بسم الله الرحمن الرحيم

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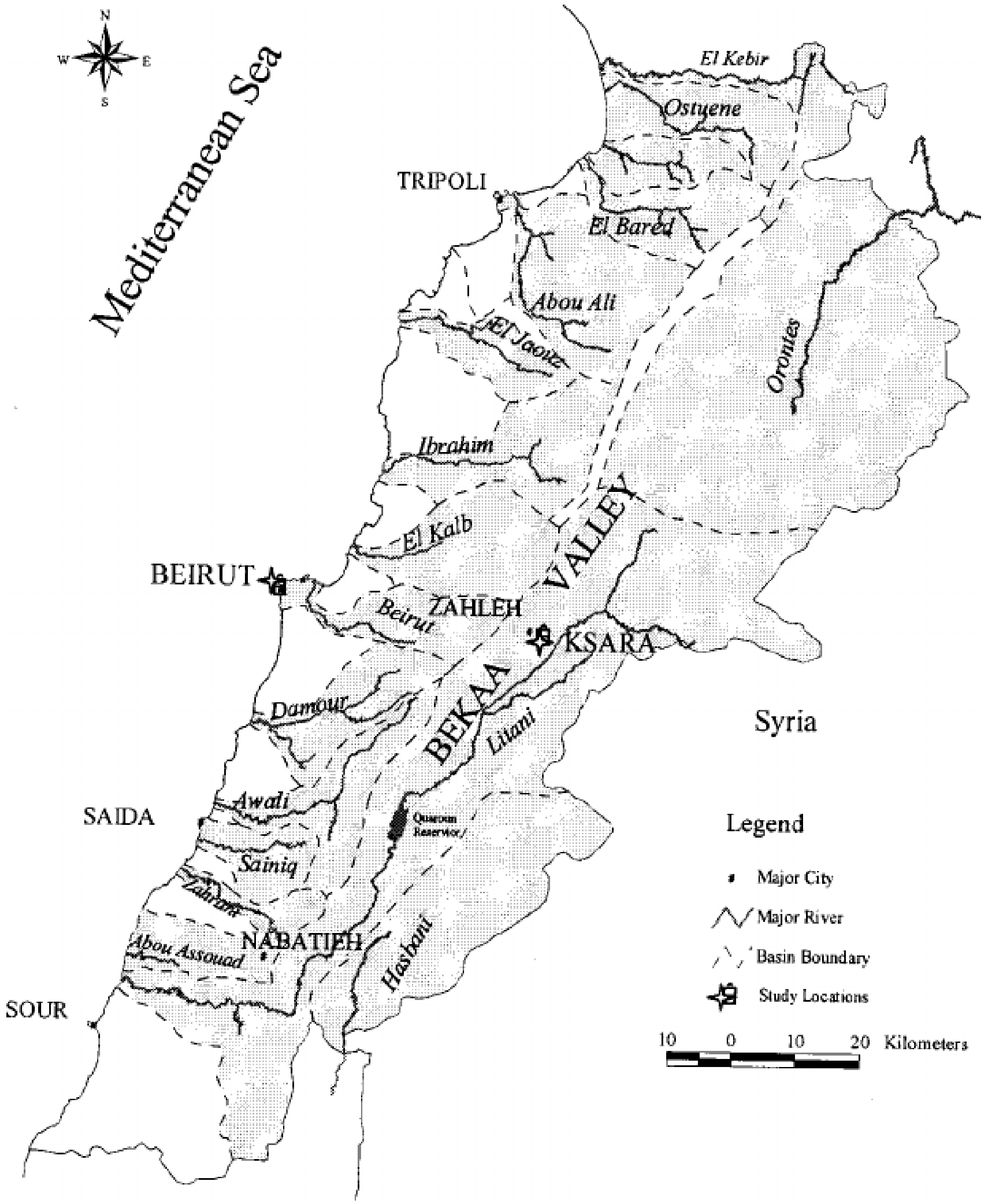
North Lebanon Water management

Author: Maryam Abdel-karim

Contents

1. Lebanon’s water sector: problem statement and underlying issues

Despite its relatively high per capita water endowment (1,000m3 /capita, making the country the fourth best-endowed in MENA), Lebanon is already using two thirds of its available water resources, high by global standards (averaging 10-30% for other regions), and there is significant groundwater mining. There is a seasonal mismatch between supply (at its peak in the rainy winter) and demand (peaking in the hot, dry summer months). Factors exacerbating this seasonal water imbalance are the very low water storage capacity (6% of total resources, compared to the MENA average of 85%), the deficiency of water supply networks and, on the demand side, fast rising demand from the municipal and industrial sectors. These seasonal imbalances are likely to lead to chronic water shortages. Already, dry season shortages are emerging and water quality is deteriorating. If no actions are taken to improve efficiency, manage demand and increase storage capacity, the country would depend in the long run on mined groundwater or on high cost desalination for incremental resources.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10 0 10 20 Kilometers

2. Shortcomings on the Lebanese water infrastructure and management fronts

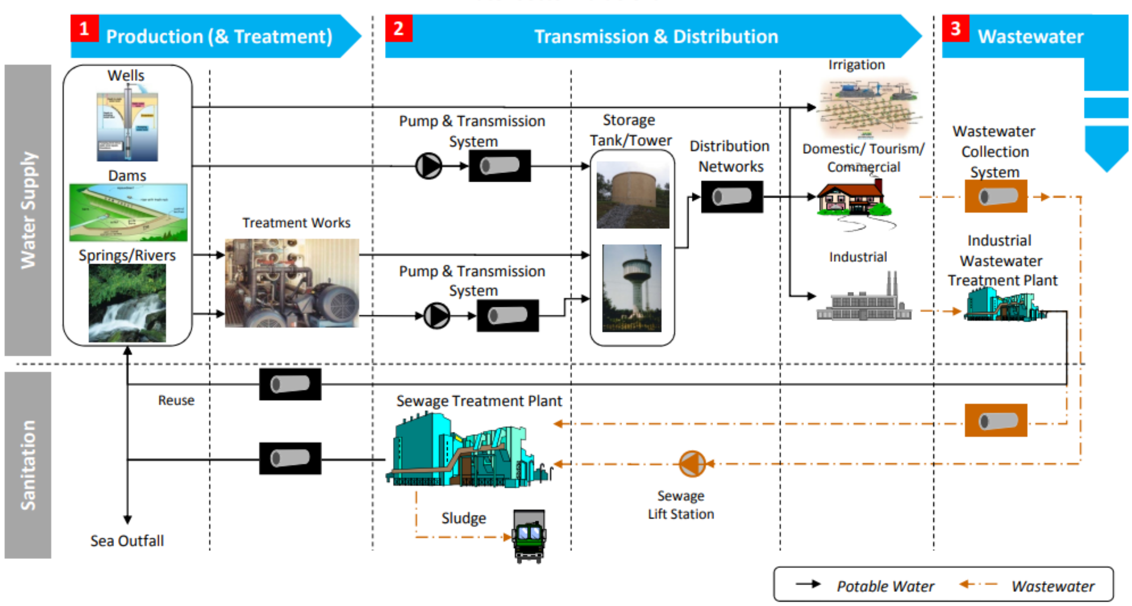
The Lebanese water sector is facing shortcomings both on the infrastructure and management fronts

Water Sector Infrastructure	1 Production	Constrained resources with suboptimal exploitation, coupled with significant demand growth
	2 Transmission & Distribution	Inefficient and poorly maintained systems and networks, leading to high losses and supply interruptions, with a limited focus on demand management
	3 Wastewater	Low coverage of wastewater networks and severe shortage in treatment efficiency
Water Sector Management	I Institutional	Incomplete implementation of reform law and weak interagency coordination
	II Financial & Commercial	Inefficient water supply and irrigation tariffs with low collection rates, and no wastewater tariff yet, increasing pollution and limiting conservation
	III Legal & Regulatory	Gaps in legal framework delaying private sector participation, water users associations, etc.
	IV Environmental Concerns	Climate change negatively impacting water resources
	V Awareness and Conservation	Limited conservation activities and high loss percentages

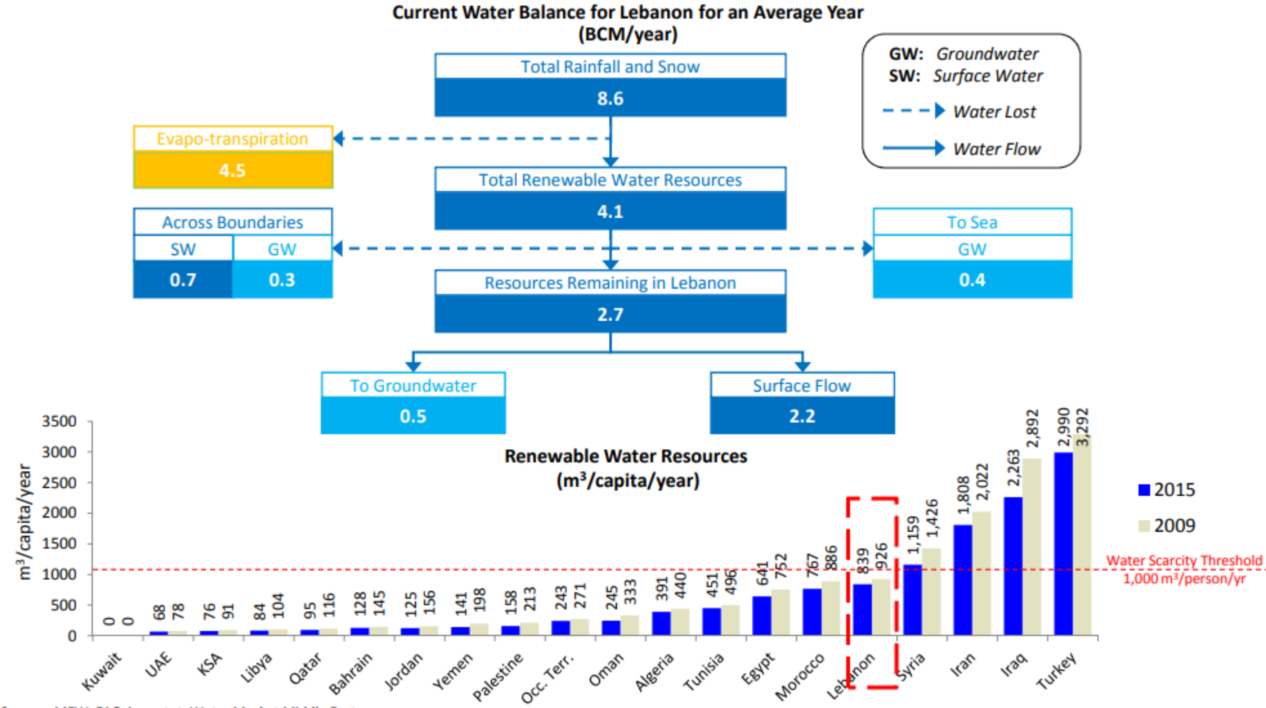
3. Lebanon's Water Sector value chain

Several steps constitute the water sector value chain

Water Sector Value Chain

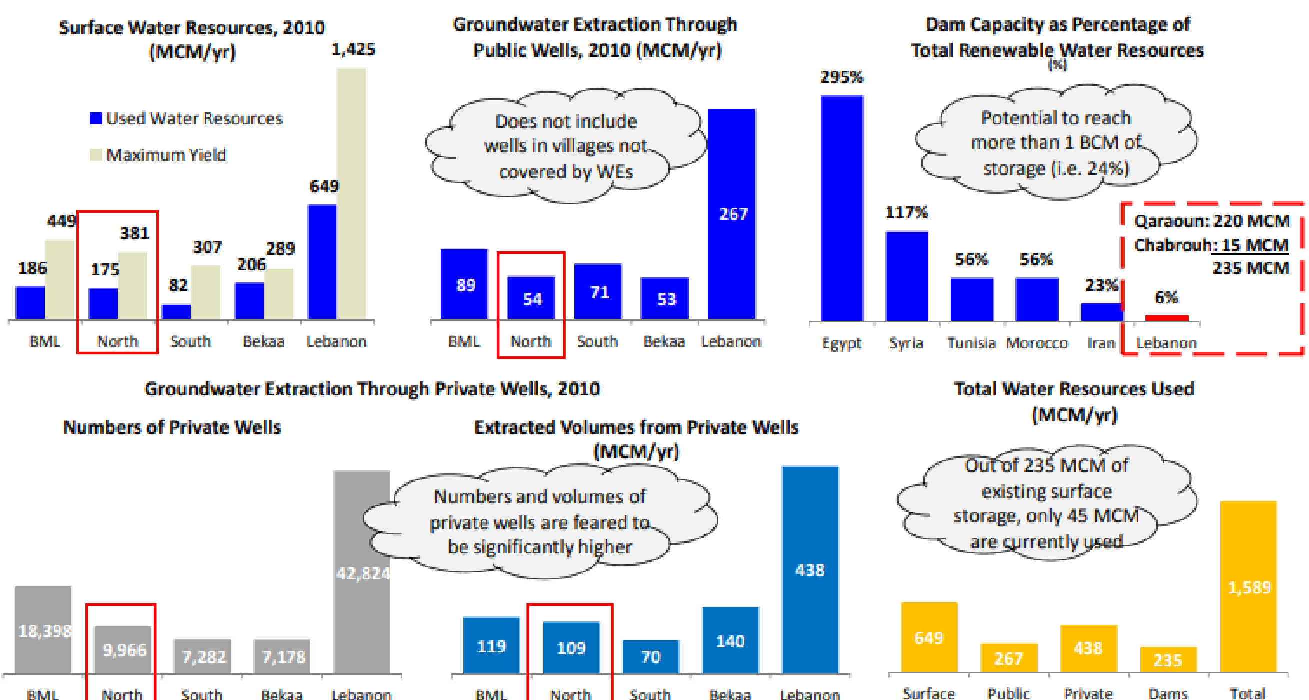


1 Renewable water resources per capita are already slightly below scarcity threshold, with expected decrease in the coming years



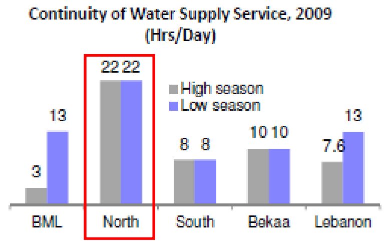
Source: MEW, FAO Aquastat, Water Market Middle East

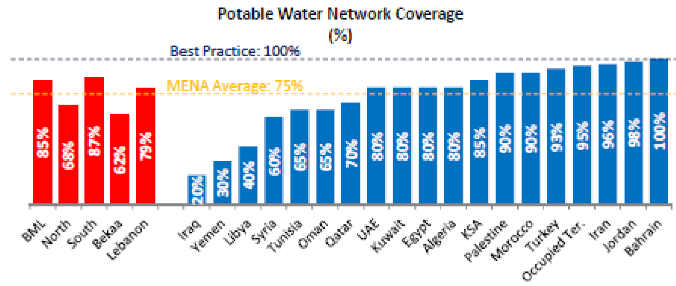
1 Surface water resources are largely exploited but with limited storage, while significant stress is put on groundwater mainly through private wells

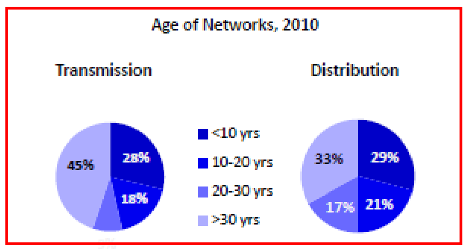


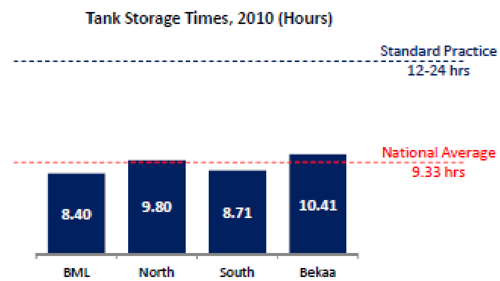
Source: MEW, WEs, FAO Aquastat

2 Although coverage is better than the regional average, more than 50% of transmission and distribution networks are past their useful life …





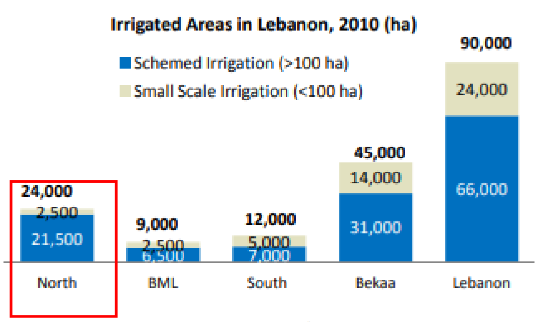


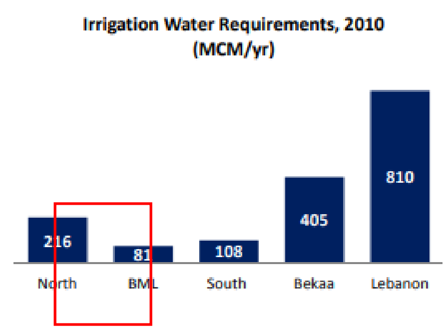


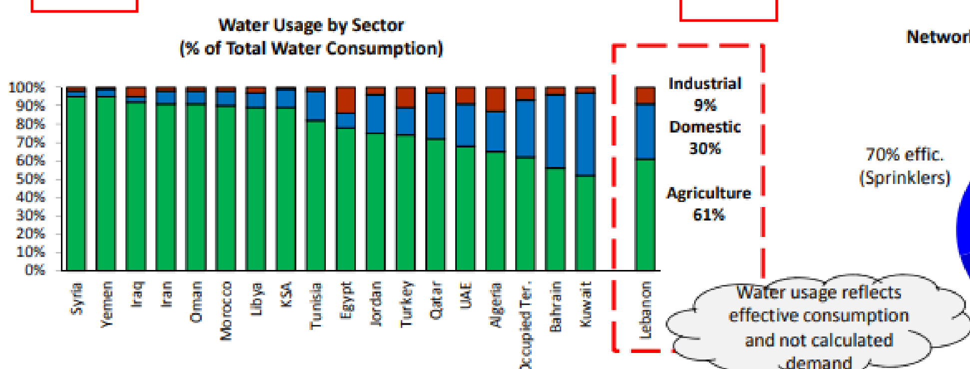
Source: MEW, WEs, WB, CAS, Water Market Middle East

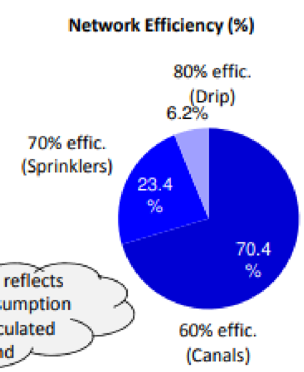
يعتبر عمر الامدادات والانابيب كبير جدا وهي بحاجة الى صيانة.

2 Irrigation is the largest water consumer with low efficiencies, as open channels still constitute the majority of the networks





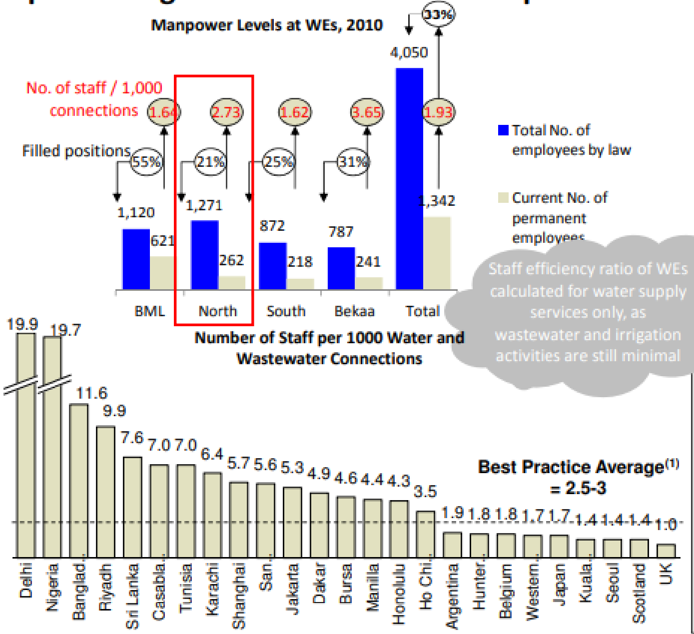


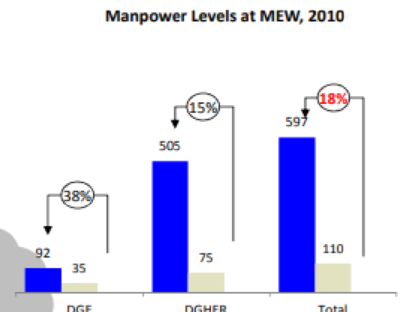


Source: MEW, WEs, World Bank

الزراعة هي المستهلك الرئيسي للمياه وتعتبر طرق الري التقليدية المستخدمة حاليا من اهم أسباب هدر الموارد.

The lack of technical capacity, financial autonomy and accountability are preventing full takeover of O&M responsibilities





Comments

- MEW and WEs are largely understaffed
- WEs rely on contractor-provided staff, mainly workers performing O&M, to partially fill the gaps. Almost 50% of total staff working in WEs are provided by contractors
- Gaps are mainly in managerial positions (Heads of Department or Unit)
- The high efficiency ratio in Bekaa reflects a low number of connections rather than a high number of employees

Note: (1) Best practice is indicative and is an average of top 15 operators. Average depends on scale, level of outsourcing as well as productivity
Source: IBNET Report and Water and wastewater utilities of the World

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4. Demand/Supply Forecast

4.1. Demand

Demand/supply forecasting methodology takes into account a number of drivers and policy levers on the demand side (1/2)

Assumptions will need to be validated/ revisited in due course during the planning phases

Drivers/Policy Levers

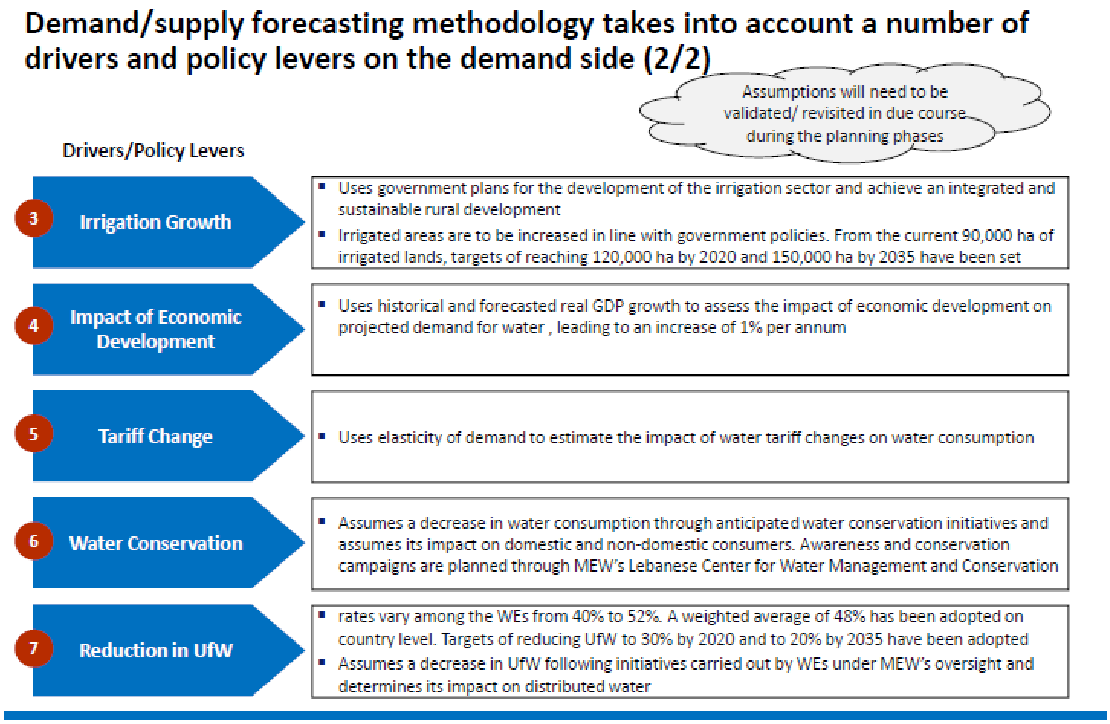
1.a Domestic Consumption per Capita
- Assumes demand per capita thresholds associated with urban development level, based on international benchmarks adapted to local conditions
- Domestic water includes water consumption for residential, commercial and governmental entities

1.b Industrial Consumption
- In the absence of recent surveys on the water consumption of the industrial sector, assumes industrial demand as a share of domestic demand

1.c Tourism Consumption
- Uses the latest figures of the Ministry of Tourism and the General Security, as well as international benchmarks to determine touristic water consumption
- Relies on Mediterranean basin benchmarks to determine daily consumption per tourist

1.d Irrigation Consumption
- Uses the latest figures of the Ministry of Agriculture, based on the latest census done by FAO, and World Bank studies
- Irrigation consumption is to be reduced, by improving irrigation efficiency of existing and planned irrigation schemes, as well as optimizing on-farm irrigation techniques

2 Population Growth
- Uses population figures and historical growth rates forecasts by Central Administration of Statistics to estimate projected population growth
- Uses numbers of Palestinian refugees based on UNRWA data



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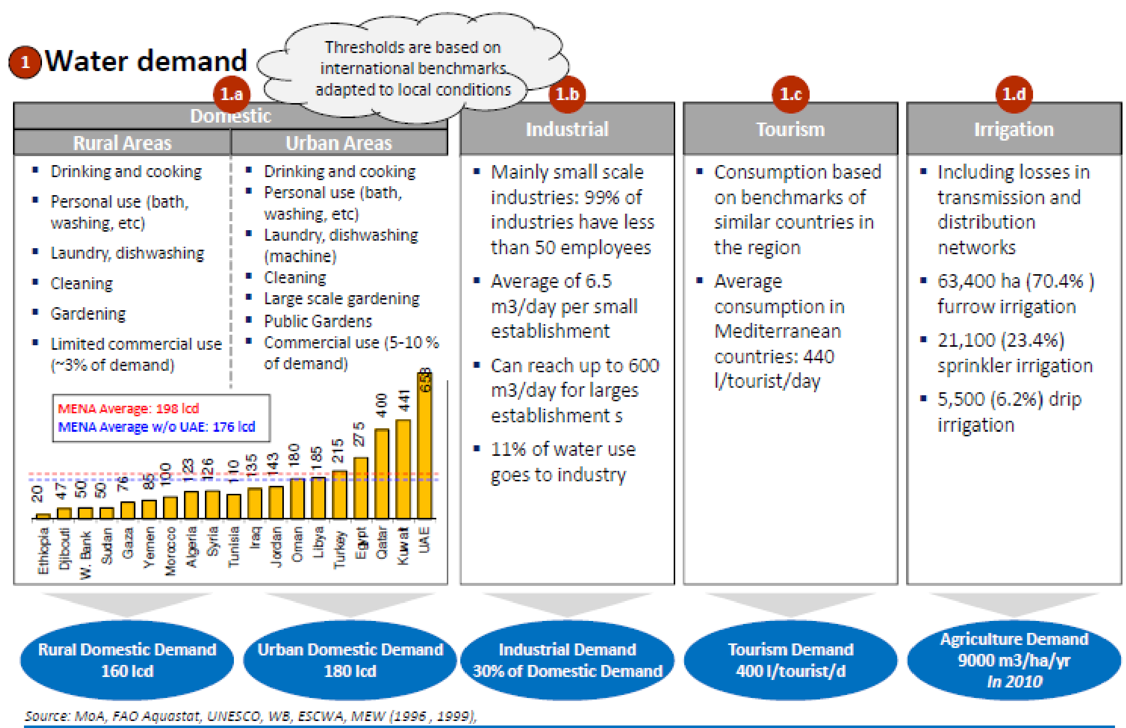

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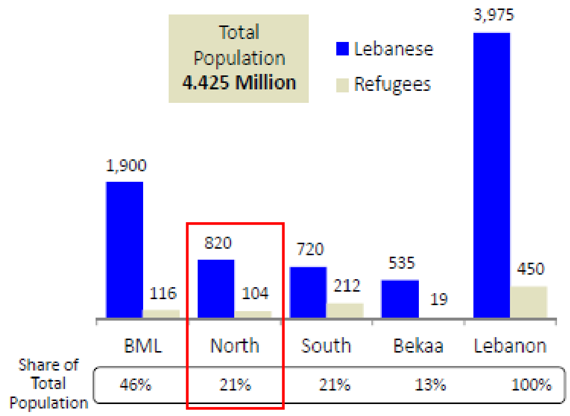
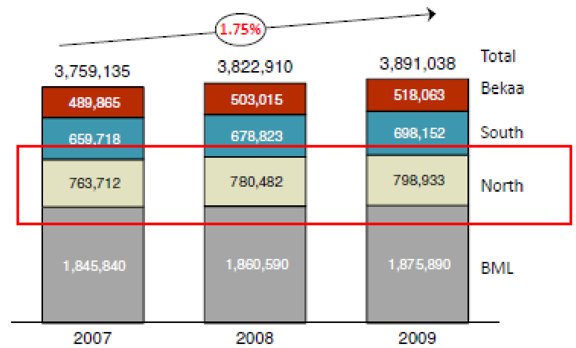
[1] http://www.databank.com.lb/docs/National%20Water%20Sector%20Strategy%202010-2020.pdf

❷ Population and growth

Distribution of Population by Region in, 2010 ('000)



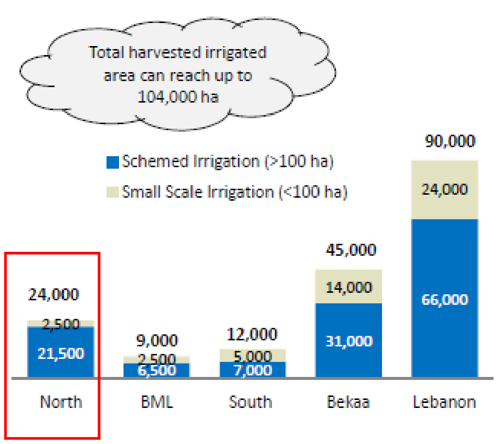
Lebanese Population Growth, 2007-2009 (%)



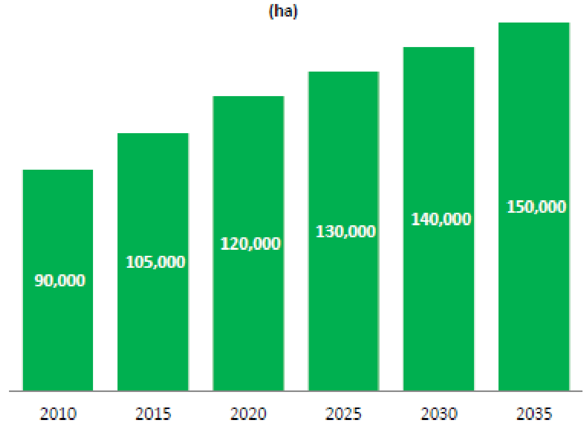
Source: CAS, UNRWA

❸ Irrigated areas and growth

Irrigated Areas in WEs , 2010 (ha)



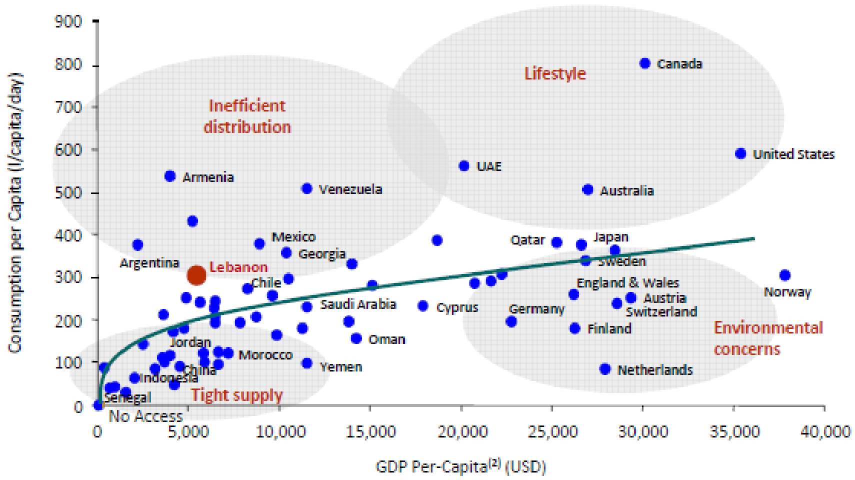
Projected Growth in Irrigated Areas in Lebanon, 2010 - 2035 (ha)



Source: MoA , FAO, WB, MEW

④ Urban water consumption and relation with economic development

Urban Water Consumption[1] and GDP per Capita

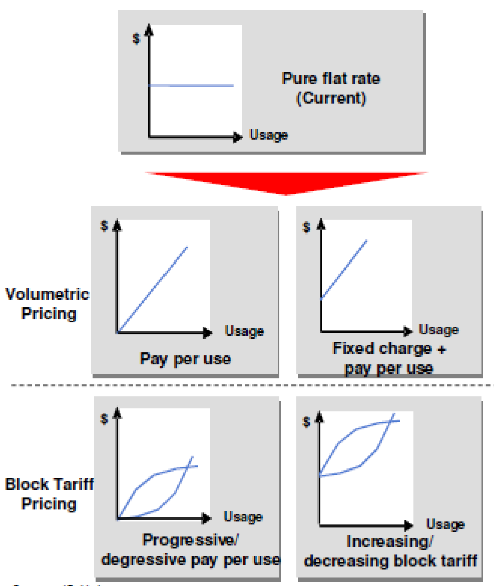


Note: (1) Includes UfW (2) Adjusted by purchasing power parity

Source: IMF, UN, MEW Analysis

⑤ Impact of tariff change (1/2)

Current and Proposed Tariff Systems



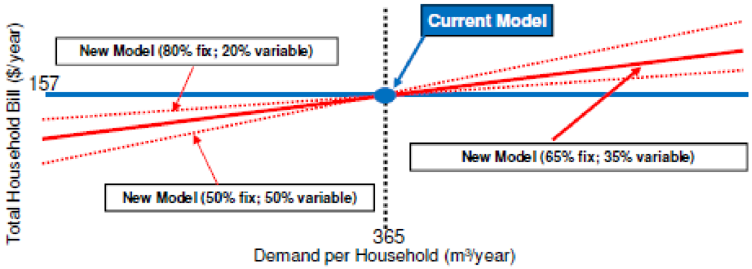
Source: IB-Net

Benchmarks on Applied Tariffs in MENA region

Country	City	Structure	Block Tariff	Level of Water Tariff	Level of WW Tariff
		V, F, M	I, D, C	USD/m3	USD/m3
Turkey	Adana	V	C	1.38	0.34
	Ankara	V	C	1.31	n/a
	Izmir	V	I	1.45	1.02
	Istambul	V	I	1.96	1.29
	Konya	V	C	0.98	n/a
Syria	Damascus	V	I	0.05	0.02
Lebanon	BMLWE	F	n/a	0.43	0
Morocco	Casablanca	V	I	0.72	0.05
Oman	Muscat	n/a	n/a	0	n/a
Occupied Territories		V	I	1.23	0.32
Palestine	Ramallah	V	I	1.23	0.32
Bahrain	Manama	V	I	0.07	n/a
Qatar	Doha	V	C	1.21	n/a
KSA	Jeddah	V	C	0.05	0
	Riyad	V	I	0.03	0
UAE	Dubai	V	I	2.16	n/a
	V = volumetric		I = increasing		
	F = fixed fee		D = decreasing		
	M = Mix		C = constant		

❺ Impact of tariff change (2/2)

	Tariffs shall be affordable	Tariffs shall cover costs	Clients able to choose consumption	Predictability for revenues
Pure flat tariff	✗	✗	✗	✓
Pure volumetric tariff	✗	✗	✓	✗
Progressive volumetric tariff	✓	✓	✓	✗
Fixed charge plus volumetric tarif	✗	✓	✓	✓
Fixed charge plus progressive volumetric tariff	✓	✓	✓	✓



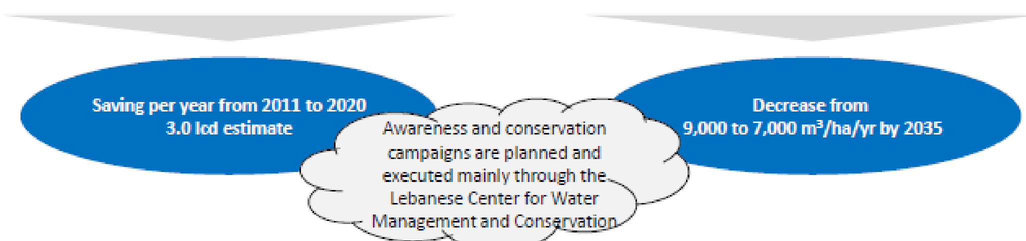
Highlights

- Tariff structures will see significant modifications:
  - For water supply: the current flat tariff structure will be replaced by a volumetric tariff structure after replacement of gauges by meters
  - For irrigation: the different forms of tariffs currently applied will be replaced by volumetric tariffs
  - For wastewater: A new tariff will be introduced in proportion with the used volumes of water supply
- Tariff changes will have an impact on the different types of consumptions. This impact needs to be defined through further studies
- Once identified, the impact of these tariff changes will be reflected in demand patterns

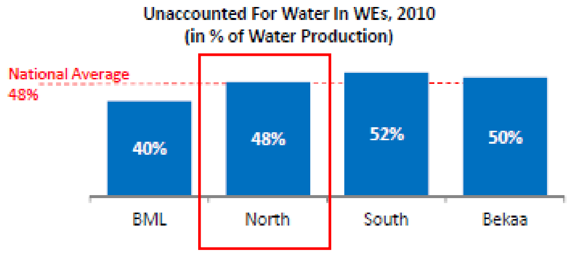
❻ Water conservation

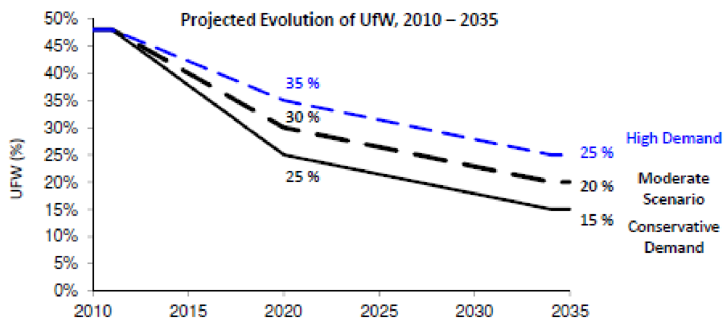
Water Conservation Initiatives

Planned Conservation Initiatives on Domestic and Industrial Demand	Planned Conservation Initiatives on Irrigation Water
▪ Installation of conservation kits (plumbing retrofits and high-efficiency toilets and showerheads, dual flush toilets, faucet aerators, kitchen aerators) ▪ High-efficiency cloth washers ▪ Complete retrofit of large water consumers, e.g., industrial, commercial ▪ Public outreach, awareness and education programs ▪ Household and establishment audits	▪ Adoption of high efficiency on-farm irrigation techniques, e.g., drip irrigation, sprinkler irrigation, overhead irrigation where applicable ▪ Coordination with Ministry of Agriculture for the adoption towards lower consumption crops ▪ Public outreach, awareness and farmer education programs ▪ Farm audits and optimization according to local conditions



7 Decrease in UFW levels





Source: WEs, MEW analysis

Comments and Key Assumptions

- To allow for more flexibility, three scenarios have been considered on the demand side: High Demand, Moderate Demand, Conservative Demand
- It is reasonable to assume that the UfW would reach 30% in the next 10 years and 20% in 2035 based on a scheduled decrease mainly due to fixing leakage (Moderate Scenario)
- International benchmarks and experience in MENA countries show that a level of 20% is feasible
- We assumed that significant leakage improvement projects will be carried out by WEs under MEW's oversight over the 2011–2020 period

To allow for more flexibility, three scenarios have been considered on the demand side: High Demand, Moderate Demand, Conservative Demand (1/2)

Drivers/Policy Levers	Scenario 1 Conservative Demand	Scenario 2 Moderate Demand	Scenario 3 High Demand
1.a Domestic Consumption per Capita	160 lcd - *Urban* 140 lcd - *Rural*	180 lcd - *Urban* 160 lcd - *Rural*	200 lcd - *Urban* 180 lcd - *Rural*
1.b Industrial Consumption	Share of domestic **25%**	Share of domestic **30%**	Share of domestic **35%**
1.c Tourism Consumption	350 l/tourist/d	400 l/tourist/d	450 l/tourist/d
1.d Irrigation Consumption	Decrease from **9,000 to 7,000 m3/ha/yr by 2035**	Decrease from **9,000 to 7,000 m3/ha/yr by 2035**	Decrease from **9,000 to 8,000 m3/ha/yr by 2035**
2 Population Growth	CAGR 2010-2035 **1.5%**	CAGR 2010-2035 **1.75%**	CAGR 2010-2035 **2.0%**

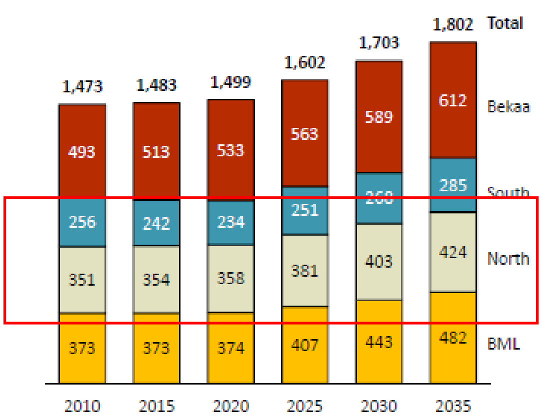
CAGR: Compound Annual Growth Rate

To allow for more flexibility, three scenarios have been considered on the demand side: High Demand, Moderate Demand, Conservative Demand (2/2)

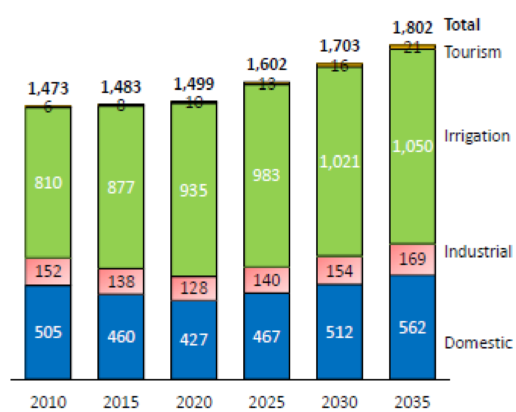
Drivers/Policy Levers	Scenario 1 Conservative Demand	Scenario 2 Moderate Demand	Scenario 3 High Demand
3 Irrigation Growth	**110,000 ha** in 2020 **130,000 ha** in 2035	**120,000 ha** in 2020 **150,000 ha** in 2035	**140,000 ha** in 2020 **180,000 ha** in 2035
4 Impact of Economic Development	Consumption Growth **0.8% per annum**	Consumption Growth **1% per annum**	Consumption Growth **1.2% per annum**
5 Tariff Change	Volumetric tariff introduction in **2012**	Volumetric tariff introduction in **2013**	Volumetric tariff introduction in **2014**
6 Water Conservation	Saving per year from 2011 to 2020 **3.5 lcd**	Saving per year from 2011 to 2020 **3.0 lcd**	Saving per year from 2011 to 2020 **2.5 lcd**
7 Reduction in UfW	Decrease from **48% to 25% by 2020 then to 15% by 2035**	Decrease from **48% to 30% by 2020 then to 20% by 2035**	Decrease from **48% to 35% by 2020 then to 25% by 2035**

Total demand under the moderate demand scenario is expected to reach 1,802 MCM/yr by 2035

Moderate Scenario for Water Demand per Region (in MCM/yr, 2010 - 2035)



Moderate Scenario for Water Demand per Usage (in MCM/yr, 2010 - 2035)

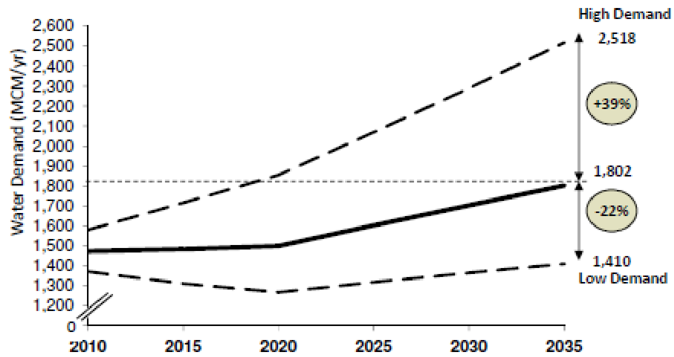


Currently the actual amount of water consumed is different form the demand due to availability and supply constraints

lcd (Urban)	180	174	167	176	185	194
Pop (M)	4.43	4.83	5.26	5.74	6.37	6.82
Irr ('000 ha)	90	105	120	130	140	150

Source: MEW, WEs,

The range between the conservative and high demand scenarios exceeds 60%



Demand Scenarios – Domestic Consumption per Capita (lcd) – Urban Area						
Low (sc. 1)	160	153	145	153	161	169
Mod (sc. 2)	180	174	167	176	185	195
High (sc. 3)	200	195	190	199	209	220

Demand Scenarios – Irrigation Consumption per Hectare (m3/ha/yr)						
Low (sc. 1)	9,000	8,600	8,200	7,800	7,400	7,000
Mod (sc. 2)	9,000	8,600	8,200	7,800	7,400	7,000
High (sc. 3)	9,000	8,800	8,600	8,400	8,200	8,000

Comments

- The range observed between the low and high demand scenarios is the result of different assumptions on the drivers in each of the scenarios
- The main drivers are consumption per capita thresholds, population growth, impact of GDP growth, industrial and irrigation consumption and growth, etc.:
  - Consumption per capita thresholds vary between 140 lcd and 200 lcd
  - Annual average population growth ranges between 1.5% and 2.0% for the low and high scenarios respectively
  - Industrial consumption varies between 25% and 35 %
  - Targets for irrigation areas in 2035 vary between 130,000 and 180,000 ha and consumption between 7000 m3/ha to 8000 m3/ha
  - Targets for UfW in 2035 vary between 15% and 25% for the low and high scenarios respectively

4.2. Supply

Main sources of water in Lebanon include surface water and groundwater while surface storage and non conventional sources are limited

Surface Water

- More than 2,000 springs exist all over Lebanon with varying flows around the year
- Total yield exceeds 1200 MCM in an average year, with less than 200 MCM available during the dry summer months
- Existing surface water resources (springs) are being currently exploited to a large extent by WEs. Limited optimization could be achieved by around 1% per year for the coming 10 years

Groundwater

- Around 650 governmental wells supply WEs throughout the country with potable water. Total volume used in 2009: more than 270 MCM
- More than 43,000 private wells are used for potable water and agriculture. Total volume used in 2009 is feared to be higher than 440 MCM. **Unlike other sources, private wells serve only a portion of the population**
- Although strict policies for groundwater extractions have been initiated, no major reductions in extractions are planned before 2015, planned date for the coming on board of sustainable alternatives. Between 2015 and 2024, private groundwater extractions are to be reduced gradually at a rate of 6%per year with increasing reliance on public wells.
- Ultimately, withdrawals from aquifers should not exceed natural replenishment rate, i.e. 500 MCM/yr

Surface Storage

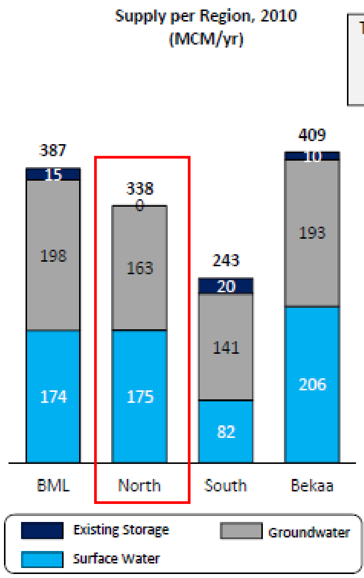
- Surface storage is mainly concentrated in 2 dams with a total capacity of 235 MCM:
  - Qaraoun Dam: 220 MCM static and 160 MCM (up to 180 MCM) dynamic
  - Chabrouh Dam: 8 MCM static and up to 15 MCM dynamic
- Currently, only 45 MCM are used for WS and irrigation, the rest for hydropower

Non Conventional Water

- The average rate of wastewater treatment reached 4% in 2009 – Virtually no reuse is being currently practiced
- Limited desalination is done by private sector (4.5MCM) and EDL (5.5 MCM)
- Additional flows are expected from non conventional sources, but have not been modeled for lack of clarity on available data

Source: MEW, WEs, Ministry of Agriculture

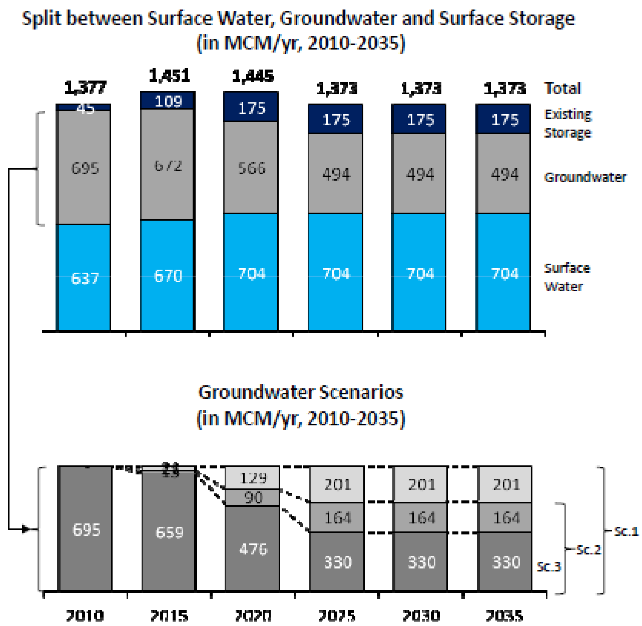
3 scenarios for water resources are studied to balance between the use of groundwater vs. surface storage



Total Supply: 1,377 MCM/yr
Surface Water: 46%
Groundwater: 51%
Used Storage: 3%

Scenarios for water resource s	
High Groundwater Supply Policy (Sc. 1)	▪ Optimize and fully utilize available renewable surface water capacities ▪ Utilize the full groundwater capacities currently used by MEW/WEs and by the private sector ▪ Provide surface storage to fill the shortage
Moderate Groundwater Supply Policy (Sc. 2)	▪ Optimize and fully utilize available renewable surface water capacities ▪ Utilize a moderate proportion of groundwater capacities currently used by MEW/WEs and by the private sector (up to 90% of the average renewable groundwater resources) ▪ Rely more on surface storage to fill the shortage
Low Groundwater Supply Policy (Sc. 3)	▪ Optimize and fully utilize available renewable surface water capacities ▪ Utilize a low proportion of groundwater capacities currently used by MEW/WEs and by the private sector (up to 60% of the average renewable groundwater resources) ▪ Rely extensively on surface storage

As surface water is limited, the tradeoff between groundwater and surface storage shall be carefully managed to ensure additional needed resources



Key Highlights

- Currently exploited storage capacity, 45 MCM:
  - Chabrouh: 15 MCM in BML
  - Qaraoun: fro m the 220 MCM total static capacity (160 MCM dynamic capacity), only 30 MCM are currently exploited: 10 MCM for the irrigation of South Bekaa Phase I (2000 ha) and 20 MCM for Qasmieh - Ras Al Ain irrigation scheme in the South. The rest of the capacity is currently used for hydropower. 110 MCM will be used in the future (2014-2018) for irrigation of South Bekaa Ph II (additional 20 MCM) and, through canal 800, for irrigation (90 MCM) and water supply (20 MCM) in the South
- Groundwater extractions to be reduced to no more than 500 MCM by 2025
- Surface water resources to be optimized to reach around 700 MCM by 2020

Table: Annual yield of private licensed wells

Mohafazat	Number	Water Uptake (Mm^3/year)			Total Yield (Mm^3/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: SOER 2010

5. State of water resources

State of Water Resources

Rivers, springs and groundwater adversely impacted by raw sewage and other wastes, both domestic and industrial, discharged without pre-treatment.

Rivers and springs

- High BOD load and faecal contamination in several river systems (see table)

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*

[2]

[2] https://unstats.un.org/unsd/envaccounting/workshops/Beirut2012/Beirut2012-11.PDF

6. Lebanon's Water Resources

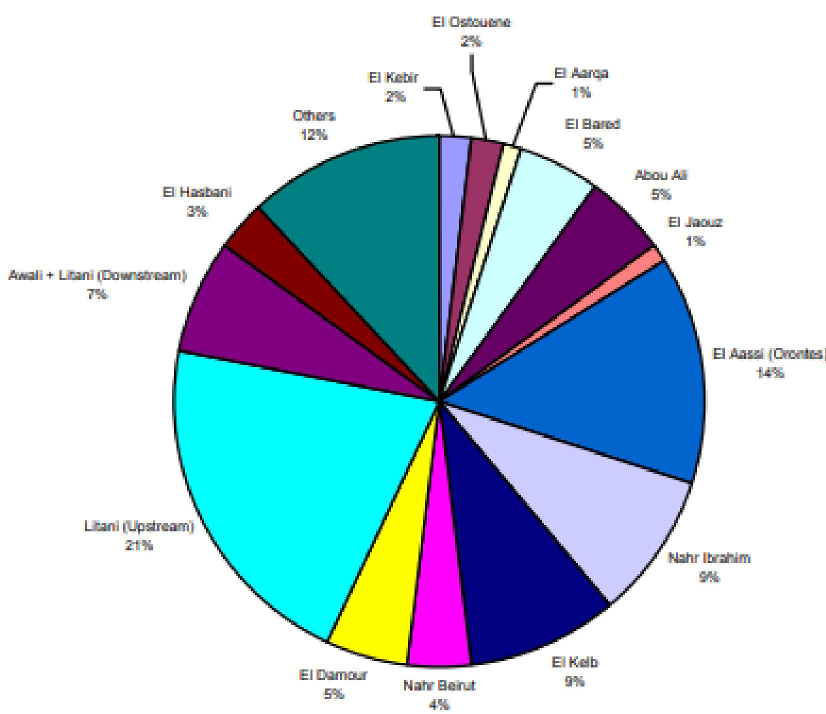
6.1. Surface water

The following table shows estimations of these flows (in MCM) in each geographic unit and for various periods of the year.

Table 1: Flows in Watercourses in Lebanon Mohafazats

Flows in Water Courses (average values) (in MCM)	North Lebanon	Mount Lebanon	North Bekaa	Central and Southern Bekaa	South Lebanon	Total
Entire year	670	990	480	830	430	3400
May to October (6 months)	270	305	240	240	25	1080
July to October (4 months)	115	95	155	115	10	490
September	22	18	38	27	2	107

The following pie-chart summarizes the contribution of the main rivers to the total yearly run-off flow:



6.2. Underground Water

Referring to all water sectors, it is noticed that:

i) The water available from the springs is no longer sufficient especially in dry seasons.

ii) The administration and individuals have overused underground water. Most of the projects studied lately by the administration are based on drilling wells.

iii) The over usage of underground water has led to the following facts:

- **a.** A decrease in spring flows limits the use for potable water and irrigation.
- **b.** A decrease in the water level in the underground reservoirs.
- **c.** The intrusion of sea water and the increase of salinity in the wells on the coast.

From what has preceded, one can clearly see the necessity of storing winter water to be used in dry seasons. Due to this fact the work plan calls:

- First:

- To prepare detailed hydrogeological plans for underground water
- To study the possibility of storing underground water
- To maximum reduce the intrusion of sea water
- To study all the necessary infrastructures to insure artificial feeding of underground water.

- Second:

- To study the possibility of water storage from the rivers in Lebanon from dams and hill lakes
- To execute the construction of dams and hill lakes in regions where their feasibility has been proven.

7. Lebanon's Organization of water sector

Numerous governmental, Ministries and autonomous and semi-autonomous agencies are involved in the water sector planning and management in Lebanon. Their responsibilities are interrelated and therefore it is difficult to discern a clear authoritative system linking promulgated decrees to the corresponding and appropriate agencies (MOEW, LRA, RWE, MOA, CDR, GP, etc.). The political power and interest involvement in the country at the institutional level led to this chaotic situation. The historical and actual perspectives concerning the main institutions involved in the water sector are described here below.

7.1. Ministry of Energy & Water (MOEW)

Created in 1966, the Ministry of Hydraulic and Electrical Resources (MOHER), now MOEW since 2000, has the following mandates:

- protect and develop hydraulic natural resources;
- assume jurisdiction over the water resources in Lebanon;
- study supply and demand, and global situation of the water resources in Lebanon;
- prepare the national water master plan;
- design, implement and operate large hydraulic facilities;
- conserve and control the water resources including surface and underground water;
- exercise administrative supervision over the WAs and the LRA.

MOEW has two General Directorates: The largest of the two: The Directorate General of Hydraulic and Electric Resources (DGHER) is responsible for research, studies and implementation of large-scale projects. The second one is the Directorate General for Operations (DGO) is responsible for overseeing the public establishment, for administration and financial aspects and for mines and quarries. MOEW exercises administrative supervision over the RWA, the autonomous Water Boards and Local Committees through the Directorate General of Operations (DGO). MOEW has about 212 staff against 578 assumed positions including 60 engineers. Due to the ban on new recruitment by the public sector, 26 the average age of MOEW staff is quite high. In recent years, some new recruitment and transfer from the other ministries were made on exceptional basis. MOEW's average yearly budget is about US$85 million and irrigation represents ten percent of this total budget.

7.2. Regional water establishment

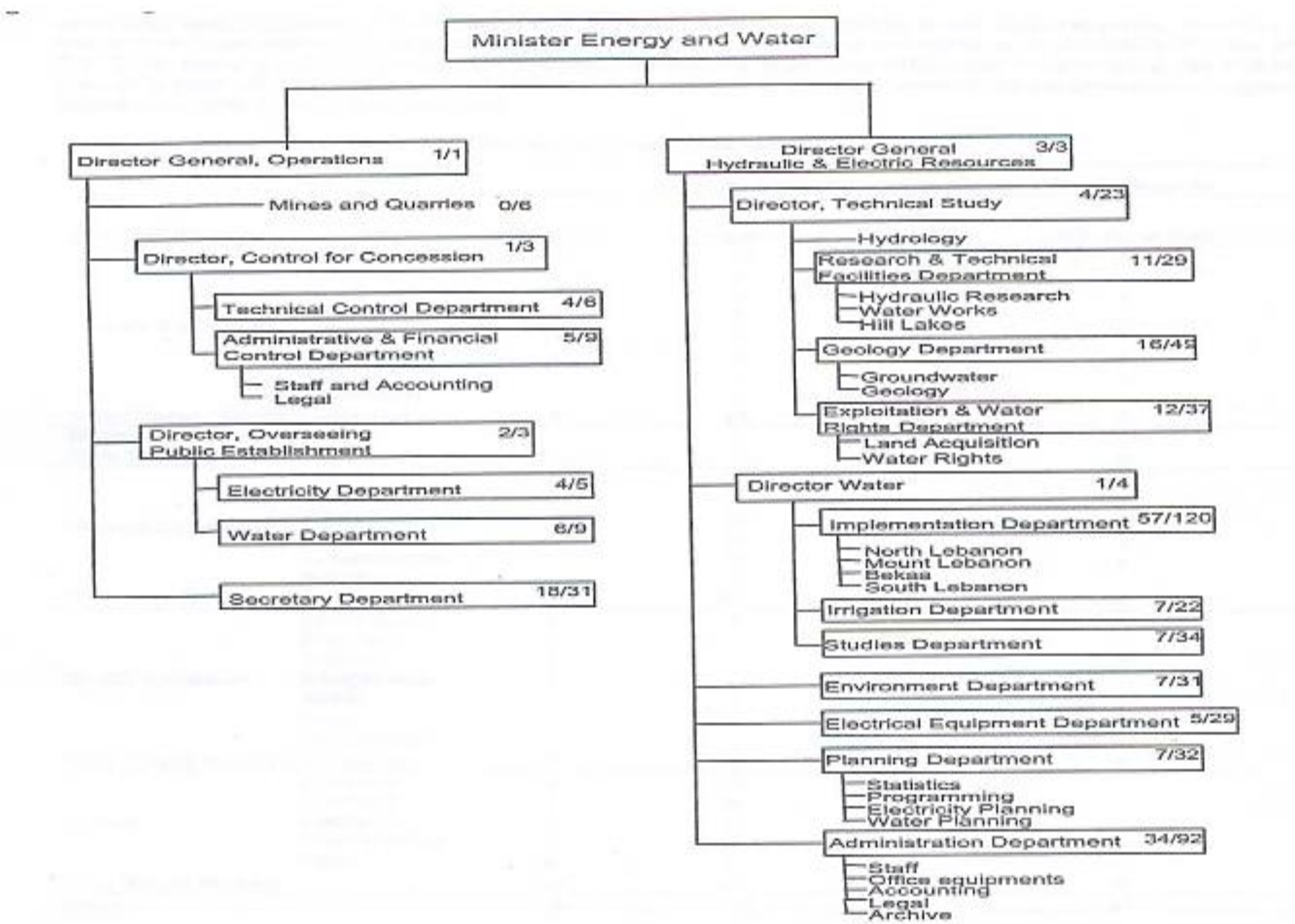


Figure 1: Organization of Ministry of Energy and Water

No	**Regional Water Authority/Committee**	**Caza**	**Population**
North Lebanon Mohafazat			
1	Tripoli Water Board	Tripoli & Akkar	481,000
2	Nabaa Al-Ghar Water Committee	Koura	77,000
3	Kubayat Water Board	Akkar	31,000
4	Nabaa Al-Kadi Water Committee	Zgharta	59,000
5	Becharre Water Committee	Becharre	33,000
6	Batroun Water Committee	Batroun	50,000
7	Akkar	Akkar	*
8	Danniyeh	Tripoli (Danniyeh)	*

Table 7: Regional Water Authorities in Lebanon

7.3. Local Committee

Table 8 describes the 209 Local Committees (LCs) with their locations and functions. These Committees were mainly established after the civil unrests of the 1980s. In general, the role of these Committees is restricted to the operation, maintenance rehabilitation and renovation of the networks and equipment. This keeps the responsibility for studying water requirements, 28 development of water resources and design and execution of extension of existing networks with the MOEW. Out of these 209 LCs, there are 25 Irrigation Committees, which are at present efficiently undertaking the O&M tasks (out of a total of 120). These Committees could easily form the nucleus of the proposed new organization based on Water User's Associations.

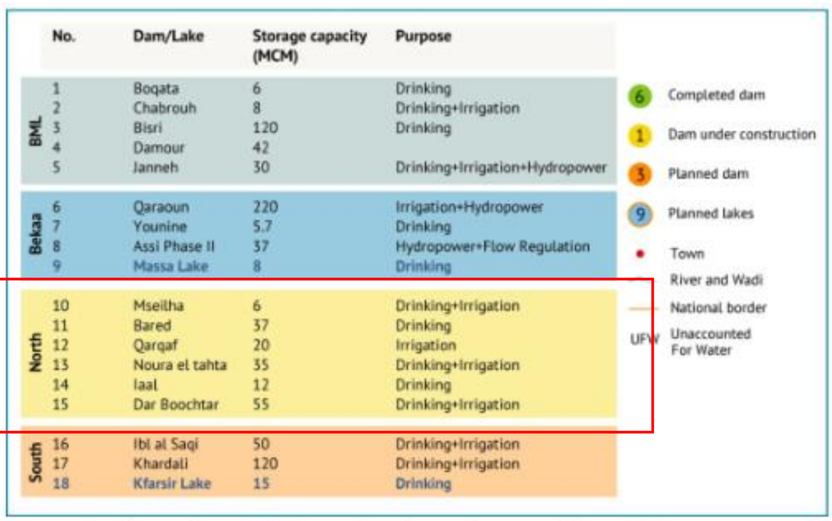
Number of Committees Serving Each Purpose						
Mohafazat	Caza	Potable	Irrigation	Potable + Irrigation	Undetermined	Total
North Lebanon	Akkar	2	10	4	1	17
	Batroun	1	6	3	-	10
	Becharre	2	3	5	1	11
	Koura	-	2	-	-	2
	Tripoli	1	6	4	2	13
	Zgharta	2	6	2	1	11
	Akkar*	-	-	-	-	-
	Danniyeh*	-	-	-	-	-
Sub Total North Lebanon		8	33	18	5	64

Table 8: Local Water Committees formed between 1984 and 1990

In 1998, a new decree was issued organizing all Regional Water Authorities into four authorities: North Lebanon, Beirut & Mount Lebanon, South Lebanon and Bekaa (table 9).

			Local Committees		
New Water Authority	No	Old Water Authority	Potable	Irrigation	Total*
1- North Lebanon	1	Tripoli Water Board	8	51	64
	2	Nabaa AI-Ghar Water Committee			
	3	Kubayat Water Board			
	4	Nabaa Al-Kadi Water Committee			
	5	Bcharri Water Committee			
	6	Batroun Water Committee			
	7	Akkar			
	8	Danniyeh			

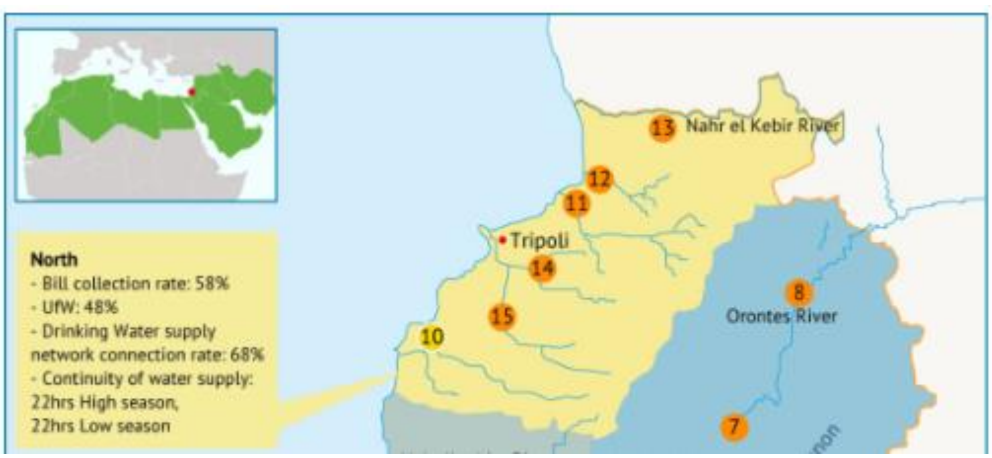
* Including undetermined Committees.
Table 9: recently created water authorities



	No.	Dam/Lake	Storage capacity (MCM)	Purpose
BML	1	Boqata	6	Drinking
	2	Chabrouh	8	Drinking+Irrigation
	3	Bisri	120	Drinking
	4	Damour	42	
	5	Janneh	30	Drinking+Irrigation+Hydropower
Bekaa	6	Qaraoun	220	Irrigation+Hydropower
	7	Younine	5.7	Drinking
	8	Assi Phase II	37	Hydropower+Flow Regulation
	9	Massa Lake	8	Drinking
North	10	Mseilha	6	Drinking+Irrigation
	11	Bared	37	Drinking
	12	Qarqaf	20	Irrigation
	13	Noura el tahta	35	Drinking+Irrigation
	14	Iaal	12	Drinking
	15	Dar Boochtar	55	Drinking+Irrigation
South	16	Ibl al Saqi	50	Drinking+Irrigation
	17	Khardali	120	Drinking+Irrigation
	18	Kfarsir Lake	15	Drinking

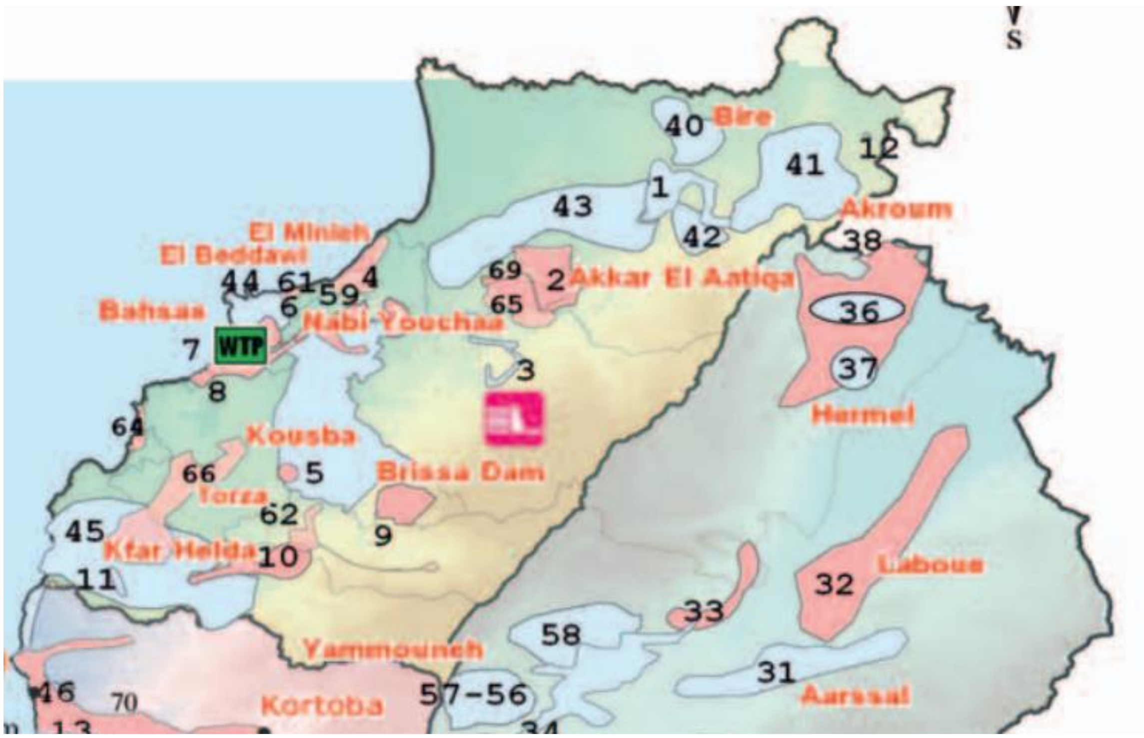
Figure 5. Planned major dams and lakes (>5 MCM) and status of water supply by establishment. Source: Fanack after MEW, 2010, updated based on personal communication with MEW, 2015.

[3]



[3] https://water.fanack.com/lebanon/water-infrastructure/#_ftn14

8. Completed and ongoing projects



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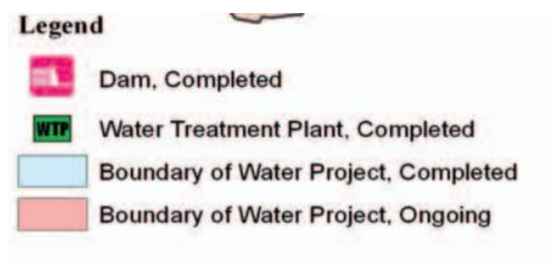
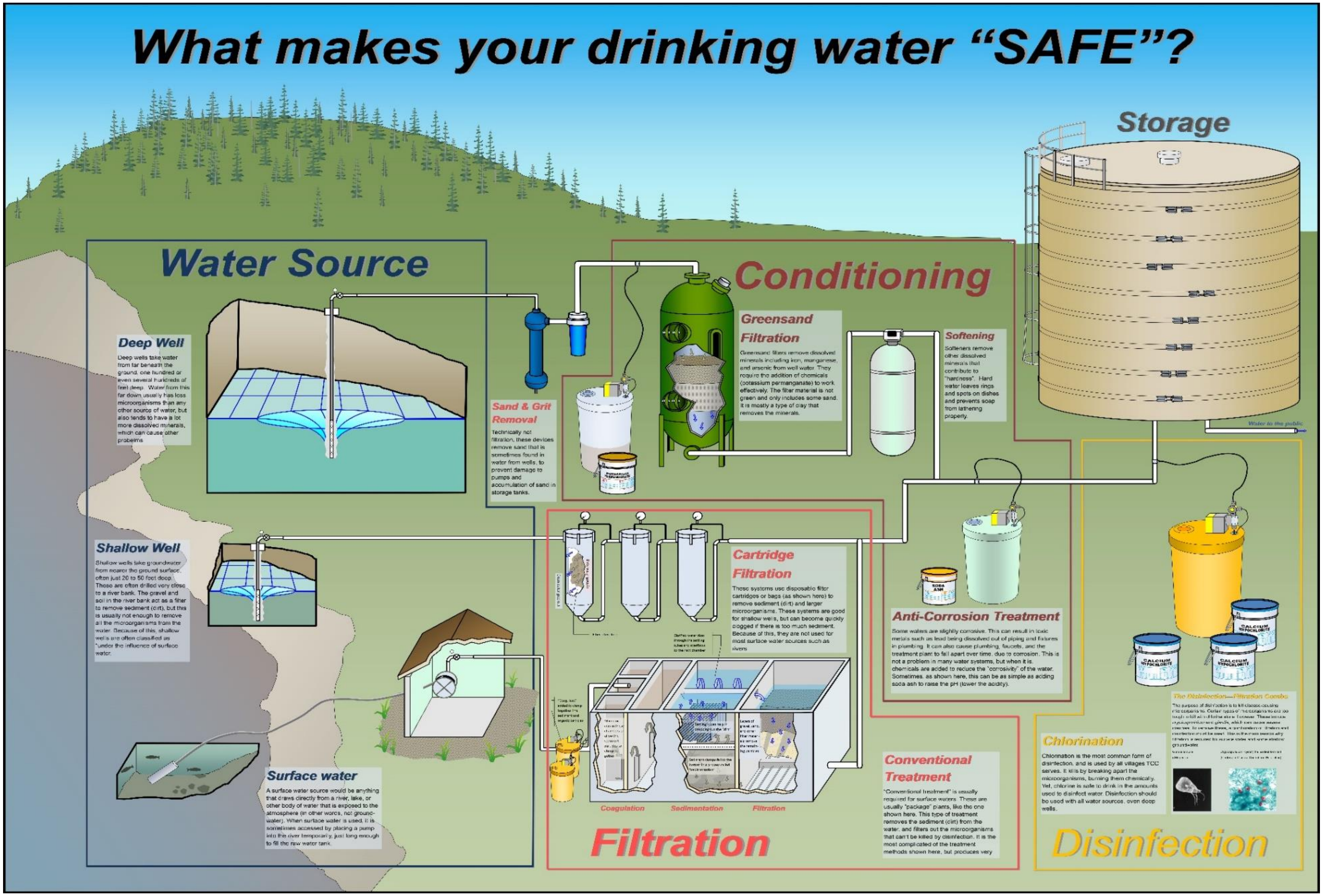


40 Qoubaiyat
41 Akroum - kfartoun
42 Ain Yaacoub
43 Beit Mellat
44 Tripoli Network & water treatment plant
45 Batroune
59 Nabi youshaa & Deir Amar well Equipments
61 secondary and Tertiary networks in Beddawi
62 water supply project in Becharre
64 Rehabilitation of water systems in Chekka and Anfeh in the coastal area of Batroun and koura
65 complete supply of water for the area of Barghash, Hrar, kaf el tine and Quabiit
66 execution of water supply networks and boreholes and pumping stations in the cazas of koura and Batroun
69 complete supply of the villages from Hrar and Quabiit water Reservoirs in South Akkar
1 water supply project in Akkar El aatiqa villages
2 water supply project in el bergosh - Hrar & kaf el tine and kabiit
3 Brisa dam construction
4 Completion of water supply project in the villages of el Minnieh - Dinnieh caza
5 implementation of various water works in Zgharta
6 Secondary and tertiary networks in Tripoli + Add nb 1
7 Extension of Bahsas water treatment plant + Add nb 1
8 Implementation of water works in koura & Tripoli
9 Construction of a new drinking water distribution network & sewerage system for Ehden
10 Completion of water supply project works in Batroun
11 Equipping of Jaran & Aabdly water plants with electric generators
12 Rehabilitation of mounseh well pumping station (caza of Akkar)

[4] http://www.cdr.gov.lb/eng/progress_reports/pr102014/Ewater.pdf

9. Water treatment scheme[5]



[5] https://www.tananachiefs.org/wp-content/uploads/2016/10/2016-TCC-Poster-Water-treatment.jpg

10. <u>Water extraction</u>

Depending upon where you live, there are two basic ways that water gets to your house. If you live in the country on a farm, your water probably comes from a deep well located on your property. If you live in a small town or larger city, however, you most likely get your water from a public water supply.

If your water comes from a public water supply, then you will pay fees to a public water utility based upon how much water you use. Your water use is measured by a water meter located in your home or on your property.

Public water utilities provide water to large numbers of customers by one of two means: surface water or ground water. Ground water is located deep underground in veins of water known as aquifers. It must be accessed by drilling a deep well and then pumping it to the surface. If you have a private well on your property, you are using ground water from an aquifer.

Surface water, on the other hand, is found at the surface of Earth in lakes, rivers, and streams. A public water utility accesses surface water by building an intake to draw water to a location where it can be analyzed, treated, and then pumped out to customers.

Most public water utilities tend to rely upon surface water sources. Millions of people around the world use ground water wells, though. Overall, both sources provide about half of the world's drinking water.

Regardless of its source, water must be analyzed to ensure it's safe to drink. Public water utilities filter and treat water with certain chemicals to remove impurities and make sure your drinking water is safe to use.

Filtered and treated water that's safe to drink (called potable water) is then stored in a reservoir from which it gets pumped through underground pipes (called water mains) to your house. A water pipe known as a service lateral line connects that water main to your house plumbing and brings the water right to your faucet when you turn it on.

Public water utilities also keep plenty of water in storage in case of emergencies. You may have noticed big water tanks located on the high hills in your town and surrounding communities. These water tanks hold thousands upon thousands of gallons of water that can be used in case of fires and water main leaks.

11. <u>Water treatment steps</u>

Drinking water sources are subject to contamination and require appropriate treatment to remove disease-causing agents. Public drinking water systems use various methods of water treatment to provide safe drinking water for their communities. Today, the most common steps in water treatment used by community water systems (mainly surface water treatment) include:

- **Coagulation and Flocculation**

Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge are added to the water. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc.

- **Sedimentation**

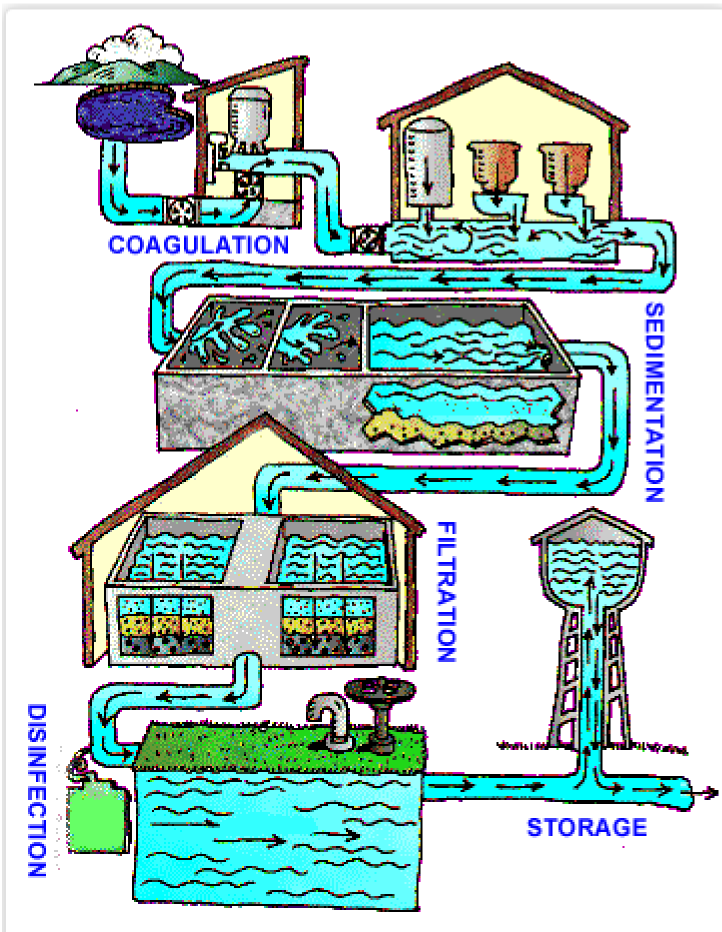
During sedimentation, floc settles to the bottom of the water supply, due to its weight. This settling process is called sedimentation.

- **Filtration**

Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel, and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses, and chemicals.

- **Disinfection**

After the water has been filtered, a disinfectant (for example, chlorine, chloramine) may be added in order to kill any remaining parasites, bacteria, and viruses, and to protect the water from germs when it is piped to homes and businesses.



[6]

[6] https://www.cdc.gov/healthywater/drinking/public/water_treatment.html

12. Water distribution system

Distribution system infrastructure is generally the major asset of a water utility. The American Water Works Association (AWWA, 1974) defines the water distribution system as "including all water utility components for the distribution of finished or potable water by means of gravity storage feed or pumps though distribution pumping networks to customers or other users, including distribution equalizing storage." These systems must also be able to provide water for no potable uses, such as fire suppression and irrigation of landscaping.

12.1. Infrastructure

Distribution system infrastructure is generally considered to consist of the pipes, pumps, valves, storage tanks, reservoirs, meters, fittings, and other hydraulic appurtenances that connect treatment plants or well supplies to consumers' taps. The characteristics, general maintenance requirements, and desirable features of the basic infrastructure components in a drinking water distribution system are briefly discussed below.

12.1.1. Pipes

The systems of pipes that transport water from the source (such as a treatment plant) to the customer are often categorized from largest to smallest as transmission or trunk mains, distribution mains, service lines, and premise plumbing. Transmission or trunk mains usually convey large amounts of water over long distances such as from a treatment facility to a storage tank within the distribution system. Distribution mains are typically smaller in diameter than the transmission mains and generally follow the city streets. Service lines carry water from the distribution main to the building or property being served. Service lines can be of any size depending on how much water is required to serve a particular customer and are sized so that the utility's design pressure is maintained at the customer's property for the desired flows. Premise plumbing refers to the piping within a building or home that distributes water to the point of use. In premise plumbing the pipe diameters are usually comparatively small, leading to a greater surface-to-volume ratio than in other distribution system pipes.

The three requirements for a pipe include its ability to deliver the quantity of water required, to resist all external and internal forces acting upon it, and to be durable and have a long life (Clark and Tippen, 1990). The materials commonly used to accomplish these goals today are ductile iron, pre-stressed concrete, polyvinyl chloride (PVC), reinforced plastic, and steel.

12.1.2. Pipe-Network Configurations

The two basic configurations for most water distribution systems are the branch and grid/loop (see Figure 1-3). A branch system is similar to that of a tree branch, in which smaller pipes branch off larger pipes throughout the service area, such that the water can take only one pathway from the source to the consumer. This type of system is most frequently used in rural areas. A grid/looped system, which consists of connected pipe loops throughout the area to be served, is the most widely used configuration in large municipal areas.

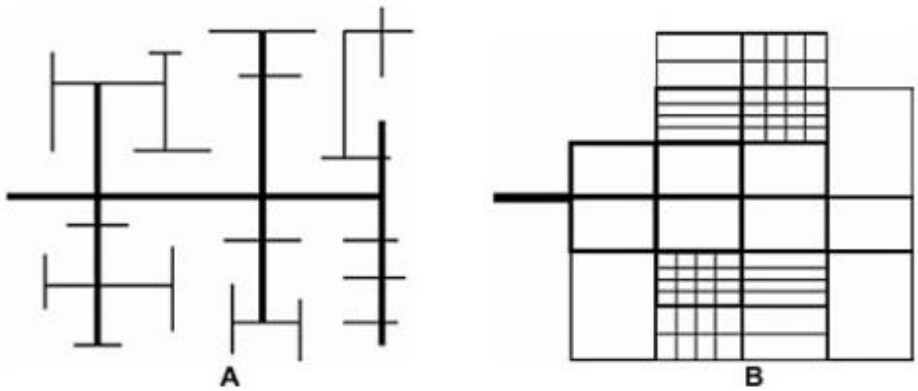


FIGURE 1-3 Two Basic Configurations for Water Distribution Systems. (A) Branched configuration. (B) Looped configuration.

12.1.3. <u>Storage Tanks and Reservoirs</u>

Storage tanks and reservoirs are used to provide storage capacity to meet fluctuations in demand (or shave off peaks), to provide reserve supply for fire-fighting use and emergency needs, to stabilize pressures in the distribution system, to increase operating convenience and provide flexibility in pumping, to provide water during source or pump failures, and to blend different water sources. The recommended location of a storage tank is just beyond the center of demand in the service area (AWWA, 1998). Elevated tanks are used most frequently, but other types of tanks and reservoirs include in-ground tanks and open or closed reservoirs. Common tank materials include concrete and steel.

12.1.4. <u>Pumps</u>

Pumps are used to impart energy to the water in order to boost it to higher elevations or to increase pressure. Pumps are typically made from steel or cast iron. Most pumps used in distribution systems are centrifugal in nature, in that water from an intake pipe enters the pump through the action of a "spinning impeller" where it is discharged outward between vanes and into the discharge piping. The cost of power for pumping constitutes one of the major operating costs for a water supply.[7]

Therefore, it is very important that pumps have a high degree of efficiency and are maintained properly. To guarantee safe water quality, cross connection of drinking water and waste removal systems must be avoided.

Main pumping stations, which supply water to the distribution system, are located near the water treatment facility or a potable water storage facility, and pump directly into the piping system. Pumps that pump directly into transmission lines and distribution systems are sometimes called high lift pumps.

[7] http://dl.mozh.org/up/Drinking%20Water%20Distribution%20Systems%20-%20Assessing%20and%20Reducing%20Risks-National%20Research%20Council-.pdf

Booster pumps are additional pumps used to increase pressure locally or temporarily. Booster pumps stations are usually remotely located from the main pump station, as in hilly topography where high-pressure zones are required, or to handle peak flows in a distribution system that can otherwise handle the normal flow requirements.
There are generally two types of pumps used for potable water pumping applications.

- The vertical turbine pump (line shaft and submersible types)
- The centrifugal horizontal or vertical split case pump designed for water-works service.

Pump discharge capacity:

- If the pump is used directly to supply water without a reservoir, the capacity must be equal to the peak hour demand.
- If the water distribution system has a reservoir, the pump capacity must be equal to the maximum daily demand.

Pump selection:

- If the pumping water level is less than 6 meters, use a centrifugal pump (maximum suction lift = 6 meters).
- If the pumping water level is from 6-20 meters, use jet pumps or a submersible.
- If the PWL is greater than 20 meters, use a submersible or a vertical line shaft turbine pump.

Power supply for pumps:
Electric, gasoline or diesel engines are commonly used as power sources for pumps. The electric motor is, however, the most favored power source because of its reliability, relatively low power cost, and environmental considerations like cleanliness, relatively low noise, and low pollutant emissions. An electrical pump may also be driven with solar power. Heat sensors installed in the windings during manufacturing should protect electric motors. These sensors shut the motor off in case of low voltage or change in phase before damage can be done.[8]

12.1.5. <u>Valves</u>

The two types of valves generally utilized in a water distribution system are isolation valves (or stop or shutoff valves) and control valves. Isolation valves (typically either gate valves or butterfly valves) are used to isolate sections for maintenance and repair and are located so that the areas isolated will cause a minimum of inconvenience to other service areas. Maintenance of the valves is one of the major activities carried out by a utility. Many utilities have a regular valve-turning program in which a percentage of the valves are opened and closed on a regular basis. It is desirable to turn each valve in the system at least once per year. The implementation of such a program ensures that water can be shut off or diverted when needed, especially during an emergency, and that valves have not been inadvertently closed.

12.1.6. <u>Hydrants</u>

Hydrants are primarily part of the firefighting aspect of a water system. Proper design, spacing, and maintenance are needed to insure an adequate flow to satisfy fire-fighting requirements.[9]

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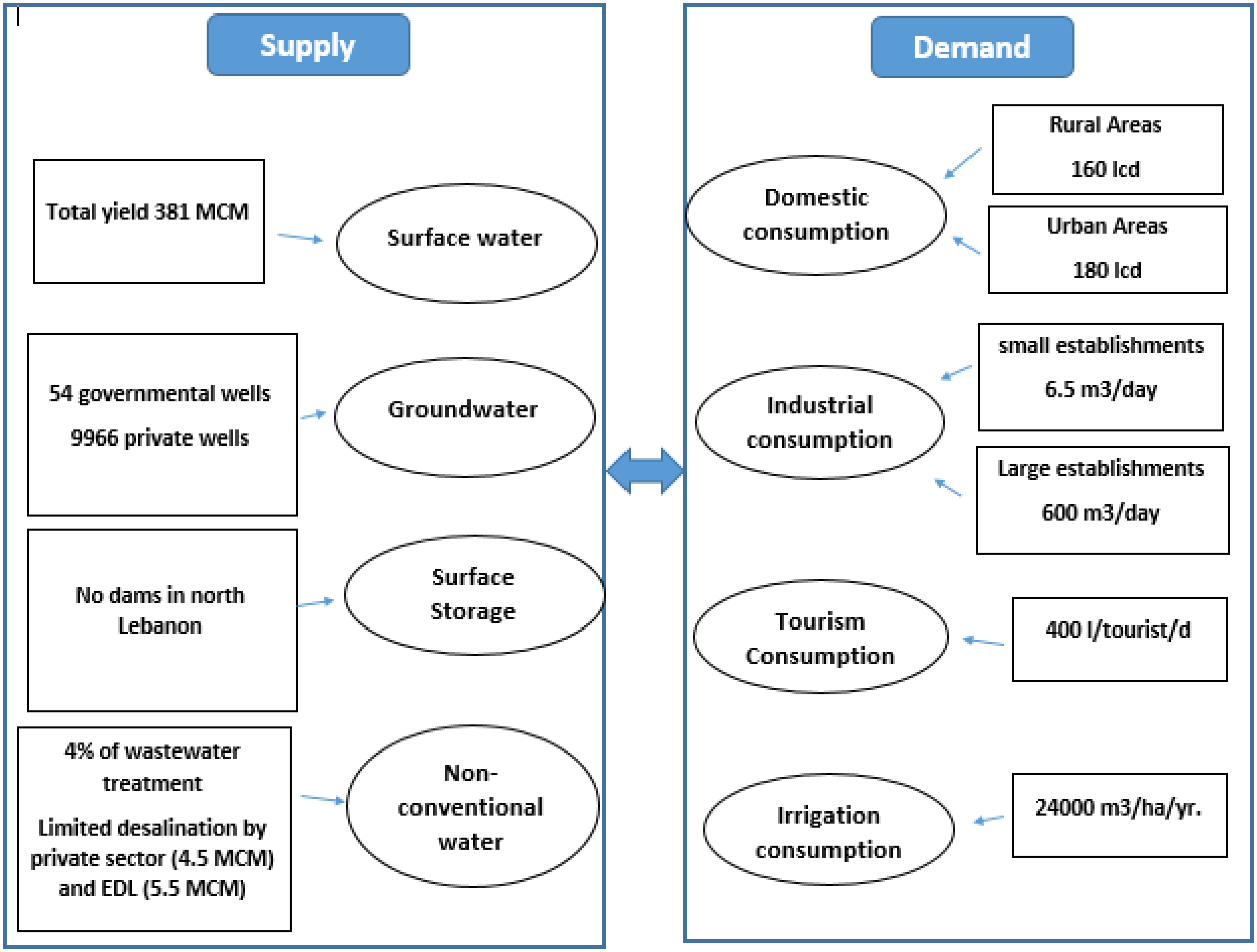
[8] https://sswm.info/sswm-university-course/module-2-centralised-and-decentralised-systems-water-and-sanitation-1/pumping-stations
[9] http://dl.mozh.org/up/Drinking%20Water%20Distribution%20Systems%20-%20Assessing%20and%20Reducing%20Risks-National%20Research%20Council-.pdf

13. Applying a System Dynamics Approach



14. Conclusion

يعتبر واقع الموارد المائية في شمال لبنان جيد حاليا الا ان القطاع يعاني من مشاكل عدة أهمها:

-الهدر (امدادات وانابيب قديمة جدا)

- التلوث (استخدام المواد الكيماوية وتسرب مياه الصرف الصحي واختلاطها بمياه الشفة)

-استخراج الماء الغير منتظم (حفر الابار بطريقة عشوائية)

-عدم استغلال مياه المسطحات والتركيز على حفر الابار

كل هذه المشاكل قد تؤدي فيما بعد الى خطر انخفاض منسوب المياه الجوفية وبالتالي نقص في الموارد المائية.