	6.7

Source: Water Consumption Study, Kesrwan Area, First Draft, BTD, 1996 April

In the study for Supply in Potable Water for Koura Caza (BTD 1999, Koura), water consumptions in the industrial zones of Chekka and Heri were estimated, where there are several cement factories. Nineteen industries were evaluated for the water consumption. Using the data surveyed, this study derived the water consumption figures as follows.

Industry more than 50 employees 592 m^3/establishment/day
Industry less than 50 employees 3.8 m^3/establishment/day

In Lebanon, 99.7 % of industries have less than 50 employees (Source: A Report on Industry in Lebanon 1998-1999, Statistics and Findings, Ministry of Environment). Therefore, the country's average consumption per establishment would be close to 3.8 m^3/est/day.

Considering the above observations, the following consumptions per establishment by Caza category are assumed in this study.

Table 5.1-3 Assumed Consumption of Establishment by Caza

Category	Caza type	Unit consumption (m^3/ establishment/day)	Remarks
High	Caza with major industrial zones or intensive industrial activities	6	(from 6.7 m^3/est/day)
Medium	Average	4	(from 3.8 m^3/est/day)
Low	Caza without industrial zones or light industry	2	(from 2.0 m^3/est/day)

The classifications of Caza by the categories are assumed based on existence of major industrial zone in the Caza and the number of water consuming establishments in the Caza (see Annex).

(e) Public water supply coverage of domestic sector

The figures in Table 2.5-2 in the section 2.5 of this report are used as current public water supply coverage rates for residential and non-residential customers.

(f) Public water supply coverage of industry

The result of Non Domestic (non-residential and industrial) Water Use in Greater Beirut (World Bank, 1996) estimated that 80 % of the water consumed by non-residential and industrial sectors were derived from private wells. In the BTD studies in several Cazas (1996), most industrial establishments in West Bekaa and Rachaya do not rely on public water networks. While most industrial establishments in Bcharri and Kesrwan rely on public water networks, in the industry zone of Chekka, about half the establishments surveyed use private wells but all large water users rely on only private wells. Generally, large water users rely on private wells. We assumed public water supply coverage for industry is half the coverage for population.

(g) Leakage

The NERP 2nd and 3rd Program recommend that leakage ratio is 35 % after following rehabilitation and 30 % by the year 2000. However, the Program is still under way and to achieve the target, considerable time and fund will be necessary.

The leakage ratio estimated by water authorities varies from 70 to 20 % but from 50 to 30 % in most Cazas. For the purpose of demand evaluation, leakage ratios are assumed to be 45 % for all Cazas except for Saida (20 %), where recently large length of new pipelines has been added to the system.

(3) Current Water Demand

Using the criteria set above, the current water demands for 2002 are estimated. The results and calculation sheets are attached in Annex and a summary by Caza is presented in Table 5.1-4. Total demand in Lebanon for 2002 is 1,180,000 m^3/day (430 million m^3/year), in which domestic demand, industrial demand and leakage account for 53 %, 10, % and 37 %, respectively. Eighty-three percent of the total demand should be delivered from public water supply networks.

Table 5.1-4 Summary of Current Domestic and Industrial Water Use

Region	Water Use in 2002				Public/Private		Domestic/Industrial incl. leakage	
	Domestic	Industry	Leakage	Total	Public supply	Private Supply	Domestic	Industry
North	122,692	26,334	81,824	230,850	181,832	49,018	195,829	35,021
Greater Beirut	241,203	49,450	178,883	469,536	397,518	72,018	401,271	68,265
North	93,088	22,854	74,250	190,192	164,998	25,194	159,010	31,182
South	72,134	9,736	38,046	119,916	99,222	20,694	108,326	11,590
Nabatiye	39,922	3,034	28,551	71,507	63,446	8,061	67,345	4,162
Bekka	81,416	9,240	48,426	139,082	107,613	31,469	127,007	12,075
Total	650,455	120,648	449,980	1,221,083	1,014,629	206,454	1,058,788	162,295

Note: Public indicates water authority.

(4) Estimated Actual Consumption

Currently the water demand is suppressed and the actual amount of water consumed is different form the demand. Current actual consumption level (per capita consumption) is estimated using the calculation sheets constructed in estimating the water demand in 2002. In the calculation, it is assumed that the water resource in the dry season is the same as the water amount put into the water supply network. The results of estimation are summarized in Annex and its details are attached in Annex.

The estimated current per capita consumptions for all consumption categories vary from 94 to 765 l/c/d and the estimated per capita residential consumption fall between 43 to 407 l/c/d. The larger consumptions occur in Akkar and Bekaa and Hermel. This is possibly due to large amount of irrigation water resources is included in the Water Authorities resource.

(5) Surplus and Deficit of Water Resource of Water Authority

Subtracting water demands from the water resources owned by Water Authorities, surplus and deficit are estimated

In the following Caza or City, an estimated current consumption level is very high as irrigation water resources may be included. We made the following adjustments of per capita consumption for these areas to evaluate the deficit/surplus of their water resources.

Table 5.1-5 Adjusted Per Capita Consumption

(Unit: l/c/d)

	Estimated per capita			Adjusted per capita	
Area	Urban	Rural	Average	Urban	Rural
Akar	305	235	161	130	100
Saida city	216	-	216	130	
Hermel	443	341	406	130	100
Baalbek	443	341	407	130	100

The result is summarized in Annex. A large deficit occurs in Beirut south area (the supply area of Ain El Delbeh Water Authority) but Beirut City and North areas (the supply area of Beirut Water Authority) result in a surplus. This large discrepancy may be attributed to the allocation of population to the areas for these two Water Authorities.

Globally, 137,000 m^3/day of water resource is deficit for Water Authorities although there are surplus and deficit depending on the areas. When the water demand attributing to private supply is included in the water demands attributing public water supply, the deficit will be 340,000 m^3/day (137,000 +203,000).

(6) Evaluation of Current Wastewater Generated and Reused

Wastewater is one of the possible water resources. Wastewater amount generated in 2002 is estimated as attached in Annex and a summary table is presented below. Currently, 551,000 m^3/day of wastewater is generated. Taking 10 % of the total wastewater sewered, wastewater reused directly for irrigation is estimated to be 23,200 m^3/day.

Table 5.1-6 Summary of Estimated Wastewater in the Dry Season (1000 m^3/day)

	Raw wastewater generated	Raw wastewater unsewered	Wastewater sewered			Total wastewater
			Raw wastewater	Infiltration /inflow	Sub-total	
All Lebanon	506	319	187	45	232	551

5.1.2 Criteria Settings

(1) Population Projection

(a) Introduction

The long-term projection of population is indispensable for formulating the future framework of socio-economic structure in the study areas; nevertheless official nationwide population projection is not available in the country. Project reports made by various organizations and institutions were reviewed, which revealed that there were many population projection conducted in the past years. However, most of them, being limited within the specific areas, did not range over nationwide scale.

Meanwhile, United Nations and World Bank announced the population data as presented in Table 5.1-7, which could be useful for the Study. However, this data extends only to year 2015, so that the objective of the Study to formulate the population projection until the target year of 2030 cannot be attained.

Table 5.1-7 Population Data of Lebanon by International Organizations

Organization	Year	Population	Average Annual Growth	Birth Rate	Mortality Rate
United Nations [1]	95-00	-	2.0%	20.3	5.4
	00-05	-	1.6%	19.0	5.4
World Bank [2]	2000	4,300,000	1.8% (Year 80-00)	20.0	6.0
	2015	5,200,000	1.2% (Year 00-15)	-	-

Source: 1) Statistical Abstract of the ESCWA Region, Twenty First Issue, United Nations
2) World Development Indicators 2001- Population Dynamics, World Bank
Note: Per 1000 persons for Birth Rate and Death Rate

Consequently, the population projection was conducted herein in two steps as presented bellow in order to attain the objective;

1. Base Population: 1) to estimate population growth rate basically from birth and mortality rate of Lebanon, and 2) to apply its country population growth rate of the year equally to every Caza over the period of the Study till year 2030

2. Projected Population: on the basis of above Base Population, to take into account domestic

migration such as movement from rural to urban area, and from urban to Beirut suburbs and/or Mohafaza Center cities. Thus the projected population over the period of the Study till the target year of 2030 can be attained by Caza.

(b) Base Population

The Base Population of the country throughout the period from 2003 to 2030 was projected based on estimated future birth and mortality rate, namely natural increase as discussed above. Social changes such as the Lebanese returnees from abroad, the Lebanese emigrants to abroad and the foreigners movement are not considered in this Study, because of three main reasons; 1) no obtainable official information or estimation on this matter, 2) a small economic capability of the country for an acceptance of such significant number of returnees and 3) a possible off-set of the number between the Lebanese returnees and the Lebanese emigrants judging from the official statistical inbound and outbound number of Lebanese (Actually embarkation number exceeded disembarkation number by around 10% over the 5 years from 1995 to 2000 according to "Bulletin Statistique from 1995 to 2001" of CAS).

The number of birth and mortality from 1999 to 2001 can be obtained from 'Bulletin Statistique' of CAS as previously discussed, from which the birth rate and mortality rate of Lebanon in the past years was estimated as shown in Table 5.1-2. Thus, the birth rate and mortality rate of year 2002 was estimated respectively at 22.5 and 5.0 per 1000 people, from which population of the year 2002 was estimated to have grown by 1.76% as previously discussed.

Table 5.1-8 Estimation of Birth Rate and Mortality Rate derived from CAS Statistics

Item	1999	2000	2001	2002
1. Birth Rate [1)]	23.2	22.9	21.5	22.5
2. Mortality Rate [1)]	5.4	5.2	4.5	5.0
3. Growth Rate	1.79 %	1.78 %	1.70 %	1.76 %

Note: 1) Per 1000 persons

Regarding the mortality rate of Lebanon, this rate presumably ranks the lowest level compared with world average of 9 per 1000 persons (World Development Indicators 2001, World Bank). Accordingly, the mortality rate of this Study was assumed to be a very slight down of 1 % in 10-year period. As a result, the mortality rate of year 2030 was estimated at 4.9 per 1000 persons.

Concerning the birth rate, four (4) scenarios were set up below;

Case-1	: Decrease to 19.0/1000persons in 2030 or 16% decrease from year 2002 rate; that is United Nations Predictions for 2000/2005 rate.
Case-2	: Decrease to 20.6/1000persons in 2030 or 8% decrease from year 2002 rate
Case-3	: Unchanged in 2030 from 22.5/1000persons of year 2002
Case-4	: Increase to 24.9/1000persons in 2030 or 10% increase from year 2002 rate.

On the basis of above criteria, year 2030 population could be estimated respectively below;

Case-1	:	6,760,000 (annual growth: 1.57%)
Case-2	:	6,920,000 (annual growth: 1.66%)
Case-3	:	7,120,000 (annual growth: 1.76%)
Case-4	:	7,610,000 (annual growth: 2.00%)

It should be noted that the birth rate would decrease with a change of social and economic elements such as improvement of a living standard and an economic development. Accordingly, case-3 and 4 might be considered an overestimation. Meanwhile, United Nations forecasted the birth rate of Lebanon to decrease to 19.0 per 1000 persons (case-1) as shown in Table-5.1-2 over the period of 2000/2005. This represents 16% decrease compared with year 2002 rate, a very big decrease, so that this rate could be deemed too low to be applied for estimation when compared to current birth rate of Lebanon. In conclusion, case-2 was considered to be an appropriate manner for estimation of year 2030 birth rate in this Study as a Base Population.

Thus Base Population was projected to reach 6,920,000 in the target year of 2030 as summarized in Table 5.1-3. Annual population growth of year 2030 would turn out to be 1.57 % compared to the previous year, a decrease of 0.2% from 1.76 % of year 2002. On the other hand, the average annual growth rate during the period from 2002 to 2030 would be 1.66 %.

Table 5.1-9 Base Population of Year 2030 by Mohafaza (in thousands)

Mohafaza	2002	2030	Annual Growth (2002 – 2030)
Beirut	440	697	1.66 %
Mount Lebanon	1,645	2,605	
North Lebanon	881	1,395	
South Lebanon	515	816	
Nabatieh	300	476	
Bekaa	589	932	
Total	4,369	6,920	

(c) Projected Population by Area

When conducting population projection by area, it must be taken into account not only natural growth but also domestic migration or movement derived from such as social, economical and political motivation. However, the accurate and reliable data and information on the kind is not available in the country.

Accordingly, projected population by area was conducted based on the following assumptions, as summarized in Table 5.1-10.

1) Beirut, due to the highest level of population density at present (22,000persons/km^2 in 2002 as previously discussed) and decentralization policy crucially required in order to mitigate environmental deterioration, might be unable to afford such a high growth of the

country, so that the growth rate was set at 1.16 % per annum (or 30 % smaller than 1.66 % of the country growth).

2) It is commonly recognized that there are dynamic cities such as Beirut suburbs and Mohafaza Center cities, namely, Tripoli, Saida and Zahle. Presumably these localities and cities might provide with employment opportunity and therefore could afford roles to absorb the majority of population increase in the country; so that the growth rate was set at 2.23 % per annum (or 35 % larger than country growth rate).

3) Urban areas, excluding Mohafaza Center cities, were assumed to be the same growth rate of the country; that is 1.66 %.

4) Presumably such a high growth as of other areas might be unlikely for rural areas, so that the growth rate was set at 0.5 % per annum (one third of country growth).

Table 5.1-10 Assumptions for Projection

Region	Population Growth over 2002-2030	
	Base Population	Projected Population by Area
Beirut	1.66 %	1.16 %
Beirut Suburbs	1.66 %	2.23 %
Mohafaza Center Cities	1.66 %	2.23 %
Urban Areas	1.66 %	1.66 %
Rural Areas	1.66 %	0.50 %

Thus projected population over the period till 2030 was estimated and summarized in Table 5.1-11. Obviously Mount Lebanon grew at the highest growth rate of 1.98 % and North Lebanon followed at 1.57 %. Meanwhile, national population density would increase to 660person/km^2 in year 2030 from 420 in year 2002.

Table 5.1-11 Projected Population by Mohafaza (in thousands)

Mohafaza	2002	2010	2020	2030	Annual Growth ('02 -'30)	Density (Person /km^2)
Beirut	440	483	542	608	1.16 %	30,707
Mount Lebanon	1,645	1,921	2,336	2,844	1.98 %	1,398
North Lebanon	881	994	1,161	1,362	1.57 %	662
South Lebanon	515	579	673	785	1.52 %	824
Nabatieh	300	332	378	432	1.31 %	383
Bekaa	588	659	762	889	1.47 %	209
Total	4,369	4,968	5,852	6,920	1.66 %	662

Projected Population of big cities such as Beirut, Beirut Suburbs, Tripoli, Saida and Zahle was also shown in Table 5.1-12. These big cities were assumed to account for 52% of national population in 2030, up from 47% in 2002.

Table 5.1-12 Projected Population of Big Cities (in thousands)

Localiy	2002	2010	2020	2030	Annual Growth (2002 - 2030)
Beirut + Beirut Suburbs	1,422	1,654	2,002	2,428	1.93 %
(Beirut Suburbs)	(982)	(1,171)	(1,460)	(1,820)	(2.23 %)
Tripoli	336	401	500	624	2.23 %
Saida	146	174	217	270	2.23 %
Zahl	135	161	201	251	2.23 %
Total	2,039	2,390	2,920	3,573	2.02 %
% of National Population	47 %	48 %	50 %	52 %	-

Further detailed Projected Population by area was presented in the GIS database.

(2) Residential Demand

"Horizon 2000 (MEHR)" gives a target of 150 l/c/d in urban area, rising to 160 l/c/d by the year 2002, and 100 l/c/d in rural areas. While, the objective of the NERP is ensured that every person receives an adequate supply of potable water. The definition of an adequate supply has been established as a minimum of 80 l/c/d (SIU criteria set up).

Ideally, water supplies in the future should be made available to satisfy the unsuppressed water demand of the population. Furthermore, to ensure water quality the supply and distribution systems should be continuously pressured. However, in some cases this will not be achievable in the short term. The following have therefore been determined as the minimum target levels of service to be achieved within the NERP 2nd and 3rd Year Program.

- Provide a supply of at least 80 l/c/d to every household
- Where possible, maintain supplies under constant pressure and hence, maintain a 24 hour supply.
- Where systems cannot be maintained under pressure, provide a rotational system of operation such that all consumers receive an equitable allocation of the available supply.

In addition, the NERP 2nd and 3rd Programme recommend the following criteria;

- Residential per capita consumption for urban: 150 l/c/d
- Residential per capita consumption for rural: 120 l/c/d
- Non-residential demand: 20 % of residential demand
- Losses: 35 % (following rehabilitation)
  30 % by the year 2000
  25 % by 2015

In Chapter 2, 130, 100 and 140 l/c/d were estimated to be the values for the current domestic water demand for urban, rural and Greater Beirut Area (GBA), respectively.

In Annex, previous projections of per capita consumption in Lebanon and past per capita consumptions of other countries are presented. Currently, 150 l/c/d was used for Greater Beirut Area in 2015. 170 l/c/d was used for Tripoli in 2014. In South Lebanon, 218 l/c/d and 128 l/c/d for urban and rural area in 2020. The people in Western European countries such as France and Germany can manage their water uses at around 150 l/c/d. Even in the future, therefore, the Lebanese people may be able to manage water uses of around 150 l/c/d. While, in Arabic countries which own very limited amount of water resource, their per capita consumption is significantly low, namely 50 to 110 l/c/d. The per capita consumption generally depends on the amount of water that they can use.

For criteria setting, considering the per capita consumption recommended by the NERP 2nd and 3rd Programme and Horizon 2000, the following scenario of per capita consumptions is assumed.

- The per capita consumptions of 130, 100, and 140 l/c/d will be satisfied in 2005 for urban, rural and GBA, respectively by completion of the projects currently implemented.
- In 2015, the NERP criteria will be satisfied.
- In 2020, the per capita consumptions reach to 160, 130, and 170 l/c/d for urban, rural and GBA, respectively. (160 l/c/d is Horizon 2000 criteria.)
- Thereafter the rates will be stable until 2030.

Table 5.1-13 Assumed Growth of Per Capita Consumption

Location	Water consumption per capita (l/c/d)						
	2002	2005	2010	2015	2020	2025	2030
Urban	130	130	140	150	160	160	160
Rural	100	100	110	120	130	130	130
Greater Beirut Area	140	140	150	160	170	170	170

Assumed growth of per capita water consumption of domestic use is visualized also in Figure 5.1-2.

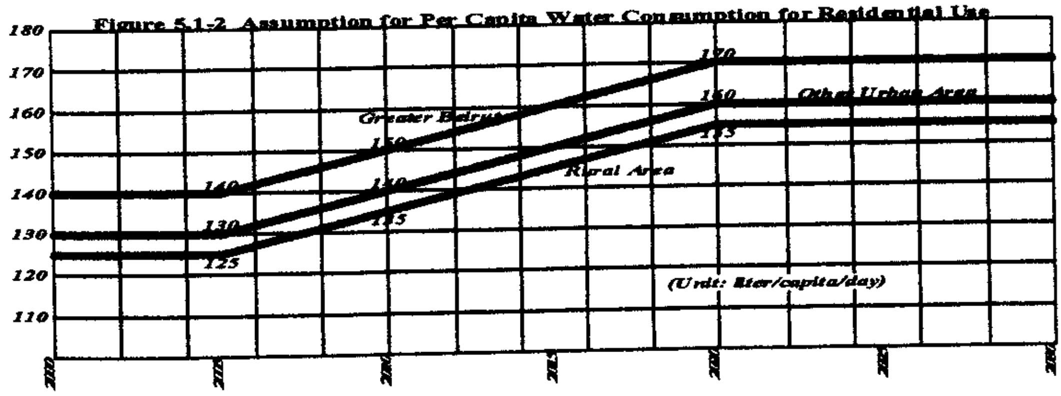


Figure 5.1-2 Assumption for Per Capita Water Consumption for Residential Use

(3) Non-Residential Demand

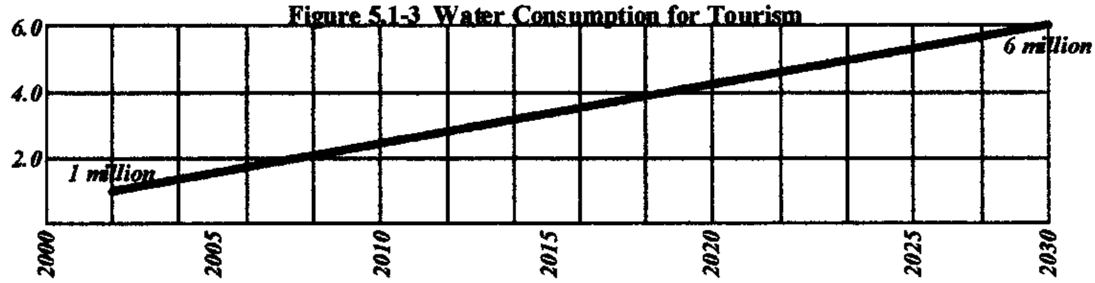
1) Users except tourism

The same percentages of domestic consumption (indoor) as the current ones are assumed.

2) Tourism

In the current demand estimation, the touristic demand is not considered because it is estimated to be very small. However, for the future projection, the touristic water demand projection is included since the Ministry of Tourism is planning to expand tourism industry in Lebanon dramatically in the near future. The following unit consumption per tourist per night assumed. The future tourism population projection is now under study by the Ministry of Tourism so JICA study team tentatively forecasts the tourism population for the purpose of water demand projection, which is presented in Annex.

Figure 5.1-3 Water Consumption for Tourism



Water Consumption = Number of Tourist x Days of Stay x 300 l/bed/day

Unit consumption per tourist per night: 0.3 m^3/day/tourist (CDR/CDM, 1982)

(4) Industrial Demand

(a) Water Consumption

The same water consumption rates per establishment are the same as current rates presented below are applied to the future projection. The number of industrial establishments is assumed to increase according to the future GDP growth projection. The industrial Caza type is assumed the same as current classifications.

(b) Projection for Gross Domestic Product

<u>Assumptions</u>

The long-term projection of GDP is also indispensable for formulating the future framework of the socio-economic structure in the project areas.

Lebanese Government developed National Emergency Recovery Program (NERP) into "The

Horizon 2000 Program" in 1995 that envisaged total public investments of US$17.7 billion (at 1995 prices) throughout the period from 1995 to 2007. Investment program by sector was classified into: 1) physical infrastructure, 37%; 2) social infrastructure, 25%; 3) public services such as water, waste, transport and railways, 22%, 4) productive sectors, 8%; and 5) state apparatus such as government buildings, security forces and rehabilitation of public administration, 8%. "The Horizon 2000 Program" expected GDP growth over the 13-year period to be 8% per annum, implying private sector investment of US$42 billion during the same period.

"The Horizon 2000 Program", however, presents the projections only until year 2007. After that, no projection scenarios were suggested in any of the development plans at present.

Incidentally, actual average annual GDP growth between 1995 and 2001 was presumed to be 2.2% according to our Study, obviously far from 8% expected by "The Horizon 2000 Program". Consequently it should be noted that expected growth rate of 8% would be unrealistic and could not be possibly attained any more.

Therefore, with absence of accurate and reliable data and information, GDP in the future was projected based on the following assumptions;

1) GDP growth

- from 2003 to 2010	2.5% (rounded-up actual average growth rate of 1995/2001)
- from 2010 to 2030	4.0% (half of growth rate expected by "The Horizon 2000 Program")

2) Distribution of GDP by Sector

- Agriculture	: a decrease of distribution from current 10% to 5% in 2030
- Industry	: a decrease of distribution from current 20% to 15% in 2030
- Services	: an increase of distribution from current 70% to 80% in 2030

<u>GDP Projection</u>

Thus GDP was projected as shown in Table 5.1-14. As a result, average annual growth over the period from 2001 to 2030 was assumed to be: 1) GDP, 3.5%; 2) Agriculture Sector, 1.0%; 3) Industry Sector, 2.7%; 4) and Services Sector, 4.0%. GDP per capita of year 2030 was assumed to be US$6,600; that is 1.7 times as much as of year 2001.

Table 5.1-14 Projected GDP

Item	2001	2002	2010	2020	2030	Annual Growth (2001 - 2030)
GDP (LBP billion)	25,188	25,818	31,456	46,563	68,925	3.5 %
GDP (US$ million)	(16,700)	(17,100)	(20,900)	(30,900)	(45,700)	
Distribution by Sector						
- Agriculture	10.0%	9.8%	8.4%	6.7%	5.0%	1.0 %
- Industry	20.0%	19.8%	18.4%	16.7%	15.0%	2.7 %
- Services	70.0%	70.3%	73.1%	76.6%	80.0%	4.0 %
GDP/capita (US$)	3,890	3,900	4,200	5,300	6,600	1.8 %

Note: at constant price of 2001

(c) Recycling ratio

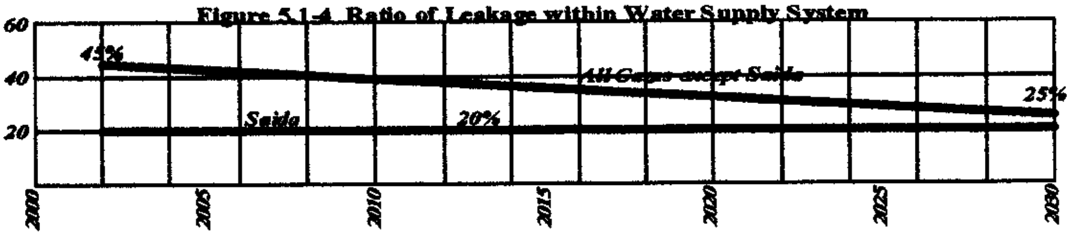
In Lebanon, recycling of industrial wastewater is currently almost not practiced. Most industries are equipped with private water wells and tap underground water at liberty with minor costs for pump operation. In this condition, industrial wastewater recycling will not be introduced to Lebanon. For this reason, industrial recycling is not considered in the basic projection in this study.

(5) System Losses (Leakage)

The current system losses are estimated at 45 % for most of the water system. Taking 35 % as the losses after the completion of the NERP 2nd & 3rd Programmes, which would be later than the year of 2005. To reduce leakage more, active leakage control measures are required and additional amount of financial resources and continuous and steady endeavours are required. If operation and maintenance of the distribution system is not adequate, the losses will increase again with time. It is not an easy task to keep 35 % leakage level.

In the basic projection, it is assumed that 25 % will be attained for the leakage of the all the system in 2030 with leakage prevention measures, except 20 % for Saida.

Figure 5.1-4 Ratio of Leakage within Water Supply System



(6) Seasonal variation

Seasonal water demand patterns vary depending on a number of factors. These include the size of the area concerned, the type of the area such as industrial, commercial areas, and whether patterns.

Peaking factors from average day to maximum day tend to range from 1.2 to 3.0. These values are system-specific, so they must be determined based on the demand characteristics of the system at hand. Generally, peaking factors of small communities, which are mostly composed of household users, tend to be large, while those of large cities, which are composed of a variety of water users, tend to be small. For very large cities, the factor is usually less than 1.2 (1.1 for Tokyo).

In general, the water consumption in the dry or summer season is largest in the year if water demand is not suppressed. Currently, water consumption in the dry season in Lebanon is more suppressed than in the wet season and the seasonal peak demand may have not appeared. Once water resource for the dry and wet season meets its demands, the consumption peak will occur in the summer.

Major factors causing seasonal demand variation are the effect of garden watering and tourist demand. In Lebanon, the tourist demand increases in the summer tourist season and occurs mainly in hotel locations. Major hotel locations are the large cities such as Beirut, its surroundings, Tripoli and Saida.

Garden watering increases in summer season in the rural areas. According to estimated water demand in Bsharri and Rachaya, the summer peak factors caused by garden watering are 1.1 and 1.05, respectively. However this peak demand may be depressed due to the current intermittent water supply.

There is no data to evaluate the peak factor or seasonal water demand fluctuations in Lebanon because the water demand is suppressed and the water consumption volume actually supplied is not measured through meter. As a purpose of water demand projection, therefore, it is assumed that a factor of 1.2 for the summer peak demand for all Cazas and the monthly factors are assumed as in the following table.

Table 5.1-15 Seasonal Fluctuation of Water Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Winter		Spring		Summer						Autumn		
0.8	0.8	0.9	1	1	1.1	1.2	1.2	1.1	1	1	0.9	1

(7) Public Water Supply Coverage

1) Domestic sector

To increase service population with reliable supply of safe water is an important mission of public water supply bodies and thus the planning of service coverage is really a policy matter accompanied by appropriate financial resources.

The current estimated coverage varies considerably from 49 % in Akkar to 95 % in Hasbaiya.

For the basic projection, the following coverage for the year of 2030 is assumed. The rates of intermediate years are interpolated.

Table 5.1-16 Assumed Growth of Water Supply Coverage

Caza Category	Current coverage (%)	Nos of Cazas	Coverage Rate Projection					
			2005	2010	2015	2020	2025	2030
C	0 < CR <70	4		80	85	90	95	**100**
B	70 < CR < 90	16		95	97.5	**100**	**100**	**100**
A	90< CR	11		**100**	**100**	**100**	**100**	**100**

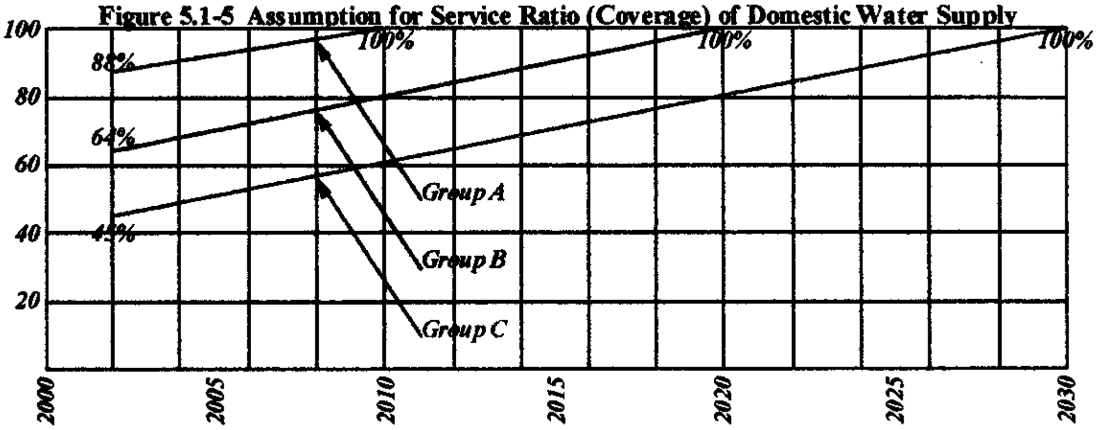


Figure 5.1-5 Assumption for Service Ratio (Coverage) of Domestic Water Supply

2) Industrial sector

According to previous studies and general rules, large and medium water users rely on private wells because in many cases the cost of water from private boreholes is cheaper than public water. For users, water is one of the major product inputs and whether they purchase it from public bodies or produce by themselves, namely from private borehole depends on mainly its costs. The current tariffs of public water are relatively expensive and in the future they would be raised more, as the water resources are scarcer. Thus large and medium water users would continuously use their borehole water in the future.

The current coverage rates are unknown but it is assumed in the previous section using a few pieces of information that public water supply coverage of industry is half the coverage for domestic users. Assuming that large and medium water users continuously use their borehole water, it is again assumed that for the future demand projection the public water coverage of industry is half the coverage for domestic users.

5.1.3 Current and Projected Water Demand

All parameters described in the previous section were put into the Digital Balancing Model

(DBM) for assessment of the current and projected water demands for domestic and industrial water uses. Results are shown in Figures 5.1-6 and 5.1-7 as well as in Tables 5.1-17, 5.1-18 and 5.1-19.

In this connection, all parameters for calculation of water demand are changeable, and various cases of demand projection would be processed according to scenarios of water resources management in the course of the next phase of the study.

Table 5.1-17 Projected Water Demand for Domestic and Industrial Supply by Mohafaza

(Unit: MCM/year)

No	Name	Category	2002	2005	2010	2015	2020	2025	2030
1	Beirut	Domestic	55.851	57.689	63.901	70.055	75.170	77.503	78.777
		Industrial	5.925	6.106	6.404	7.112	7.939	8.937	9.966
		Total	61.776	63.796	70.305	77.167	83.109	86.440	88.744
2	Mount Lebanon	Domestic	162.430	169.346	192.198	217.838	242.297	257.004	269.288
		Industrial	30.451	31.379	32.876	36.644	41.016	46.166	51.489
		Total	192.881	200.725	225.074	254.482	283.313	303.170	320.777
3	North Lebanon	Domestic	74.495	77.425	87.722	99.323	110.239	114.984	118.559
		Industrial	12.794	13.270	13.991	15.752	17.780	20.039	22.367
		Total	87.289	90.695	101.713	115.075	128.019	135.023	140.926
4	South Lebanon	Domestic	41.601	42.964	48.460	54.867	61.291	64.288	67.057
		Industrial	4.235	4.425	4.744	5.407	6.213	7.106	8.083
		Total	45.836	47.389	53.204	60.275	67.504	71.393	75.141
5	Bekaa	Domestic	48.495	50.618	57.682	64.801	71.416	74.294	76.361
		Industrial	4.409	4.606	4.904	5.516	6.223	7.023	7.849
		Total	52.904	55.224	62.586	70.317	77.639	81.317	84.209
6	Nabatieh	Domestic	26.005	26.322	28.692	31.594	34.171	34.965	35.393
		Industrial	1.522	1.570	1.641	1.830	2.050	2.307	2.573
		Total	27.528	27.892	30.332	33.423	36.221	37.271	37.966
Total		Domestic	408.878	424.365	478.655	538.478	594.584	623.038	645.436
		Industrial	59.336	61.357	64.559	72.262	81.221	91.577	102.328
		Total	468.214	485.722	543.215	610.740	675.805	714.614	747.764

Table 5.1-18 Projected Water Demand of Domestic Supply by Caza

(Unit: MCM/Year)

No	Name	2002	2005	2010	2015	2020	2025	2030
10	Beirut	55.851	57.689	63.901	70.055	75.170	77.503	78.777
20	Baabda Center	50.918	53.174	60.589	68.781	76.800	82.130	86.814
21	Metn Center	40.088	41.958	47.923	54.480	60.879	65.171	68.932
22	Chouf Center	2.863	2.990	3.407	3.867	4.318	4.618	4.881
23	Aaley Center	7.913	8.264	9.416	10.689	11.935	12.764	13.492
24	Kesrwan	12.540	13.022	14.648	16.368	17.910	18.740	19.343
25	Jbail	6.250	6.964	8.371	9.993	11.415	12.360	13.067
26	Baabda Other	8.401	8.682	9.762	11.049	12.253	12.730	13.073
27	Metn Other	13.901	14.289	15.923	17.576	19.077	19.754	20.224
28	Chouf Other	12.091	12.291	13.495	15.261	16.909	17.551	18.010
29	Aaley Other	7.464	7.712	8.664	9.773	10.802	11.186	11.452
31	Tripoli	31.950	33.414	38.306	44.751	51.148	54.798	57.987
32	Koura	7.171	7.377	8.227	9.134	9.942	10.137	10.224
33	Zgharta	8.976	9.081	9.890	10.974	11.937	12.163	12.259
34	Batroun	7.639	7.879	8.804	9.681	10.435	10.534	10.519
35	Akkar	10.290	10.983	12.839	14.085	15.156	15.469	15.566
36	Bcharri	5.289	5.412	5.992	6.682	7.304	7.480	7.577
37	Minieh-Dinnieh	3.179	3.278	3.663	4.015	4.317	4.403	4.427
41	Saida Center	9.696	10.428	12.656	15.323	18.450	20.627	23.050
42	Saida Other	7.152	7.276	7.992	8.944	9.810	10.081	10.244
43	Sour	17.358	17.785	19.702	21.907	23.864	24.363	24.596
47	Jezzine	7.395	7.475	8.109	8.694	9.167	9.217	9.167
51	Zahle	21.681	22.671	25.957	29.830	33.583	35.441	36.976
52	West Bekaa	7.543	7.629	8.298	8.991	9.583	9.743	9.799
53	Baalbek	13.923	14.776	17.191	19.184	20.988	21.805	22.326
54	El Hermel	1.967	2.165	2.637	2.935	3.205	3.322	3.395
55	Rachaiya	3.380	3.378	3.600	3.861	4.056	3.982	3.865
61	Nabatieh	10.093	10.288	11.335	12.444	13.442	13.856	14.132
62	Bent Jbeil	6.261	6.308	6.829	7.552	8.187	8.313	8.351
63	Marjaayoun	5.918	5.967	6.467	7.202	7.863	8.041	8.135
64	Hasbaya	3.733	3.760	4.062	4.396	4.681	4.754	4.776
Total		408.878	424.365	478.655	538.478	594.584	623.038	645.436

Table 5.1-19 Projected Demand of Industrial Water Supply by Caza

(Unit: MCM/Year)

No	Name	2002	2005	2010	2015	2020	2025	2030
10	Beirut	5.925	6.106	6.404	7.112	7.939	8.937	9.966
20	Baabda Center	6.422	6.619	6.940	7.707	8.601	9.682	10.799
21	Metn Center	11.125	11.469	12.029	13.359	14.909	16.781	18.718
22	Chouf Center	0.354	0.366	0.383	0.425	0.474	0.534	0.596
23	Aaley Center	1.164	1.200	1.260	1.399	1.562	1.756	1.961
24	Kesrwan	2.357	2.435	2.547	2.828	3.156	3.553	3.962
25	Jbail	1.645	1.687	1.754	1.976	2.229	2.508	2.795
26	Baabda Other	1.769	1.833	1.935	2.178	2.456	2.764	3.081
27	Metn Other	0.803	0.830	0.873	0.969	1.082	1.218	1.358
28	Chouf Other	4.276	4.384	4.566	5.140	5.797	6.527	7.279
29	Aaley Other	0.536	0.557	0.589	0.663	0.748	0.842	0.939
31	Tripoli	9.083	9.379	9.814	11.045	12.463	14.028	15.642
32	Koura	0.826	0.860	0.912	1.027	1.158	1.303	1.451
33	Zgharta	0.562	0.579	0.607	0.684	0.772	0.869	0.968
34	Batroun	0.706	0.738	0.788	0.886	0.999	1.125	1.254
35	Akkar	0.841	0.900	0.995	1.122	1.269	1.444	1.624
36	Bcharri	0.101	0.106	0.113	0.128	0.143	0.162	0.181
37	Minieh-Dinnieh	0.675	0.708	0.763	0.861	0.975	1.109	1.248
41	Saida Center	2.503	2.630	2.853	3.281	3.816	4.408	5.075
42	Saida Other	0.598	0.617	0.646	0.727	0.821	0.924	1.030
43	Sour	0.999	1.040	1.100	1.238	1.396	1.572	1.753
47	Jezzine	0.135	0.139	0.145	0.162	0.180	0.202	0.226
51	Zahle	2.940	3.059	3.236	3.641	4.108	4.624	5.158
52	West Bekaa	0.342	0.353	0.371	0.412	0.459	0.517	0.577
53	Baalbek	0.921	0.980	1.069	1.207	1.366	1.554	1.748
54	El Hermel	0.066	0.071	0.078	0.089	0.100	0.113	0.128
55	Rachaiya	0.140	0.144	0.150	0.168	0.190	0.214	0.239
61	Nabatieh	0.847	0.874	0.916	1.018	1.135	1.278	1.426
62	Bent Jbeil	0.340	0.353	0.369	0.415	0.469	0.527	0.589
63	Marjaayoun	0.196	0.201	0.208	0.233	0.263	0.296	0.330
64	Hasbaya	0.139	0.143	0.147	0.164	0.182	0.205	0.228
Total		59.336	61.357	64.559	72.262	81.221	91.577	102.328

Figure 5.1-6 Projected Demand of Domestic Water Supply

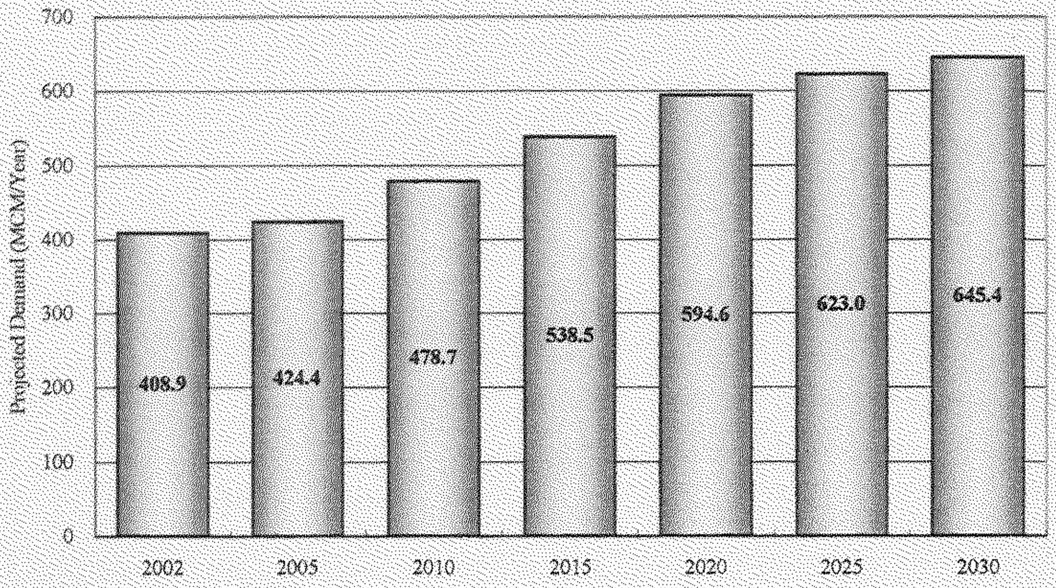
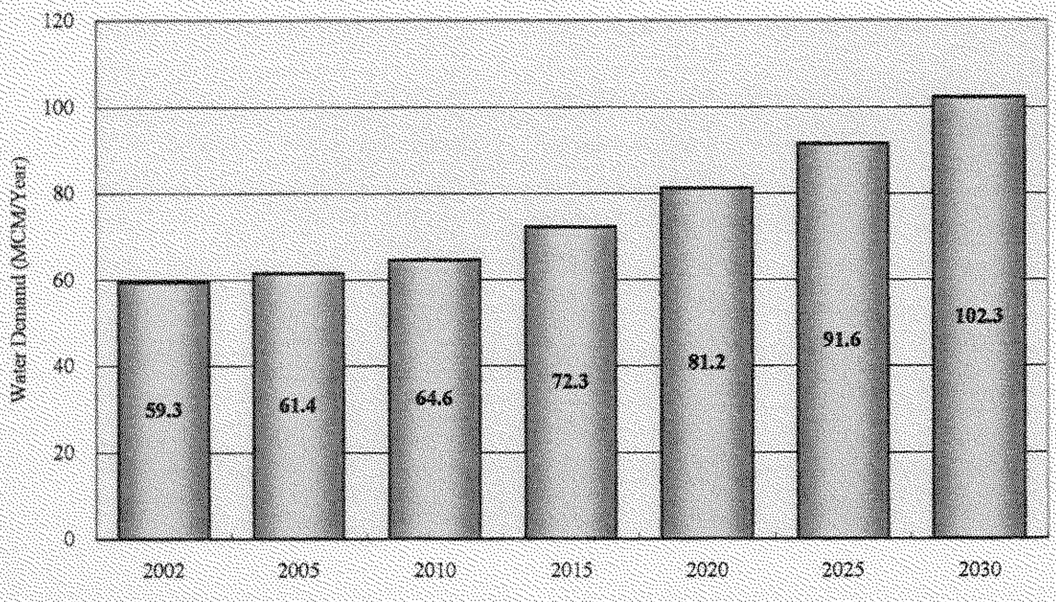


Figure 5.1-7 Projected Demand of Industrial Water Supply



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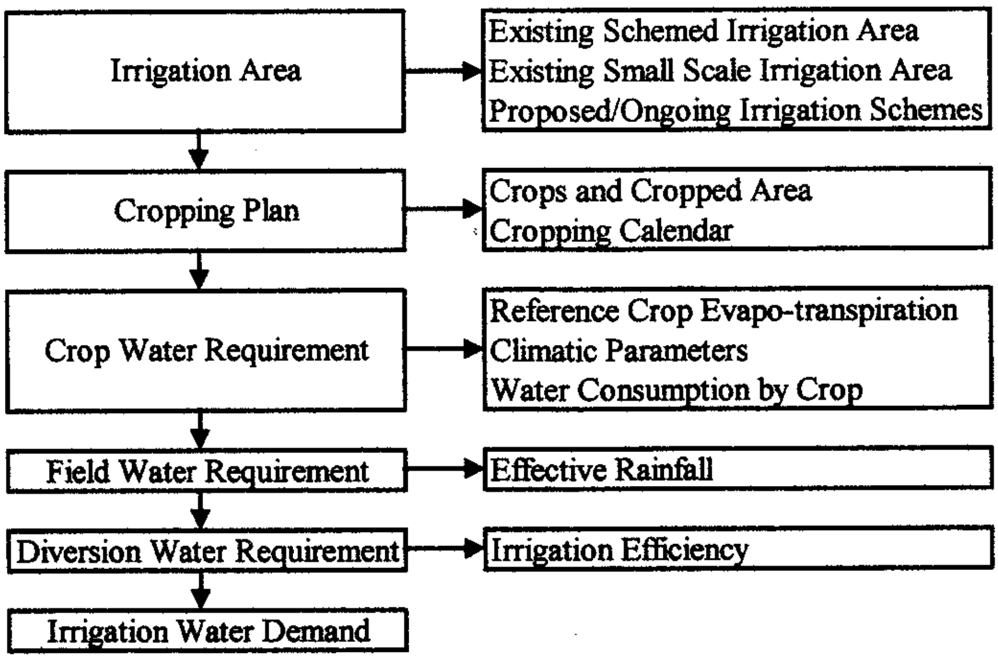
5.2 Irrigation Water Demand

5.2.1 Introduction

The agriculture sector is the main water consumer in the country using 60 to 70% of water collected mainly from surface and groundwater sources. A firm grasp of present use of water for irrigation is therefore essential to estimate overall demand of water, however, data and information to identify actual consumption of irrigation water such as the volumes of water diverted and applied in the field are scarce. Irrigation water demand per crop or per unit area of farmland extracted from the previous studies, such as "Staff Appraisal Report, Lebanese Republic Irrigation Rehabilitation and Modernization Project, 1994 by World Bank" meet sometimes with severe criticisms because of their smaller values as compared with those currently used for planning and design of irrigation projects A nation-wide master plan of water resources development and management inevitably requires regional differences in potential and available water resources against water demands from various water users. Water consumption of crops depends on climate, cropping calendar and farming practice. Rate of irrigation water application has a close relation with the method of irrigation such as surface, sprinkler and drip irrigations. On the other hand, under the recognition that the water is becoming short and valuable, the administration is forced to comply relatively high irrigation efficiencies.

In order to distinguish all the parameters to affect irrigation water demand, the study takes the following procedures;

Figure 5.2-1 Procedure of Estimation of Irrigation Water Demand



Areas of existing schemed irrigation and small scale irrigation operated by private farmers and also proposed/ongoing irrigation schemes are described previously in sections 2.6.2 and 2.6.3 of this report. Then information regarding crops, cropped area and cropping calendar is required and estimation of crop water consumption requires calculation of reference crop evapo-transpiration employing FAO method on the basis of the climatic parameters characterized in different regions. In order to estimate the field water requirement, effective rainfall on the cropped land is to be evaluated and estimation of diversion water requirement for irrigation requires evaluation of irrigation efficiency.

5.2.2 Parameters for Estimation of Irrigation Water Demand

(1) Irrigation Area

Existing schemed and small scale irrigation area is evaluated in the section 2.6.2 of this report as follows. The total equipped area accounts for 90,000 ha of which the net irrigated area is evaluated to be 81,030 ha.

Table 5.2.1 Existing Schemed and Small Scale Irrigation Area

Category	67 Schemed Irrigation	Small Scale Irrigation	Total
Equipped Area (ha)	65,600	24,400	90,000
Net Irrigated Area (ha)	59,070	21,960	81,030

In total, 12 irrigation projects are under detailed study or proposed for future implementation with the net irrigation area accounting for 63,025 ha including 38,530 ha to be newly expanded, as summarized in Table 5.2.2.

Table 5.2.2 Proposed/Ongoing Irrigation Schemes

No.	Scheme Name	Net Irrigation Area (ha)	Newly Expanded Area (ha)	Starting Year (assumed)
1	Noura Et Tahta Dam	5,000	2,300	2020
2	El Bared Dam	750	0	2015
3	Assi River Basin	6,700	6,700	2010
4	Younine Dam	1,545	0	2030
5	Southern Qaraoun Irrigation	500	500	2020
6	South Bekaa (Phase 2), Left Bank	6,700	0	2015
7	South Bekaa, Right Bank & North	12,800	0	2025
8	South Lebanon-Conveyor 800	13,230	13,230	2005
9	Conveyor Anane-Nabatieh	3,500	3,500	2015
10	Saida-Jezzine	1,200	1,200	2015
11	Qasmieh-Ras El Ain (Phase 2)	2,100	2,100	2020
12	Khardale	9,000	9,000	2030
	Total	63,025	38,530	

(2) Cropping Plan

The relative distribution of cultivated land in Lebanon according to the regions can be simplified as; 1) the coastal plains planted with fruit trees represented by citrus, bananas and vegetables with water supplied from the nearby rivers, 2) the mountainous areas planted with fruit trees represented by apple with water supplied from small springs that emerge at high elevation, and 3) the Bekaa plain planted with vegetable crops supported by the industrial processing of sugar cane and utilizing water from nearby rivers and groundwater aquifer and treated wastewater. Such various crops are simply categorized into three, namely cereals represented by winter wheat, vegetables and fruit trees in order to grasp water requirement for irrigation. Ratios of cropped areas against the net irrigated area, after categorized into above three, are given previously in Table 2.6.3 for schemed irrigation and in Table 2.6.5 for small scale irrigation by Caza.

Most of crops except perennial crops and wheat are planted in summer season starting from middle of April to the end of October as shown in Figure 5.3-2.

Figure 5.2-2 Cropping Period

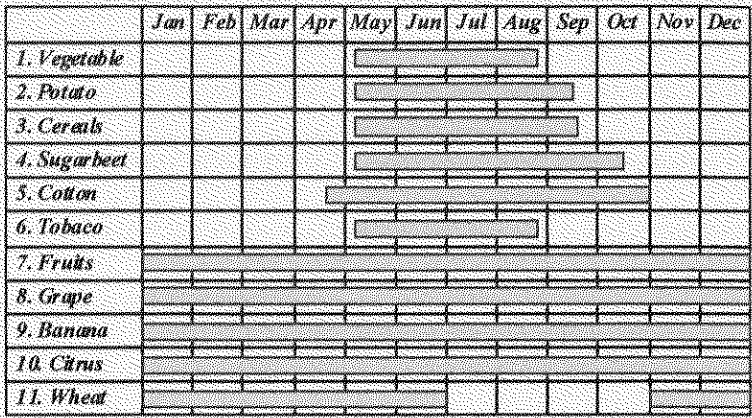
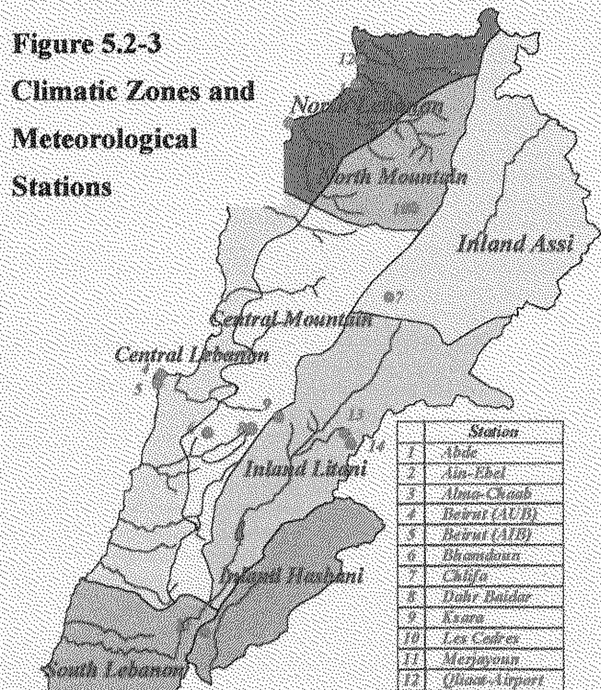


Figure 5.2-3
Climatic Zones and
Meteorological
Stations



(3) Reference Crop Evapo-transpiration

In order to calculate reference crop evapo-transpiration based on climatic parameters, the entire country was divided into 8 climatic zones according to FAO definition as is seen in Figure 5.3-3, and climatic parameters required for estimation of reference crop evapo-transpiration were extracted from FAO database at 16 meteorological stations. A part of climatic parameters collected from the Beirut International Airport for the year 2001 is shown in Table 5.2-3 as a sample.

Table 5.2-3 Climatic Parameters Collected at Beirut International Airport (2001)

		2001												
		JAN	FEV	MAR	APR	MAI	JUN	JUL	AOU	SEP	OCT	NOV	DEC	Tot/Ave
Rainfall	mm	53.8	104	238.2	193.8	64.2	108	91.8	15.2	0	0	0	2.2	871.2
Temp_Max	Degree	18.2	17.4	22.3	24.5	26.1	28.2	29.7	31.9	32.3	27.4	28.7	21.9	25.7
Temp_Min	Degree	11.9	11.5	14.6	16.9	19	22	24.4	24.8	22.9	22.5	11.8	9.2	17.6
Temp_Avg	Degree	15	14.4	18.4	20.7	22.5	25	27	28.3	27.6	24.9	20.2	15.5	21.6
Mois_Max	%	81.2	84.9	84.8	85.2	88	85.2	86.1	80.1	77.0	80	77.1	87	83.0
Mois_Min	%	49.4	48.3	48.9	44.9	46	55.2	64.4	60.2	57.9	52	44.2	52	51.9
Mois_Avg	%	65.3	66.6	66.9	65.1	70	70.2	75.2	70.1	67.5	66	60.7	69	67.7
Evap_Total	mm/day	77.7	85.5	79.6	141.7	153.1	137.7				132.1	124.1		116.4
Sun_Avg	hour	6.6	6.8	9.5	9.7	11.4	12.5	12.4	11.5	10.0	8.1	6.6	4.0	9.1
Sun_Eng		1014.0	1218.4	1884.5	2125.8	2497.6	2699.2	2733.7	2418.3	2009.2	1420.1	1163.9	640.0	1818.7

Reference crop evapo-transpiration calculated by FAO method indicates the highest values given to the Inland Assi zone where climate is dry, while the lowest values observed in the North Mountain. The peak value of averaged evapo-transpiration is found at 6 mm/day during July and August as is seen in Table 5.2-4 and Figure 5.2-4..

Table 5.2.4 Reference Crop Evapo-transpiration by Climatic Zone

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North Lebanon	1.74	2.19	2.82	3.53	4.16	4.96	5.24	5.04	4.29	3.24	2.39	1.90
North Mountain	0.95	1.31	1.90	2.85	3.75	4.52	**5.07**	4.77	3.53	2.50	1.57	1.06
Central Lebanon	1.76	2.17	2.79	3.70	4.72	5.78	6.05	5.66	4.44	3.31	2.23	1.75
Central Mountain	1.36	1.55	2.23	3.28	4.19	5.67	5.82	5.80	4.46	3.15	2.17	1.52
South Lebanon	2.10	2.46	3.26	4.24	5.25	6.11	6.02	5.78	4.78	3.50	2.66	2.22
Inland Assi	1.58	2.07	2.97	4.30	5.51	7.15	**8.04**	7.29	5.43	3.51	2.08	1.55
Inland Litani	1.37	1.81	2.71	4.00	5.18	6.52	7.05	6.55	5.05	3.42	2.09	1.40
Inland Hasbani	1.59	1.95	2.74	3.61	4.80	5.73	5.38	5.24	4.71	3.98	2.77	1.88
Average	1.56	1.94	2.68	3.69	4.69	**5.81**	**6.08**	**5.77**	4.59	3.33	2.24	1.66

Figure 5.2-4 Reference Crop Evapo-transpiration

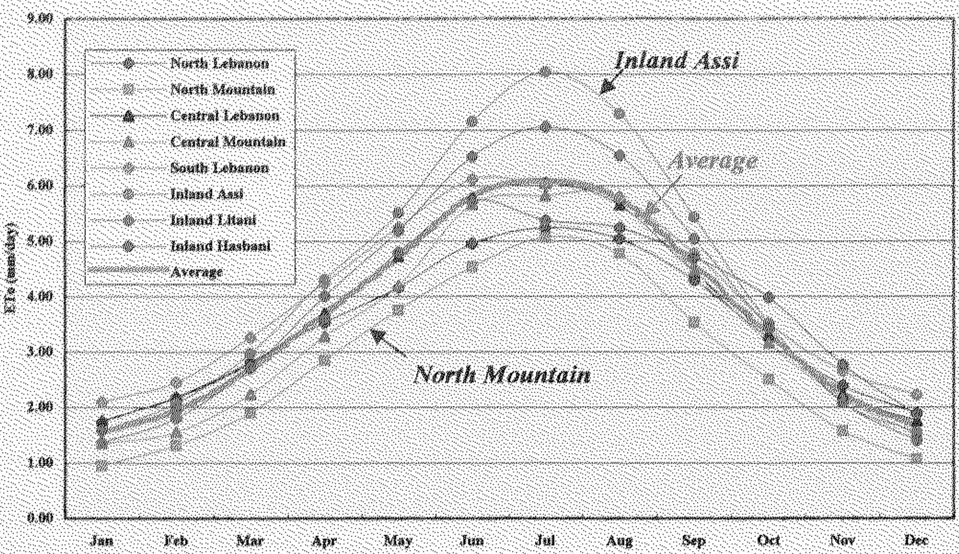
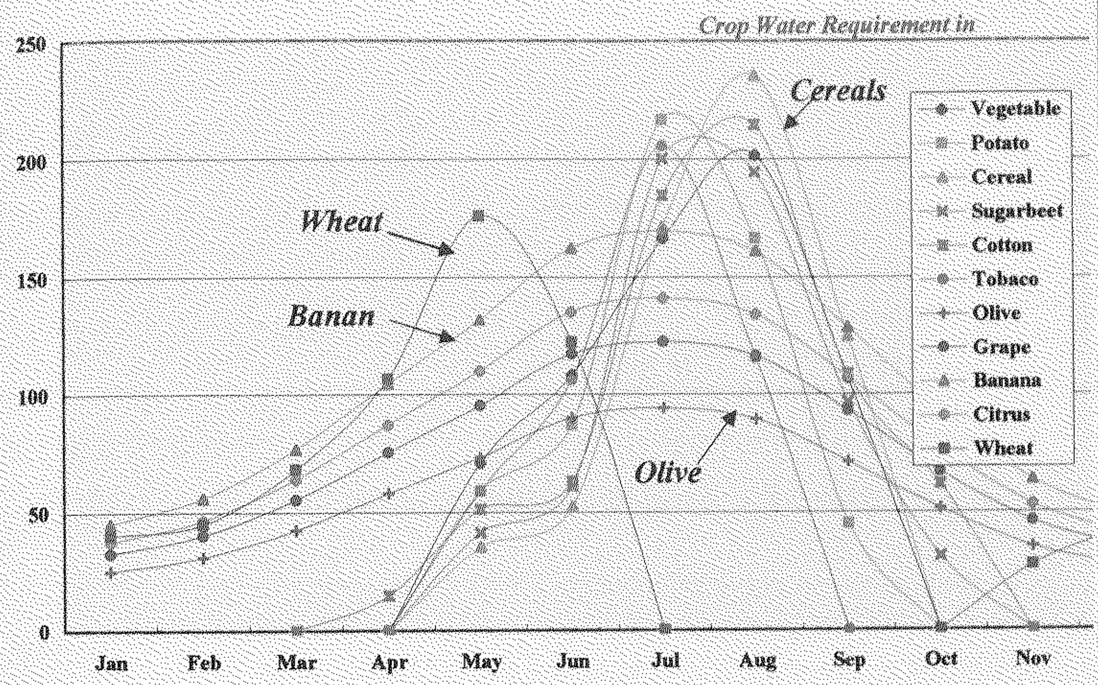


Table 5.2-5 and Figure 5.2-5 show seasonal fluctuation of the crop water requirement derived from reference crop evapo-transpiration after consideration of crop coefficient. Banana consumes the largest amount of water, 1,240 mm/year, while potato needs 575 mm per crop, both on the irrigated field. As for seasonal fluctuation, maize consumes 235 mm in August while 95 mm is required in July by olives that are also irrigated in some places of Lebanon.

Table 5.2-5 Crop Water Requirement (Average in mm/month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vegetable				0	70.9	108	166	202	107	0		
Potato				0	59.1	87.3	217	166	45	0		
Cereal				0	35.5	52.4	171	235	125	0		
Sugarbeet				0	41.4	61.1	200	194	96.9	31.4	0	
Cotton			0	14.9	51.3	63.1	185	215	109	62.1	0	
Tobaco				0	59.1	106	206	115	0			
Olive	25.2	31.1	42.6	58.1	73.3	90.2	94.1	89.4	71.6	51.7	35.5	26.7
Grape	32.7	40.5	55.4	75.6	95.3	117	122	116	93	67.3	46.1	34.7
Banana	45.3	56	76.8	105	132	162	169	161	129	93.1	63.9	48.1
Citrus	37.8	46.7	64	87.2	110	135	141	134	107	77.6	53.2	40.1
Wheat	40.3	45	68.2	107	176	122	0			0	27.5	42.8

Figure 5.2-5 Crop Water Requirement by Crop (Averaged)



75% dependable rainfalls were taken as effective rainfalls as given in Table 5.2-6. Almost no effective rainfall can be expected during the months from June to September.

Table 5.2-6 Effective Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North Lebanon	133.3	96.6	92.3	48.5	15.9	1.0	0.3	0.7	11.1	49.2	88.0	128.6
North Mountain	147.6	138.4	111.4	60.6	30.4	5.0	1.0	1.0	5.0	30.4	79.2	118.1
Central Lebanon	133.4	116.1	80.6	47.7	18.4	2.0	0.0	0.0	5.9	43.5	104.1	129.4
Central Mountain	154.2	151.0	138.5	77.4	34.4	2.0	0.5	0.5	5.0	42.5	104.7	147.4
South Lebanon	135.0	111.4	72.5	39.4	6.9	0.7	0.0	0.0	4.6	32.4	68.9	131.5
Inland Assi	81.3	69.8	48.5	29.5	13.7	1.0	0.0	0.0	1.0	6.9	43.5	65.2
Inland Litani	112.9	93.7	69.7	37.7	14.6	0.7	0.0	0.0	0.7	20.9	53.7	99.3
Inland Hasbani	133.4	128.6	102.4	64.5	24.9	1.0	1.0	1.0	3.0	23.1	77.8	120.0
Average	128.9	113.2	89.5	50.7	19.9	1.7	0.4	0.4	4.5	31.1	77.5	117.4

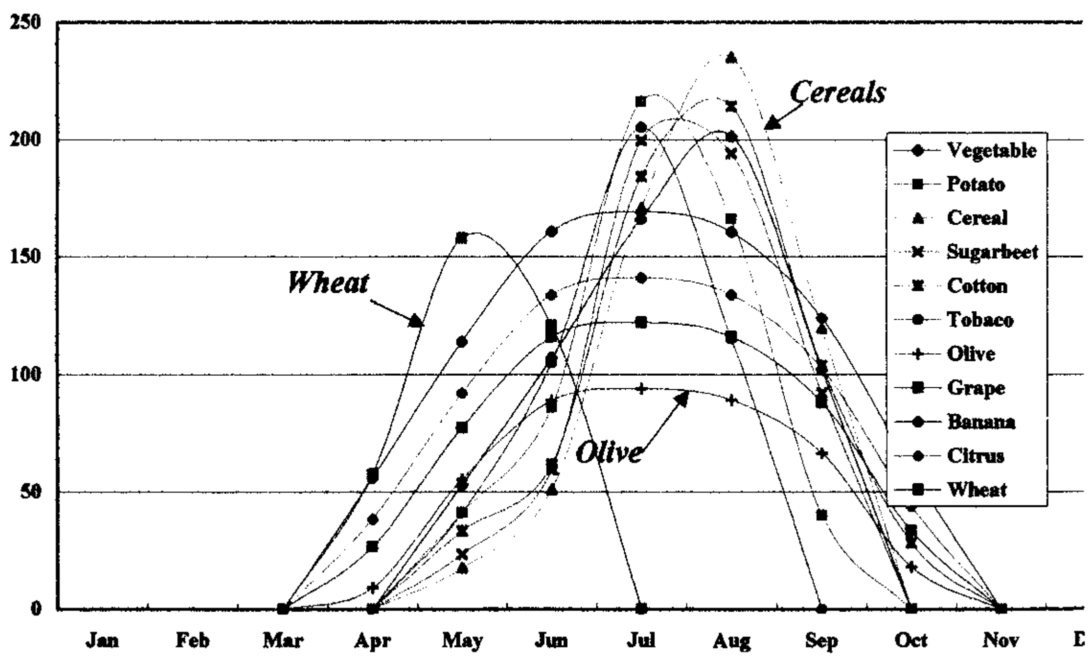
(6) Field Water Requirement

Field water requirements of crops, derived from crop water requirements after subtracting effective rainfalls, are given in Table 5.2-7 and Figure 5.2-6. Banana requires 844 mm/year or 8,440 m^3/ha of irrigation water to be supplied on the cropped field, while the winter wheat consumes 336 mm/crop or 3,360 m^3/ha of water for irrigation.

Table 5.2-7 Field Water Requirement in mm/month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vegetable				0	53	107	166	201	102	0		
Potato				0	41.2	85.9	216	166	40	0		
Cereal				0	17.5	51	171	235	120	0		
Sugarbeet				0	23.4	59.7	200	194	91.9	0		
Cotton				0	33.4	61.7	184	214	104	28.3	0	
Tobaco				0	41.2	105	205	115	0			
Olive			0	9.3	55.4	88.8	93.9	89.1	66.6	18	0	
Grape			0	26.7	77.3	116	122	116	88	33.5	0	
Banana			0	55.8	114	161	169	161	124	59.4	0	
Citrus			0	38.4	92	134	141	134	102	43.8	0	
Wheat			0	57.7	158	121	0					

Figure 5.2-6 Field Water Requirement by Crop (Averaged)



Irrigation efficiencies adopted in Lebanon are as previously described in Table 2.6.6.

Table 2.6.6 Irrigation Efficiency Adopted (Copied from Section 2.6)

Irrigation System	Efficiency			
	Conveyance	Distribution	On-farm	Overall
Sprinkler	0.95	0.95	0.8	0.7
Drip			0.9	0.8

From the above table, an overall irrigation efficiency for surface irrigation is simply assumed to be 0.6.

As for irrigation method, surface irrigation system such as furrow irrigation is adopted over 70.4% of the total irrigated land in Lebanon, while sprinkler and drip irrigation systems are adopted respectively in 23.4% and 6.2% of irrigated land. All water diverted from surface sources are used for surface irrigation, and on the other hand, 43%, 45% and 12% of water extracted from groundwater resources are used for surface, sprinkler and drip irrigation systems, respectively, as previously mentioned in the section 2.6.

(8) Diversion Water Requirement

Diversion water requirement for irrigation, after application of irrigation efficiencies, are summarized as follows.

<u>For Surface Irrigation</u>

Table 5.2-8 Diversion Water Requirement for Surface Irrigation

	Vegetable	Potato	Cereals	Sugarbeet	Cotton	Tobaco	Olive	Grape	Banana	Citrus	Wheat
North Lebanon	9083	7850	8600	8350	9083	6717	6017	8383	12050	9983	4900
North Mountain	10317	9033	9717	9317	6933	7700	6767	9350	13683	11050	5550
Central Lebanon	10967	9567	10283	9917	10917	8167	7817	10633	15683	12633	6917
Central Mountain	8100	7083	7700	7317	7950	5967	5033	6883	10300	8250	3650
South Lebanon	9833	8567	9400	8950	9617	7167	6217	8350	12317	9875	4233
Inland Assi	13350	11833	12683	12650	13717	10033	9800	13150	19083	15517	7633
Inland Litani	12033	10600	11400	11133	12183	8967	8517	11450	16633	13450	6617
Inland Hasbani	4863	8400	9167	8757	10067	7067	6817	9250	13567	10983	5183
Average	**9818**	**9117**	**9869**	**9549**	**10058**	**7723**	**7123**	**9681**	**14165**	**11468**	**5585**

<u>For Sprinkler Irrigation</u>

Table 5.2-9 Diversion Water Requirement for Sprinkler Irrigation

	Vegetable	Potato	Cereals	Sugarbeet	Cotton	Tobaco	Olive	Grape	Banana	Citrus	Wheat
North Lebanon	7786	6729	7371	7157	7786	5757	5157	7186	10329	8557	4200
North Mountain	8843	7743	8329	7986	5943	6600	5800	8014	11729	9471	4757
Central Lebanon	9400	8200	8814	8500	9357	7000	6700	9114	13443	10829	5929
Central Mountain	6943	6071	6600	6271	6814	5114	4314	5900	8829	7071	3129
South Lebanon	8429	7343	8057	7671	8243	6143	5329	7157	10557	8464	3629
Inland Assi	11443	10143	10871	10843	11757	8600	8400	11271	16357	13300	6543
Inland Litani	10314	9086	9771	9543	10443	7686	7300	9814	14257	11529	5671
Inland Hasbani	4169	7200	7857	7506	8629	6057	5843	7929	11629	9414	4443
Average	**8416**	**7814**	**8459**	**8185**	**8621**	**6620**	**6105**	**8298**	**12141**	**9829**	**4788**

For Drip Irrigation

Table 5.2-10 Diversion Water Requirement for Drip Irrigation

	Vegetable	Potato	Cereals	Sugarbeet	Cotton	Tobaco	Olive	Grape	Banana	Citrus	Wheat
North Lebanon	6813	5888	6450	6263	6813	5038	4513	6288	9038	7488	3675
North Mountain	7738	6775	7288	6988	5200	5775	5075	7013	10263	8288	4163
Central Lebanon	8225	7175	7713	7438	8188	6125	5863	7975	11763	9475	5188
Central Mountain	6075	5313	5775	5488	5963	4475	3775	5163	7725	6188	2738
South Lebanon	7375	6425	7050	6713	7213	5375	4663	6263	9238	7406	3175
Inland Assi	10013	8875	9513	9488	10288	7525	7350	9863	14313	11638	5725
Inland Litani	9025	7950	8550	8350	9138	6725	6388	8588	12475	10088	4963
Inland Hasbani	3648	6300	6875	6568	7550	5300	5113	6938	10175	8238	3888
Average	**7364**	**6838**	**7402**	**7162**	**7544**	**5792**	**5342**	**7261**	**10623**	**8601**	**4189**

5.2.3 Current and Projected Water Demand

All parameters described in the previous section, together with development scenarios as summarized in Table 5.2-11, were put into the Digital Balancing Model (DBM) for assessment of the current and projected water demands for irrigation. Results are shown in Figure 5.2-7 as well as in Tables 5.2-12 and 5.2-13.

In this connection, all parameters for calculation of water demand are changeable, and various cases of demand projection would be processed according to scenarios of water resources management in the course of the next phase of the study.

Figure 5.2-7 Projected Water Demand for Irrigation

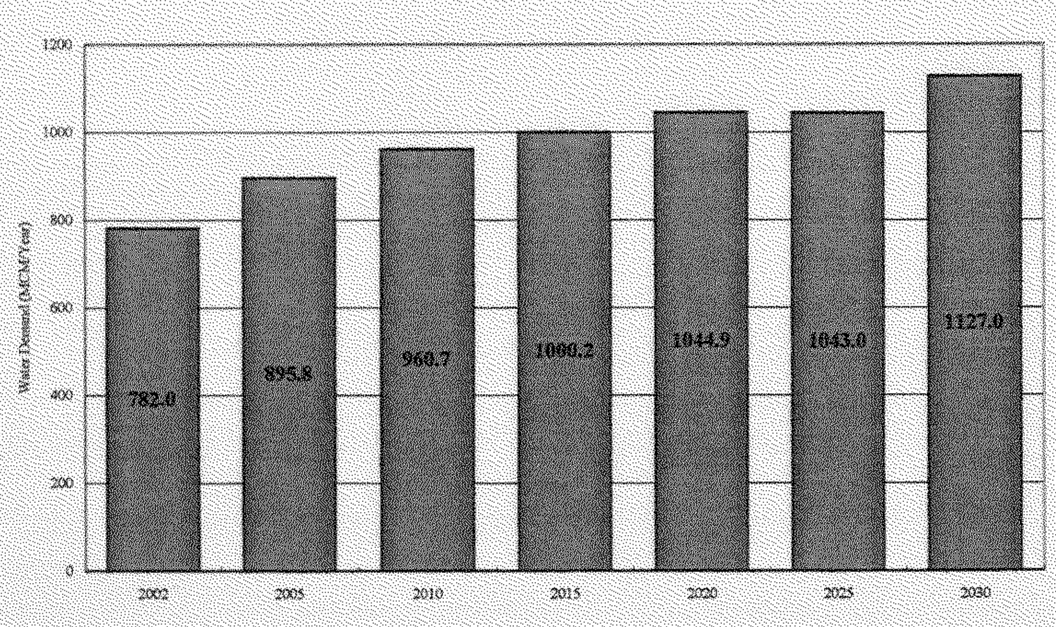


Table 5.2-11 Parameters and Scenarios of Existing and Proposed Irrigation Development Used for Projection of Water Demand (Base-case)

	Scheme Type	Parameter	Present			2030			Remarks
Existing Irrigation	Scheme Irrigation	Area	Equipped (ha)	Net (ha)		Equipped (ha)	Net (ha)		constant
			65,600	59,070		65,600	59,070		
		Application	Surface	Sprinkler	Drip	Surface	Sprinkler	Drip	to be improved
			70.4%	23.4%	6.2%	70.4%	23.4%	6.2%	
		Crops	winter wheat, vegetables, fruit tree			winter wheat, vegetables, fruit tree			constant
			Caza data from MOA/FAO census			Caza data from MOA/FAO census			
		Efficiency	Surface	Sprinkler	Drip	Surface	Sprinkler	Drip	constant
			60%	70%	80%	60%	70%	80%	
		Source	Surface	Groundwater		Surface	Groundwater		constant
			48%	52%		48%	52%		
	Caza Irrigation	Area	Equipped (ha)	Net (ha)		Equipped (ha)	Net (ha)		decrease with expansion of proposed projects
			24,400	21,960		24,400	21,960		
		Application	Surface	Sprinkler	Drip	Surface	Sprinkler	Drip	to be improved
			70.4%	23.4%	6.2%	70.4%	23.4%	6.2%	
		Crops	winter wheat, vegetables, fruit tree			winter wheat, vegetables, fruit tree			constant
			Caza data from MOA/FAO census			Caza data from MOA/FAO census			
		Efficiency	Surface	Sprinkler	Drip	Surface	Sprinkler	Drip	constant
			60%	70%	80%	60%	70%	80%	
		Source	Surface	Groundwater		Surface	Groundwater		to be changed by expansion of proposed projects
			48%	52%		48%	52%		

	Scheme Name	Net Irrigated Area (ha)	New Area (ha)	Water Req. (m3/ha)	Efficiency (%)	Source		Starting Year
						Surface	GW	
Proposed Schemes	P1. Noura Et Tahta Dam Scheme	5,000	2,300	calculated by DBM	75%	100%	0%	2020
	P2. El Bared Dam Scheme	750	0		75%	100%	0%	2015
	P3. Assi River Basin Project	6,700	6,700		75%	100%	0%	2010
	P4. Younine Dam Scheme	1,545	0		75%	100%	0%	2030
	P5. Southern Qaraoun Irrigation Scheme	500	500		75%	100%	0%	2020
	P6. South Bekaa (Phase 2), Left Bank	6,700	0		75%	73%	27%	2015
	P7. South Bekaa, Right Bank and North Zone	12,800	0		75%	33%	67%	2025
	P8. Hydro Agricultural Development of South Lebanon- Conveyor 800	13,230	13,230		75%	100%	0%	2005
	P9. Conveyor Anane-Nabatieh	3,500	3,500		75%	100%	0%	2015
	P10. Saida-Jezzine	1,200	1,200		75%	100%	0%	2015
	P11. Qasmieh - Ras El Ain (Phase 2)	2,100	2,100		75%	40%	60%	2020
	P12. Khardale	9,000	9,000		75%	100%	0%	2030

New area: newly developed area for irrigation
Net irrigated area of proposed projects, except new area, will be subtracted from caza base irrigation area.

Table 5.2-12 Projected Water Demand for Irrigation by Mohafaza

(Unit: MCM/Year)

No	Name	2002	2005	2010	2015	2020	2025	2030
1	Beirut	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	Mount Lebanon	78.404	78.404	78.404	78.404	78.404	78.404	78.404
3	North Lebanon	158.312	158.312	158.312	158.329	174.825	174.685	174.544
4	South Lebanon	117.749	145.419	145.190	167.886	192.256	191.623	220.465
5	Bekaa	411.658	412.237	478.085	477.707	481.818	481.555	480.996
6	Nabatieh	15.847	101.459	100.750	117.862	117.561	116.697	172.578
	Total	781.969	895.830	960.740	1000.187	1044.864	1042.964	1126.988

Table 5.2-13 Projected Irrigation Water Demand by Caza

(Unit: MCM/Year)

No	Name	2002	2005	2010	2015	2020	2025	2030
10	Beirut	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	Baabda Center	2.626	2.626	2.626	2.626	2.626	2.626	2.626
21	Metn Center	3.750	3.750	3.750	3.750	3.750	3.750	3.750
22	Chouf Center	4.059	4.059	4.059	4.059	4.059	4.059	4.059
23	Aaley Center	0.136	0.136	0.136	0.136	0.136	0.136	0.136
24	Kesrwan	11.712	11.712	11.712	11.712	11.712	11.712	11.712
25	Jbail	20.919	20.919	20.919	20.919	20.919	20.919	20.919
26	Baabda Other	4.872	4.872	4.872	4.872	4.872	4.872	4.872
27	Metn Other	7.276	7.276	7.276	7.276	7.276	7.276	7.276
28	Chouf Other	14.505	14.505	14.505	14.505	14.505	14.505	14.505
29	Aaley Other	8.550	8.550	8.550	8.550	8.550	8.550	8.550
31	Tripoli	2.247	2.247	2.247	2.247	2.247	2.247	2.247
32	Koura	1.236	1.236	1.236	1.236	1.236	1.236	1.236
33	Zgharta	11.819	11.819	11.819	11.819	11.819	11.819	11.819
34	Batroun	5.125	5.125	5.125	5.125	5.125	5.125	5.125
35	Akkar	88.821	88.821	88.821	88.822	105.318	105.178	105.037
36	Bcharri	8.315	8.315	8.315	8.315	8.315	8.315	8.315
37	Minieh-Dinnieh	40.749	40.749	40.749	40.765	40.765	40.765	40.765
41	Saida Center	0.403	0.403	0.403	0.403	0.484	0.483	0.483
42	Saida Other	62.959	62.959	62.959	77.695	90.096	89.866	89.634
43	Sour	50.296	77.962	77.733	77.504	89.461	89.128	118.271
47	Jezzine	4.092	4.095	4.095	12.284	12.215	12.146	12.077
51	Zahle	111.859	111.859	111.859	111.953	111.952	112.115	112.113
52	West Bekaa	90.124	90.703	90.698	90.777	94.690	94.816	94.776
53	Baalbek	184.807	184.807	211.831	211.606	211.380	211.158	210.974
54	El Hermel	23.290	23.290	62.119	61.795	61.471	61.146	60.821
55	Rachaiya	1.576	1.576	1.576	1.576	2.325	2.318	2.312
61	Nabatieh	8.294	8.294	8.294	26.115	26.523	26.368	28.186
62	Bent Jbeil	0.761	41.709	41.370	41.030	40.691	40.352	69.720
63	Marjaayoun	3.848	47.220	46.861	46.502	46.142	45.783	70.490
64	Hasbaya	2.943	4.236	4.225	4.214	4.204	4.193	4.182
	Total	781.969	895.830	960.740	1000.187	1044.864	1042.964	1126.988

5.3 Overall Water Demand

Overall water demands including domestic, industrial and irrigation demands are summarized as per Figure 5.3-1 and Tables 5.3-1 and 5.3-2.

Figure 5.3-1 Projected Total Water Demand

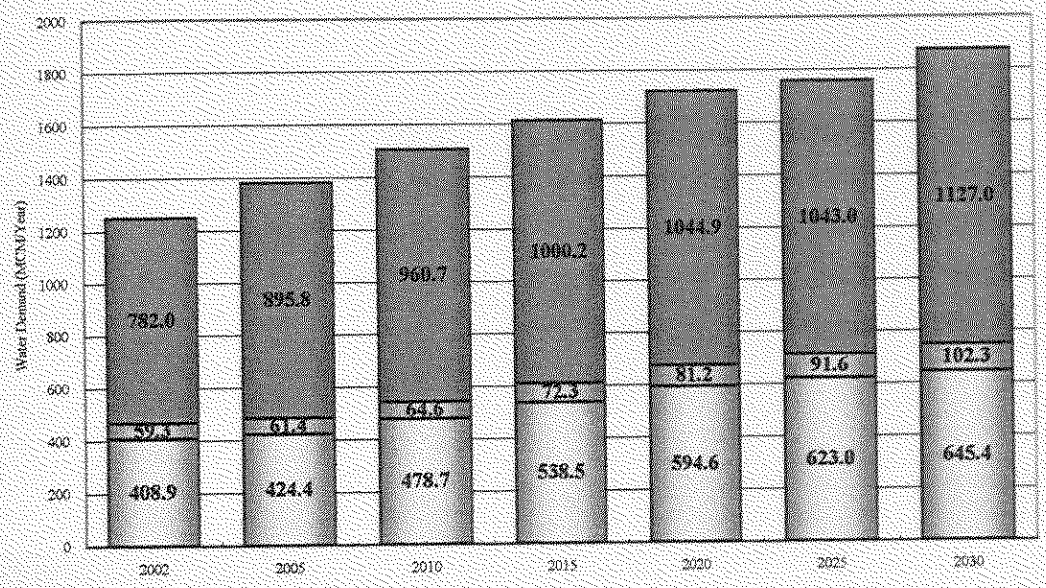


Table 5.3.1 Projected Total Water Demand by Mohafaza

No	Name	Category	2002	2005	2010	2015	2020	2025	2030
1	Beirut	Domestic	55.85	57.69	63.90	70.05	75.17	77.50	78.78
		Industrial	5.92	6.11	6.40	7.11	7.94	8.94	9.97
		Irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Total	61.78	63.80	70.31	77.17	83.11	86.44	88.74
2	Mount Lebanon	Domestic	162.43	169.35	192.20	217.84	242.30	257.00	269.29
		Industrial	30.45	31.38	32.88	36.64	41.02	46.17	51.49
		Irrigation	78.40	78.40	78.40	78.40	78.40	78.40	78.40
		Total	271.28	279.13	303.48	332.89	361.72	381.57	399.18
3	North Lebanon	Domestic	74.50	77.42	87.72	99.32	110.24	114.98	118.56
		Industrial	12.79	13.27	13.99	15.75	17.78	20.04	22.37
		Irrigation	158.31	158.31	158.31	158.33	174.83	174.69	174.54
		Total	245.60	249.01	260.03	273.40	302.84	309.71	315.47
4	South Lebanon	Domestic	41.60	42.96	48.46	54.87	61.29	64.29	67.06
		Industrial	4.23	4.43	4.74	5.41	6.21	7.11	8.08
		Irrigation	117.75	145.42	145.19	167.89	192.26	191.62	220.46
		Total	163.59	192.81	198.39	228.16	259.76	263.02	295.61
5	Bekaa	Domestic	48.50	50.62	57.68	64.80	71.42	74.29	76.36
		Industrial	4.41	4.61	4.90	5.52	6.22	7.02	7.85
		Irrigation	411.66	412.24	478.08	477.71	481.82	481.55	481.00
		Total	464.56	467.46	540.67	548.02	559.46	562.87	565.21
6	Nabatieh	Domestic	26.01	26.32	28.69	31.59	34.17	34.96	35.39
		Industrial	1.52	1.57	1.64	1.83	2.05	2.31	2.57
		Irrigation	15.85	101.46	100.75	117.86	117.56	116.70	172.58
		Total	43.37	129.35	131.08	151.29	153.78	153.97	210.54
Grand Total		Domestic	408.88	424.36	478.66	538.48	594.58	623.04	645.44
		Industrial	59.34	61.36	64.56	72.26	81.22	91.58	102.33
		Irrigation	781.97	895.83	960.74	1,000.19	1,044.86	1,042.96	1,126.99
		Total	1,250.18	1,381.55	1,503.95	1,610.93	1,720.67	1,757.58	1,874.75

Table 5.3-2(1) Projected Total Water Demand by Caza (1)

(Unit: MCM/Year)

No	Name	Category	2002	2005	2010	2015	2020	2025	2030
10	Beirut	Domestic	55.851	57.689	63.901	70.055	75.170	77.503	78.777
		Industrial	5.925	6.106	6.404	7.112	7.939	8.937	9.966
		Irrigation	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Total	61.776	63.796	70.305	77.167	83.109	86.440	88.744
20	Baabda Center	Domestic	50.918	53.174	60.589	68.781	76.800	82.130	86.814
		Industrial	6.422	6.619	6.940	7.707	8.601	9.682	10.799
		Irrigation	2.626	2.626	2.626	2.626	2.626	2.626	2.626
		Total	59.966	62.419	70.155	79.114	88.026	94.438	100.239
21	Metn Center	Domestic	40.088	41.958	47.923	54.480	60.879	65.171	68.932
		Industrial	11.125	11.469	12.029	13.359	14.909	16.781	18.718
		Irrigation	3.750	3.750	3.750	3.750	3.750	3.750	3.750
		Total	54.963	57.177	63.701	71.589	79.538	85.701	91.400
22	Chouf Center	Domestic	2.863	2.990	3.407	3.867	4.318	4.618	4.881
		Industrial	0.354	0.366	0.383	0.425	0.474	0.534	0.596
		Irrigation	4.059	4.059	4.059	4.059	4.059	4.059	4.059
		Total	7.276	7.414	7.849	8.351	8.852	9.211	9.536
23	Aaley Center	Domestic	7.913	8.264	9.416	10.689	11.935	12.764	13.492
		Industrial	1.164	1.200	1.260	1.399	1.562	1.756	1.961
		Irrigation	0.136	0.136	0.136	0.136	0.136	0.136	0.136
		Total	9.213	9.599	10.812	12.224	13.633	14.656	15.588
24	Kesrwan	Domestic	12.540	13.022	14.648	16.368	17.910	18.740	19.343
		Industrial	2.357	2.435	2.547	2.828	3.156	3.553	3.962
		Irrigation	11.712	11.712	11.712	11.712	11.712	11.712	11.712
		Total	26.609	27.169	28.907	30.908	32.778	34.005	35.017
25	Jbail	Domestic	6.250	6.964	8.371	9.993	11.415	12.360	13.067
		Industrial	1.645	1.687	1.754	1.976	2.229	2.508	2.795
		Irrigation	20.919	20.919	20.919	20.919	20.919	20.919	20.919
		Total	28.815	29.570	31.045	32.889	34.563	35.787	36.782
26	Baabda Other	Domestic	8.401	8.682	9.762	11.049	12.253	12.730	13.073
		Industrial	1.769	1.833	1.935	2.178	2.456	2.764	3.081
		Irrigation	4.872	4.872	4.872	4.872	4.872	4.872	4.872
		Total	15.043	15.388	16.568	18.100	19.582	20.366	21.027
27	Metn Other	Domestic	13.901	14.289	15.923	17.576	19.077	19.754	20.224
		Industrial	0.803	0.830	0.873	0.969	1.082	1.218	1.358
		Irrigation	7.276	7.276	7.276	7.276	7.276	7.276	7.276
		Total	21.979	22.394	24.071	25.821	27.434	28.247	28.858
28	Chouf Other	Domestic	12.091	12.291	13.495	15.261	16.909	17.551	18.010
		Industrial	4.276	4.384	4.566	5.140	5.797	6.527	7.279
		Irrigation	14.505	14.505	14.505	14.505	14.505	14.505	14.505
		Total	30.871	31.180	32.566	34.905	37.211	38.583	39.794
29	Aaley Other	Domestic	7.464	7.712	8.664	9.773	10.802	11.186	11.452
		Industrial	0.536	0.557	0.589	0.663	0.748	0.842	0.939
		Irrigation	8.550	8.550	8.550	8.550	8.550	8.550	8.550
		Total	16.550	16.819	17.803	18.986	20.100	20.578	20.941
31	Tripoli	Domestic	31.950	33.414	38.306	44.751	51.148	54.798	57.987
		Industrial	9.083	9.379	9.814	11.045	12.463	14.028	15.642
		Irrigation	2.247	2.247	2.247	2.247	2.247	2.247	2.247
		Total	43.280	45.040	50.367	58.043	65.858	71.073	75.875
32	Koura	Domestic	7.171	7.377	8.227	9.134	9.942	10.137	10.224
		Industrial	0.826	0.860	0.912	1.027	1.158	1.303	1.451
		Irrigation	1.236	1.236	1.236	1.236	1.236	1.236	1.236
		Total	9.233	9.473	10.375	11.397	12.336	12.676	12.911
33	Zgharta	Domestic	8.976	9.081	9.890	10.974	11.937	12.163	12.259
		Industrial	0.562	0.579	0.607	0.684	0.772	0.869	0.968
		Irrigation	11.819	11.819	11.819	11.819	11.819	11.819	11.819
		Total	21.358	21.480	22.317	23.477	24.528	24.851	25.047
34	Batroun	Domestic	7.639	7.879	8.804	9.681	10.435	10.534	10.519
		Industrial	0.706	0.738	0.788	0.886	0.999	1.125	1.254
		Irrigation	5.125	5.125	5.125	5.125	5.125	5.125	5.125
		Total	13.470	13.742	14.717	15.693	16.560	16.785	16.898
35	Akkar	Domestic	10.290	10.983	12.839	14.085	15.156	15.469	15.566
		Industrial	0.841	0.900	0.995	1.122	1.269	1.444	1.624
		Irrigation	88.821	88.821	88.821	88.822	105.318	105.178	105.037
		Total	99.951	100.703	102.655	104.029	121.743	122.091	122.228

Table 5.3-2(2) Projected Total Water Demand by Caza)2)

(Unit: MCM/Year)

No	Name	Category	2002	2005	2010	2015	2020	2025	2030
36	Bcharri	Domestic	5.289	5.412	5.992	6.682	7.304	7.480	7.577
		Industrial	0.101	0.106	0.113	0.128	0.143	0.162	0.181
		Irrigation	8.315	8.315	8.315	8.315	8.315	8.315	8.315
		Total	13.706	13.833	14.420	15.125	15.762	15.957	16.072
37	Minieh-Dinnieh	Domestic	3.179	3.278	3.663	4.015	4.317	4.403	4.427
		Industrial	0.675	0.708	0.763	0.861	0.975	1.109	1.248
		Irrigation	40.749	40.749	40.749	40.765	40.765	40.765	40.765
		Total	44.604	44.736	45.175	45.641	46.057	46.276	46.439
41	Saida Center	Domestic	9.696	10.428	12.656	15.323	18.450	20.627	23.050
		Industrial	2.503	2.630	2.853	3.281	3.816	4.408	5.075
		Irrigation	0.403	0.403	0.403	0.403	0.484	0.483	0.483
		Total	12.601	13.461	15.912	19.006	22.751	25.518	28.608
42	Saida Other	Domestic	7.152	7.276	7.992	8.944	9.810	10.081	10.244
		Industrial	0.598	0.617	0.646	0.727	0.821	0.924	1.030
		Irrigation	62.959	62.959	62.959	77.695	90.096	89.866	89.634
		Total	70.709	70.851	71.597	87.366	100.727	100.870	100.908
43	Sour	Domestic	17.358	17.785	19.702	21.907	23.864	24.363	24.596
		Industrial	0.999	1.040	1.100	1.238	1.396	1.572	1.753
		Irrigation	50.296	77.962	77.733	77.504	89.461	89.128	118.271
		Total	68.653	96.786	98.535	100.649	114.721	115.063	144.620
47	Jezzine	Domestic	7.395	7.475	8.109	8.694	9.167	9.217	9.167
		Industrial	0.135	0.139	0.145	0.162	0.180	0.202	0.226
		Irrigation	4.092	4.095	4.095	12.284	12.215	12.146	12.077
		Total	11.622	11.710	12.350	21.139	21.562	21.565	21.470
51	Zahle	Domestic	21.681	22.671	25.957	29.830	33.583	35.441	36.976
		Industrial	2.940	3.059	3.236	3.641	4.108	4.624	5.158
		Irrigation	111.859	111.859	111.859	111.953	111.952	112.115	112.113
		Total	136.480	137.589	141.052	145.424	149.644	152.181	154.246
52	West Bekaa	Domestic	7.543	7.629	8.298	8.991	9.583	9.743	9.799
		Industrial	0.342	0.353	0.371	0.412	0.459	0.517	0.577
		Irrigation	90.124	90.703	90.698	90.777	94.690	94.816	94.776
		Total	98.009	98.684	99.367	100.179	104.733	105.076	105.152
53	Baalbek	Domestic	13.923	14.776	17.191	19.184	20.988	21.805	22.326
		Industrial	0.921	0.980	1.069	1.207	1.366	1.554	1.748
		Irrigation	184.807	184.807	211.831	211.606	211.380	211.158	210.974
		Total	199.652	200.563	230.091	231.996	233.734	234.517	235.048
54	El Hermel	Domestic	1.967	2.165	2.637	2.935	3.205	3.322	3.395
		Industrial	0.066	0.071	0.078	0.089	0.100	0.113	0.128
		Irrigation	23.290	23.290	62.119	61.795	61.471	61.146	60.821
		Total	25.323	25.526	64.834	64.819	64.776	64.582	64.343
55	Rachaiya	Domestic	3.380	3.378	3.600	3.861	4.056	3.982	3.865
		Industrial	0.140	0.144	0.150	0.168	0.190	0.214	0.239
		Irrigation	1.576	1.576	1.576	1.576	2.325	2.318	2.312
		Total	5.097	5.098	5.327	5.606	6.571	6.515	6.416
61	Nabatieh	Domestic	10.093	10.288	11.335	12.444	13.442	13.856	14.132
		Industrial	0.847	0.874	0.916	1.018	1.135	1.278	1.426
		Irrigation	8.294	8.294	8.294	26.115	26.523	26.368	28.186
		Total	19.234	19.456	20.545	39.577	41.100	41.503	43.744
62	Bent Jbeil	Domestic	6.261	6.308	6.829	7.552	8.187	8.313	8.351
		Industrial	0.340	0.353	0.369	0.415	0.469	0.527	0.589
		Irrigation	0.761	41.709	41.370	41.030	40.691	40.352	69.720
		Total	7.363	48.370	48.568	48.997	49.347	49.193	78.659
63	Marjaayoun	Domestic	5.918	5.967	6.467	7.202	7.863	8.041	8.135
		Industrial	0.196	0.201	0.208	0.233	0.263	0.296	0.330
		Irrigation	3.848	47.220	46.861	46.502	46.142	45.783	70.490
		Total	9.962	53.388	53.536	53.937	54.268	54.121	78.955
64	Hasbaya	Domestic	3.733	3.760	4.062	4.396	4.681	4.754	4.776
		Industrial	0.139	0.143	0.147	0.164	0.182	0.205	0.228
		Irrigation	2.943	4.236	4.225	4.214	4.204	4.193	4.182
		Total	6.816	8.138	8.434	8.774	9.066	9.151	9.186
Grand Total		Domestic	408.878	424.365	478.655	538.478	594.584	623.038	645.436
		Industrial	59.336	61.357	64.559	72.262	81.221	91.577	102.328
		Irrigation	781.969	895.830	960.740	1000.187	1044.864	1042.964	1126.988
		Total	1250.184	1381.552	1503.955	1610.927	1720.669	1757.578	1874.751