Groundwater Governance in Lebanon
The case of Central Beqaa

A Policy White Paper

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List of Acronyms

Bm^3	Billion cubic meters
BWE	Beqaa Water Establishment
CDR	Council for Development and Reconstruction
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
LPS	Liter per second
LRA	Litani River Authority
LRBMS	Litani River Basin Management Support Program
Mm^3	Million cubic meters
MoE	Ministry of the Environment
MEW	Ministry of Energy and Water
NGO	Non-Governmental Organization
NWSS	National Water Sector Strategy
ULRB	Upper Litani River Basin
UNDP	United Nations Development Programme
UN-ESCWA	United Nations Economic and Social Commission for Western Asia
USAID	United States Agency for International Development
RWE	Regional Water Establishments

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Foreword

This policy white paper is part of a project on "Groundwater Governance in the Arab World" funded by USAID. It provides a review of groundwater management and policy options in the world, with a focus on the MENA region, as well as case studies of Tunisia (Haouaria region), Jordan (Azraq groundwater basin) and Lebanon (Central Beqaa). Each country case study has been the subject of two scientific reports: a study of the groundwater policy background and history; and a report on field investigations in each basin carried out to document current dynamics and problems of groundwater-based agriculture. Further to these studies, *Dialogues* have been conducted with and between local stakeholders and policy-makers in each location. Problems and management options have been discussed and confronted at length, and opinions and suggestions have been shared. This White Paper is meant to tease out important points from all these research output in order to provide policy ideas and orientations in a summary form. Analyses and recommendations stem from the ideas advanced by stakeholders during the workshops held, but also from field work and from the evidence synthesized from experience at the world level by this project. The control and regulation of groundwater abstraction is perhaps the most vexing challenge of water management worldwide, with very few encouraging or 'success stories'. Mindful of the political complexities of groundwater regulation, this White Paper is an attempt to contribute to groundwater policy thinking in Lebanon.

1 Introduction

Although part of the Middle-East and Northern-Africa region, Lebanon distinguishes itself by its relatively abundant water resources (800 mm on average), the importance of snow, and the prevalence of a karstic geology. Sometimes dubbed the *water tower* of the Middle-East it is nevertheless facing challenges with regard to both infrastructures (e.g. limited storage, incomplete water networks or wastewater treatment capacity) and management itself: knowledge of the resource, allocation, licensing, etc.

Groundwater is a key resource in Lebanon, for both domestic/industrial and agricultural needs. More importantly, its diffuse nature and relative availability has allowed individuals and villages in rural areas to develop local and autonomous domestic water systems, as well as irrigated agriculture, notably during the war times when public services were basically non-existent.

To put it simply, groundwater in Lebanon mostly occurs in quaternary alluviums (along the coast and in the central plain of the Beqaa) and in various karstic formations. Karstic formations are associated with springs and therefore surface water originates for a large part from karstic aquifers discharging through springs. The Beqaa Valley is a good illustration of Lebanon hydrogeology, since it combines a quaternary alluvium with several karstic formations on both sides of the valley which feed numerous springs that make up around half of the Litani River's superficial runoff.

Starting in the late 1950s, well drilling and pumping technology have unsettled the early natural balance. Villages and farmers alike have gradually tapped a growing portion of both surface and groundwater resources for domestic uses and irrigation. Between 1960 and present times irrigation almost quadrupled. Runoff at the level of the Qaraoun dam by and large dwindled from 400 to 300 Mm^3/year on average (USAID-LRBMS 2011). But a special feature of Lebanon's central valley is its relatively limited width (around 10 km) associated with a large number of available surface and groundwater sources. With time, water users have been able to withdraw water from several sources and to shift from one to the other depending on their respective status and level of exploitation. Conjunctive use strategies, however, come at a cost because of the investments needed to access these different sources. The result of these strategies is also that unraveling who is using which source and how much is often mindboggling. Consequently, 'managing' water resources in the Beqaa can only be knowledge-intensive and must start from an understanding of both the local hydrology and existing uses.

This White Paper takes a sub-area of the Beqaa Valley as a representative example of water management in the Valley and uses it to question existing regulation and planning processes in Lebanon, in the hope of informing debates about groundwater governance in the country.

2 Background on Groundwater Governance in Lebanon

2.1 Groundwater Resources and Use

Geological karst formations are dominant in more than two-thirds of Lebanon. Geologic studies identified 15 major aquifers in Lebanon, of which 14 are in karstified carbonate strata (Edgell 1997). These rocky carbonated and calcareous limestone formations favor infiltration and give birth to 250 perennial springs and 17 rivers (ibid.). Surface runoff in Lebanon is mostly dependent on groundwater flows from karst aquifers.

The United Nations Development Program (UNDP) made the first groundwater map and aquifer assessment in 1970. These data are often still referred to without considering the changes that have occurred ever since. This study has fortunately been recently updated (UNDP 2014), though with less resources and details.

Available water resources are assessed in the 2012 National Water Sector Strategy at 2.7 billion m^3 (Bm^3), with 2.2 Bm^3 of surface water and 0.5 Bm^3 of groundwater recharge. Net exploitable surface and groundwater is estimated at around 2 Bm^3 (MEW 2010). Since total groundwater abstraction by wells is estimated at 0.70 Bm^3, it is considered that under normal climatic conditions there is a yearly deficit of 0.2 Bm^3 in groundwater. However UNDP (2014) has come up with much higher values for groundwater natural recharge (3,570 Mm^3 in a dry year and 6,105 Mm^3 in a wet year). This gives a measure of the degree of uncertainty about the resource itself.

Available water resources are expected to decrease slightly with climate change. Overall snow cover and precipitation rates decreased by 12–16% between the 1960s and 2000s, while spring flows showed a 23–29% drop and river flows reached half of their average volumes (Shaban 2009). According to scenarios made by the Second Communication Report on Climate Change for Lebanon (MoE 2011), Lebanon is likely to witness an increase of 1°C in average yearly temperature before 2040, reducing water availability by 6-8%.

The intensive use of groundwater resources in Lebanon is of relatively recent origin, dating back to the late 1950s. The irrigated area rose from 40,000 ha in 1960s to 120,000 ha in recent years (MoA and FAO 1963, 2010). Improved pumping equipment incentivized groundwater use for urban, industrial or agricultural purposes.

In the 1970s, official reports identified around 3,000 wells in the country (CDR 2005a). In the 2000s, documents refer to about 50,000 private boreholes (World Bank 2003, MEW 2010). UNDP (2014) recently put their number at 80,000 (i.e. a density of 8 wells/km^2), of which 59,000 are unregistered and 21,000 registered. With the impressive hike in drilling triggered by the 2014 drought, it is likely that 100,000 is a fair estimate of the current number of wells in Lebanon. These figures are huge when compared to the 842 public wells supplying public water networks (with a total volume given at 270 Mm^3/y in 2009, MEW 2012). This exponential increase in the number of private wells is primarily the consequence of citizens seeking autonomy due the absence of, or deficiencies in, public networks. Informal and illegal practices accelerated during the war and later during the reconstruction period.

Irrigation in Lebanon uses 60-70% of the total annual freshwater diversions in the country (MEW 2010, MoE 2010). There is unfortunately no accurate data about the share of groundwater. It is estimated that about one half of irrigation is supplied from rivers and spring water and the other half from groundwater (World Bank 2003, NWSS 2010).

2.2 Legal and Regulatory Framework

Current groundwater policy reflects elements inherited from customary law, the Ottoman Medjelle and the French Mandate. The Medjelle permits anyone to dig one well or more on private property, but Article 1235 states that ownership of groundwater is forbidden. Groundwater is considered the property of the state since the French Mandate, and several successive laws organized private groundwater use (Riachi 2016). The first legal text imposing limits on private groundwater use is Decree No.320 (issued in 1926). It imposed the need to obtain authorizations for drilling wells exceeding depths of 150 m or withdrawing groundwater in excess of 100 m^3 per day (irrespective of the depth).

Given the increasing proliferation of boreholes coupled with the boom in private irrigation that started in the 1950s and 1960s, a specific legislation on groundwater was issued on May 2, 1970 with Decree 14438 organizing the exploration and use of groundwater. Article 2 of this Decree requires obtaining a permit (that comes with fees) prior to conducting groundwater prospecting or drilling but, like Decree 320/1926, it reaffirms the exemption of a drilling license if the depth of the well is less than 150 meters. The application is replaced by a declaration when the drilling depth is less than 150 meters and a notice of receipt is given to the applicant specifying the number, the date of registration of the application and location of prospection. The decree also introduced use fees to be paid annually for those abstracting more than 100 m^3/d (although no obligation of installing meters is mentioned). These fees have been gradually increased over the years and are set now at USD 333/year (500,000 L.L/year) for the drilling fee, USD 0.066/m^3 (100 L.L/m^3) for irrigation use and USD 0.4/m^3 (600 L.L/m^3) for industrial use.[1]

Law 221 of 2000 kicked in an important institutional reform, with the merging of the existing 21 water authorities into four Regional Water Establishments (RWEs), reportedly to allow economies of scale and better oversight by the Ministry of Energy and Water (MEW). RWEs would be able to recruit qualified staff and their corporatization would allow a soft transition to private participation in their management (Catafago and Jaber 2001). They are mainly concerned with extending domestic water networks in rural areas but are also (formally) in charge of supervising communal irrigation schemes.

In 2010, under the initiative of a new Minister for Electricity and Water, a new Decision (No.118) was issued with the purpose of better enforcing groundwater regulations.[2] The new licensing process of wells involves the new RWEs, the Ministry of Energy and Water and the municipalities. The applications for permits through Decision 118 are centralized at the ministry level. In response to the understaffing problem and lack of technical capacity of the Department of Groundwater and Hydrogeology, the Decision entrusted private firms with the role of assisting in the technical aspects of permit applications. These firms were also assigned the responsibility of conducting field visits and equip wells with meters (for wells requiring a permit). This reform also dramatically changed the administrative procedure to be followed by users and the cost for applying for well permits. Prior to submitting their request with the MEW, users have to submit their application to one of the 3 licensed private companies in order to get their technical endorsement, against a fee of US$ 935.

[1] It must be noted that in 1963, a legal text forbidding any well digging/drilling in the Beqaa for 2 years was issued by the MEW. This limitation was probably put in place following an episode of drought that occurred during this period, as described by Baldy (1960).

[2] Some amendments were made by decrees 547/1990 and 13034/1998, applying new fees of the permits to be coherent with the high inflation that Lebanon has witnessed during the war. Resolution 31/2009 also preceded Order 118/2010 setting up a new process for registration applications and declaration, for wells exploration, cleaning and exploitation (also found in the former).

The 2010 also included a provision according to which owners of unregistered existing wells should declare their wells within one year. The decision, however, was only made effective in 2015 but only 110 persons showed up. Consequently, the registration period was extended by one year and is about to lapse. When going to the Ministry for their declaration, well owners are actually asked to go through the private companies and pay them, so that the depth and discharge of their well should be ascertained. Unsurprisingly, under such circumstances hardly anyone complied.

A new Water Law (or Code) has been drafted in 2005 and has been discussed since that date. The *Code de l'Eau* talks about 'groundwater basin contracts' without giving details or a definition. In all its versions, the code intends to establish a Water Cadastral Registry compiling all water rights and well data. The text does not clearly address the issue of well permit exemptions. It mentions the possible establishment of surface and groundwater protection zones but does not clearly define them.

Despite the key role it plays in Lebanon’s water supply landscape, groundwater has only been granted limited attention. This is apparent, for example, from the 2000-09 '*Plan Décennal*' which emphasizes reaching water security through the construction of around twenty dams on Lebanon's 17 perennial rivers. According to this view, it is only through the storage potential of dams that the current pressure on groundwater can be relieved, while aquifers should be kept as strategic reservoirs (Riachi 2016).

3 Groundwater Use in the Central Beqaa

3.1 Available Water Resources

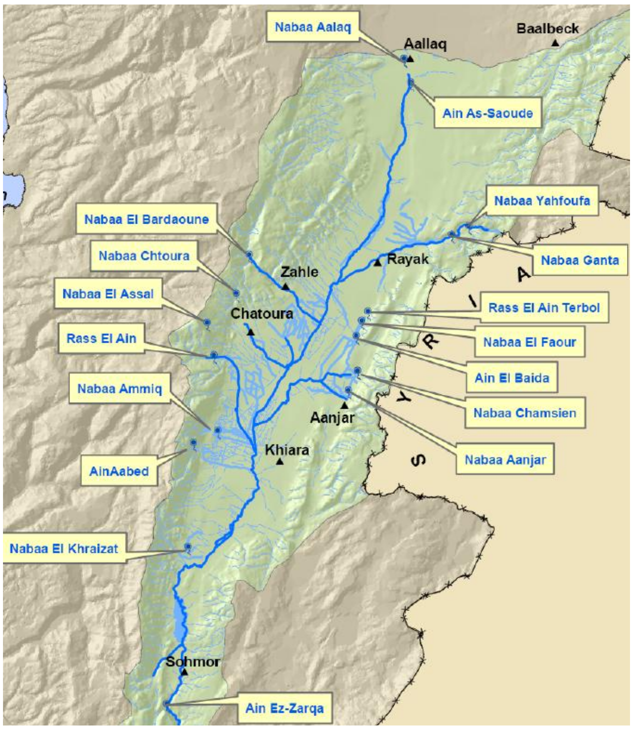
We are focusing here on the Upper Litani River Basin (ULRB), comprised between its upper limit (roughly Baalbeq city) and the Qaraoun Lake.

Annual runoff into the dam is around 300 Mm^3/year, that is 100 Mm^3/year less than what it was in the 1960s (USAID-LRBMS 2011). This decline is due to growing direct abstraction from the river and its tributaries and from the fact that spring discharges (Figure 1). This 100 Mm^3 is also an order of magnitude of the added consumption of water by evapotranspiration in the expanding irrigated agriculture sector.

To simplify, the Beqaa aquifers are comprised of: 1) sediments (Quaternary and Neogene) that are layered and heterogeneous, with poor water bearing capacity and transmissivity (with typical well discharges of 5 LPS); and 2) several layers of Karstic aquifers which outcrop on both sides of the valley (Figure 2). More precisely:

- The Quaternary aquifer is a layer of unconsolidated sediments (fine-grained silts and clays with sand and gravel), that cover the centre of the Beqaa valley and constitute most of the agricultural soils.
- The Neogene (or Upper Miocene) aquifer lies below the Quaternary and consists of older alluvial deposits and conglomerates. This layer also surfaces (outcrops) on both sides of the valley. It is similar to the quaternary.
- The Eocene aquifer comes underneath and is separated from the Neogene and Quaternary aquifers by a low transmissivity layer (later Eocene Marl). The Eocene is karstic limestone and surfaces mainly around Joub Jannine, and in thin stripes (less than 1 km) on the east (north of Anjar) and west (north of Zahle) sides of the valley.

Figure 1. Main springs in the Upper Litani River Basin (LRA, 2007; in MENBO, 2007).



- The Cretaceous aquifer is also made of karstic limestone, but even older. It covers all the eastern flank of the Anti-Lebanon mountain range, and the north-western flank of Mount Lebanon (Mount Sannine).
- The Jurassic aquifer (200 to 145 million years old) surfaces on the western flank of Mount Lebanon, from Chtaura to Lake Qaraoun. It is also karstic.

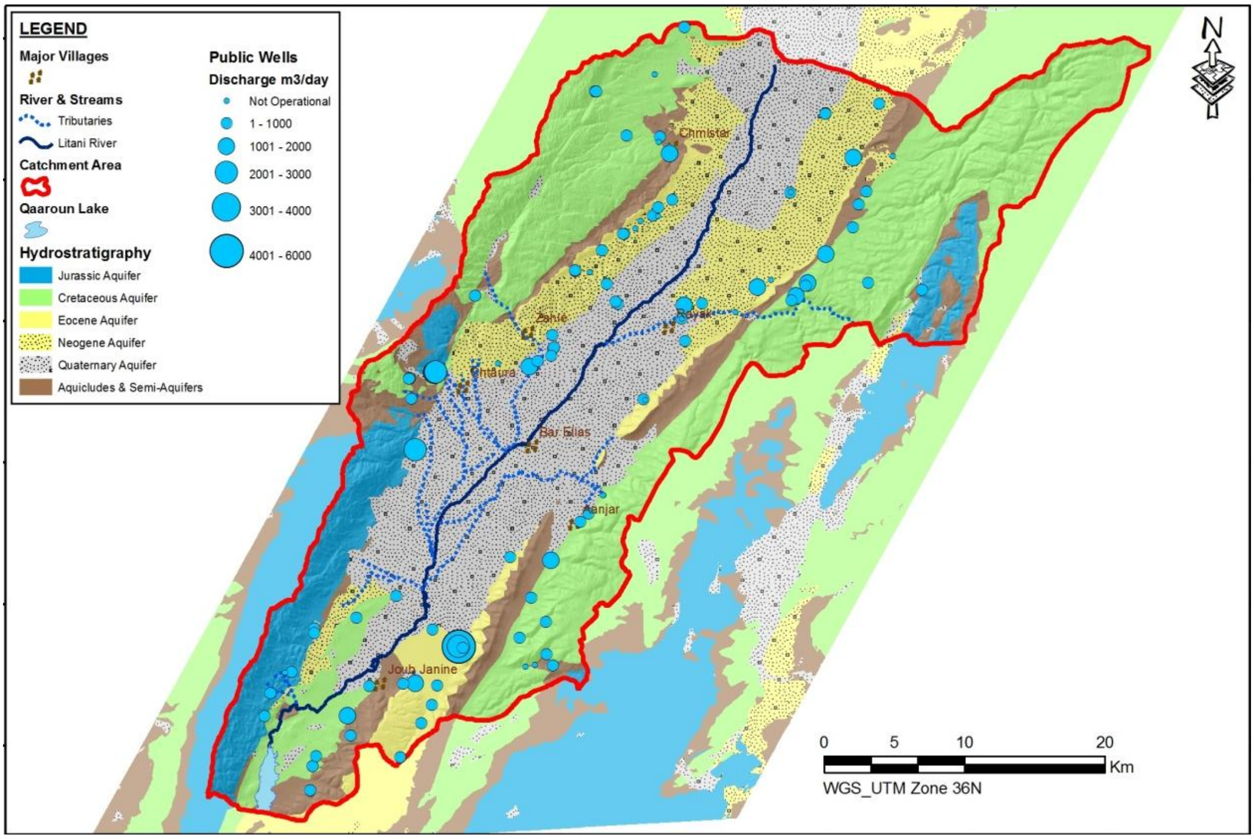
The water balance of the different aquifers in the ULRB is not known accurately. A study by DAI (2005) estimated the average recharge in the basin around 388 Mm^3/y, JICA (2003) at 484 Mm^3/y, UNDP (1970) at 220 Mm^3/y, and USAID-LRBMS (2011) at 210 Mm^3/y. If anything this shows that hydrologic knowledge is still far from adequate to provide adequate guidance to water resource planning.

Declining aquifer levels, however, generate a consensus that groundwater stocks are being depleted. According to UNDP (2014), the South Beqaa Neogene/Quaternary aquifer shows an annual deficit of 45.7 Mm^3. USAID-LRBMS's (2011) water balance of the ULRB points to a yearly overall depletion of groundwater of 70 Mm^3.

USAID-LRBMS (2014) has shown that the drawdown in groundwater levels from 1970 to 2010 ranged from 4.8 m up to 40.3 m, with an average decrease of 14 m over 40 years, at an average rate of 0.35 m/year (Figure 3). This decline in groundwater levels is expected to increase in the coming years as more wells are being drilled and the only available water source in the area is groundwater. Figure 3 shows the example of Anjar and predicted drops in water levels for different scenarios.

Extensive development of wells in the Eocene and Cretaceous aquifers on the eastern side of the valley have resulted in severe drops in water levels, as illustrated by a well in the ICARDA farm where levels have dropped by more than 30 m in the past 10 years. The drop in water level has dried up the nearby Ras el Ain Spring, as well as two other nearby springs (the Faouar and Ain el Baida Springs); and so has the Aallayq Spring, where the Litani River used to originate from (USAID-LRBMS 2011).

Figure 2. Hydrogeological Map of the Upper Litani basin (IRG, 2012, 2013)



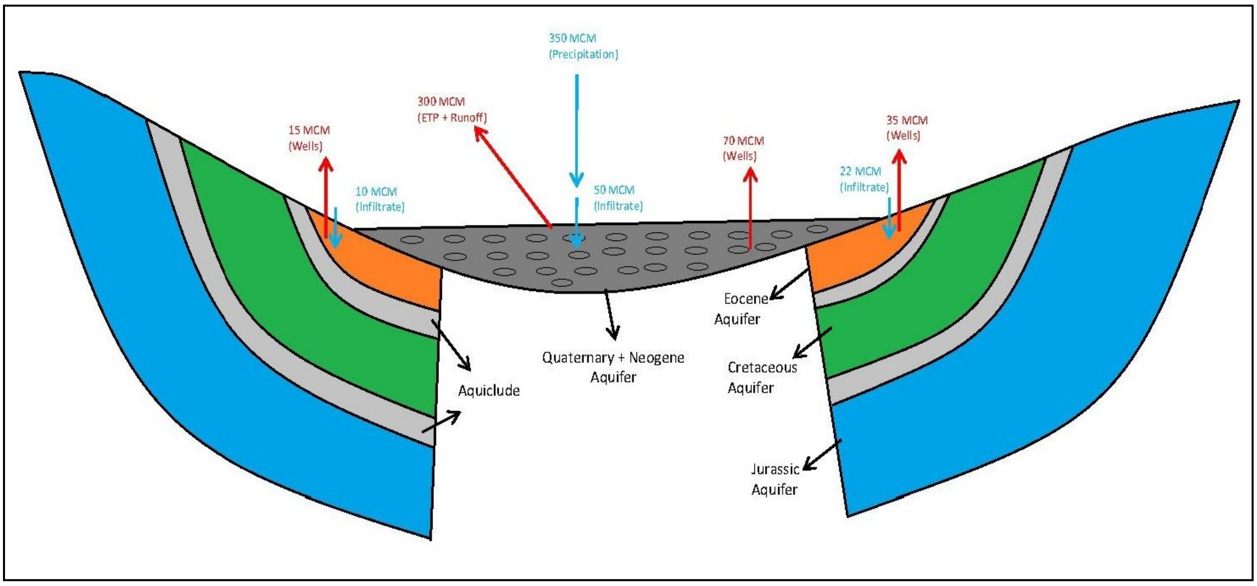
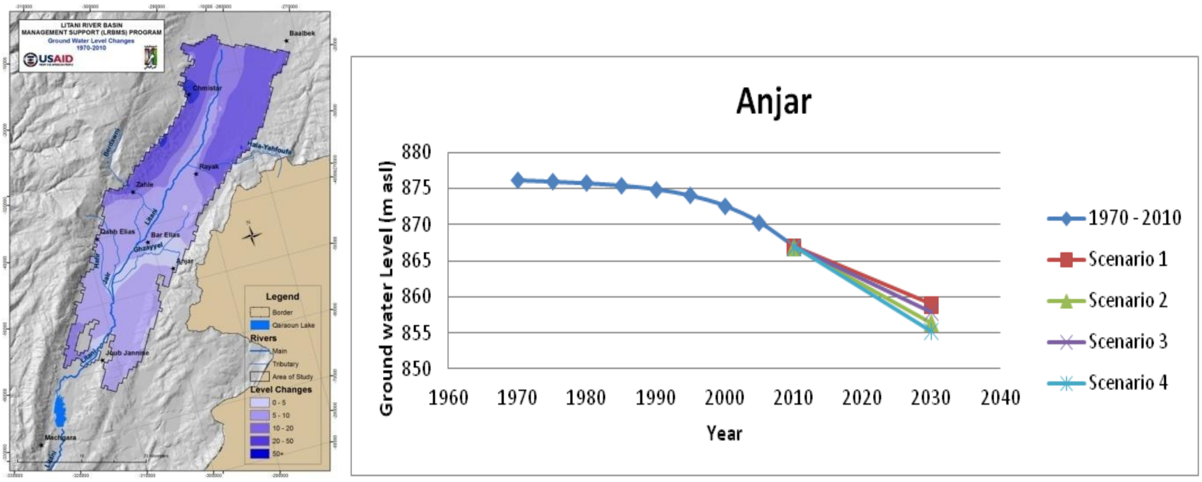


Figure 3. Change in Water Level between 1970 and 2010 (Upper Beqaa and Anjar)(IRG, 2013)



3.2 Agricultural and Domestic Use of Groundwater in the Central Beqaa

Nowadays, groundwater irrigates the largest share of agricultural areas in the Beqaa, estimated at 65% of the total irrigated area in 2007, against 35% for surface water (Verdeil et al. 2007). The number of irrigation wells in the Upper Litani River Basin is unknown and difficult to estimate, as most of them are unregistered. The LRBMSP (Litani River Basin Management Support Program, funded by USAID) estimated that there are between 5,000 and 10,000 wells in the Upper Litani Basin, including approximately 2,000 registered private wells (USAID-LRBMS 2012b). The recent assessment by UNDP (2014) inventoried 2,732 private registered wells in the area managed by the Beqaa Water Establishment (i.e., in the two Mohafazas of Beqaa and Baalbeq-Hermel), and estimated the number of private unregistered wells at 18,228.

In 2010, the Beqaa Valley represented 43% of the national agricultural area and 55% of the total irrigated area (MoA 2012), with 55% of it under sprinkler and 20% under drip irrigation. The use of pumps to capture surface water or groundwater is strongly correlated with the size of farms. According to data from the 2010 agricultural census, 10 % only of the farms of less than 5 hectares were equipped with pumps against 60 % for farms of over 20 hectares, but this might reflect locational or other variables.

A recent study identified 45,700 ha of irrigated agriculture in the ULRB (including around 10,000 ha of wheat), with a corresponding (net) water consumption of 249 Mm^3/y (Jaafar and King-Okumu 2016). Water withdrawals are estimated to be 415 Mm^3/y, considering the efficiencies of the different irrigation systems. This is much higher than withdrawals estimated earlier at 200 Mm^3/y by MoA (1998), 130 Mm^3 of which from groundwater. The total volume of groundwater abstracted yearly for irrigation use is difficult to estimate, USAID-LRBMS (2011) giving an estimate of 150 Mm^3/y (net abstraction), against 115 Mm^3 according to UNDP (2014).

With regard to domestic water, BWE (2015) pumps water from 209 wells at a rate of 33 Mm^3/y (for West Beqaa and Zahle cazas). This estimate does not include the current increase in pumping rates due to the Syrian refugee crisis (Jaafar and King-Okumu 2016).

More wells are projected to be drilled in the upcoming years by the BWE in the vicinity of Chamsine and Anjar Springs and other locations.

3.3 Groundwater Management in the Beqaa

As described by the 'Water Supply and Wastewater Systems Master Plan' recently proposed by the BWE, *"Until the adoption by the Council of Ministers of Resolution 35 dated 17/10/2010 of the NWSS [National Water Sector Strategy], no systematic strategy had existed in Lebanon for the management of water resources and the provision of a potable water supply to the population. Water supply and distribution systems developed historically in an organic fashion around population centers as the needs increased. Local springs were tapped when available and wells were dug when the need increased"* (BEW 2015: P8).

Out of a total number of 196 independent potable water supply systems identified by the same study, *"up to 36 systems are supplied from small, medium or local springs, whereas the other 160 systems are supplied from an estimated 238 wells. Small village systems are typically supplied from a single well whereas larger systems are supplied by group of wells"* (BEW 2015: P6).

Irrigation, similarly, has developed based first on available surface water (springs and rivers, initially by gravity and then through pumps), and later on groundwater. Agricultural wells are dug/drilled according to necessity, without going through declaration or registration processes, and with a degree of uncertainty on their yield. In the Barr Elias Plain, for example, several farmers have tried to drill wells in the quaternary aquifer of the plain, reaching depths of 100 m without obtaining more than 5 LPS, a discharge judged in most cases as insufficient to use the well. In Zahle Maallaqa and Dalhamyeh, just north of the Barr Elias Plain, many wells are found along the Litani River and were reported to yield from 30 to 40 LPS whereas, just further north in Fourzol along the Litani River, water availability decreases again with well yields ranging from 5 to 10 LPS. In contrast, a very limited number of wells was reported in the towns of Marj and Saadnayel, despite several attempts made by farmers to drill wells with sufficient yields.

Drilling is more successful in karstic aquifers, where well yields range between 30 and 50 LPS. It is in these aquifers that the bulk of groundwater withdrawals occur. However withdrawal rates from both irrigation and domestic wells are difficult to assess because they are not monitored. Moreover, some wells were observed to be subject to serious problems of illegal tapping. For example, due to the irregular water supply from public networks in most of the surrounding towns, water-vendors have multiplied around Chamsine and Anjar, filling their trucks with water from some of the unused wells drilled by the CDR (Nassif 2016). Thus, there is no real 'management' of groundwater.

The case of karstic aquifers can be briefly commented upon in order to better understand their advantages and drawbacks (Figure 4).[3] Recharge through infiltration of rainfall and snow (totalling here an hypothetic 100 units) is usually rather high, with orders of magnitude which, for the case of Lebanon, are around 25, with another 25 for surface runoff and 50 going to evapotranspiration. In undisturbed conditions, the average aquifer discharge, mainly through springs or baseflow, will correspond to the recharge (25). Actual discharge varies with the year and the month but in the long run reflects average recharge. When the aquifer reservoir is tapped through wells, part of the stock is abstracted, resulting in a drop in the water level and therefore in a reduction of the outflow through the springs(s). In the (arbitrary) case illustrated below, a total of 20 is abstracted by wells and the spring discharge is reduced to 15:[4] on balance 35 units are abstracted from the system, more than in natural conditions, which means that the reservoir has been depleted by 10 units. If this is repeated in the following years, the level will go down and the spring will dry but exploitation of the stock underneath is still possible. Estimating

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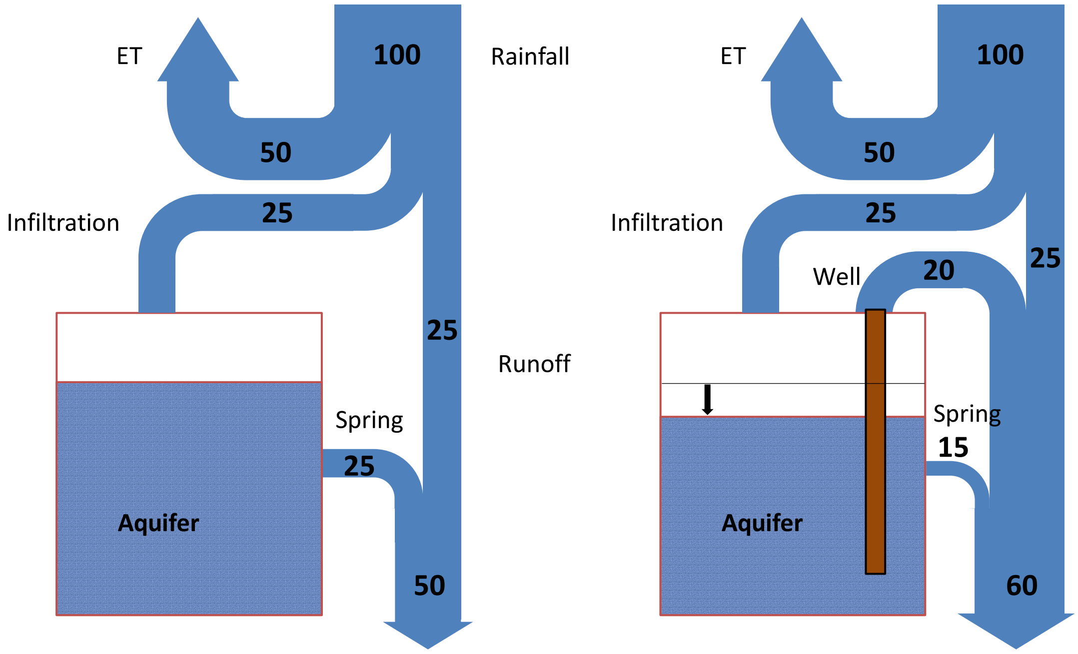
[3] The process for a quaternary aquifer is not radically different (but discharge is less easy to localize).

[4] Chamsine spring was producing an average of 15 Mm^3 annually in 1970, a number that has no dropped to 6 Mm3.

the remaining stock is difficult but the end result is certain, even if a possible exceptional year may replenish the aquifer and help buy some time. In all cases the risk for users increases: in the case of a dry spell of a few years the water level in the aquifer will drop dramatically and many wells will find themselves dry[5], forcing those who can afford it to invest in deepening their well, until exhaustion of the resource[6].

In other words it is important to understand that wells do not increase the resource *naturally available*. They increase actual supply by gradually depleting the stock, while *increasing vulnerability* in case of a dry spell. Another fundamental but not well understood point is the *reallocation of water* that comes with wells. Water is shifted from those who were using stream water downstream of the spring to those who tap it upstream, before it flows, through their wells.

Figure 4. Management of karstic aquifers



4 Assessing Governance Options in the Face of Current Dynamics

This section examines a few specific salient aspects of groundwater management in Lebanon. For each point a quick summary of the current situation is first given in italics and then followed by some comments and a discussion based on both the practical knowledge gained in the Beqaa case study (Nassif 2016), and (whenever relevant) on the lessons drawn from the analysis of groundwater governance at the world level (Molle and Closas 2017). More explicit proposals are then made in section 4.2.

[5] 80 wells dried up during the last dry spell in Qaa, fostering deepening.

[6] As can be seen in the case of the Ras –El-Ain and Faour Springs in Terbol and Faour.

4.1 Examining Current Practices against International Experience

4.1.1 Institutional setting

The institutional setting, regarding the management of groundwater resources, is fragmented. In the ULRB area, the LRA (Litani River Authority) is responsible for the planning, implementation and management of public irrigation schemes, and for the monitoring of water quality and (recently) groundwater levels[7]. The BWE is in charge of water supply and sanitation. The CDR (Council for Development and Reconstruction), is in charge of planning infrastructure development, mobilizing funds for major developments projects and supervising project execution. It used to implement wells for water supply. Municipalities have historical responsibilities in water and wastewater management, but Law 221 of 2000 has imposed the centralization of water management at the level of the RWEs, and the distribution of these responsibilities between municipal and state institutions is subject to disagreements and remains unclear. Last, the MEW has responsibilities in planning, infrastructure development (directly or through autonomous water bodies), and water resource protection at the national level. It is responsible for studying water supply and demand in the country, developing hydraulic and power-generation projects, overseeing the work of autonomous authorities operating water and energy projects (the RWEs and the LRA). With regard to groundwater management, it directly issues permits for drilling wells and using groundwater, and also collects user fees.

The World Bank (2010) emphasized (a) "a growing disconnect between legal and de facto sector responsibilities; (b) Lack of integration of policy-making with investment planning functions, accompanied by limited inter-agency coordination; (c) Inadequacy of regulatory instruments to exercise effective central oversight over the water sector; and (d) Limited management and financial autonomy devoted effectively to Regional Water Authorities". USAID-LRBMS (2012) considers that "currently in Lebanon, coordination between central agencies (horizontal coordination) and between central and regional/local entities (vertical coordination) is token at best, if not absent". Comair (2007) also underlines the "fragmentation and lack of cooperation or coordination of agencies in charge of water resource management: MOEW, LRA, RWE, CDR, MOA, MOE and local water committees".

Organizations in charge of delivering a water service (water supply, sanitation, irrigation, etc.) should in principle be evaluated and regulated by an independent regulator, but this is not a normal practice in Lebanon[8]. Indeed the MWE is responsible for water resource management (including planning, allocation of water rights, definition of water charges, etc.), but also for water services. No country in the MENA region can boast an independent regulator and when one body is entrusted –on paper– with that function, it is in general placed within a strong conventional Ministry (Agriculture; Mines and Energy; Public Works, etc. depending on the country), or a weak Ministry of Environment, and has limited power. In the current administrative configuration of Lebanon it is probably illusory, in the short term, to envision a

[7] Groundwater Monitoring is not officially part of the LRA mandate. Groundwater Monitoring started following the implementation of monitoring wells by the LRBMSP

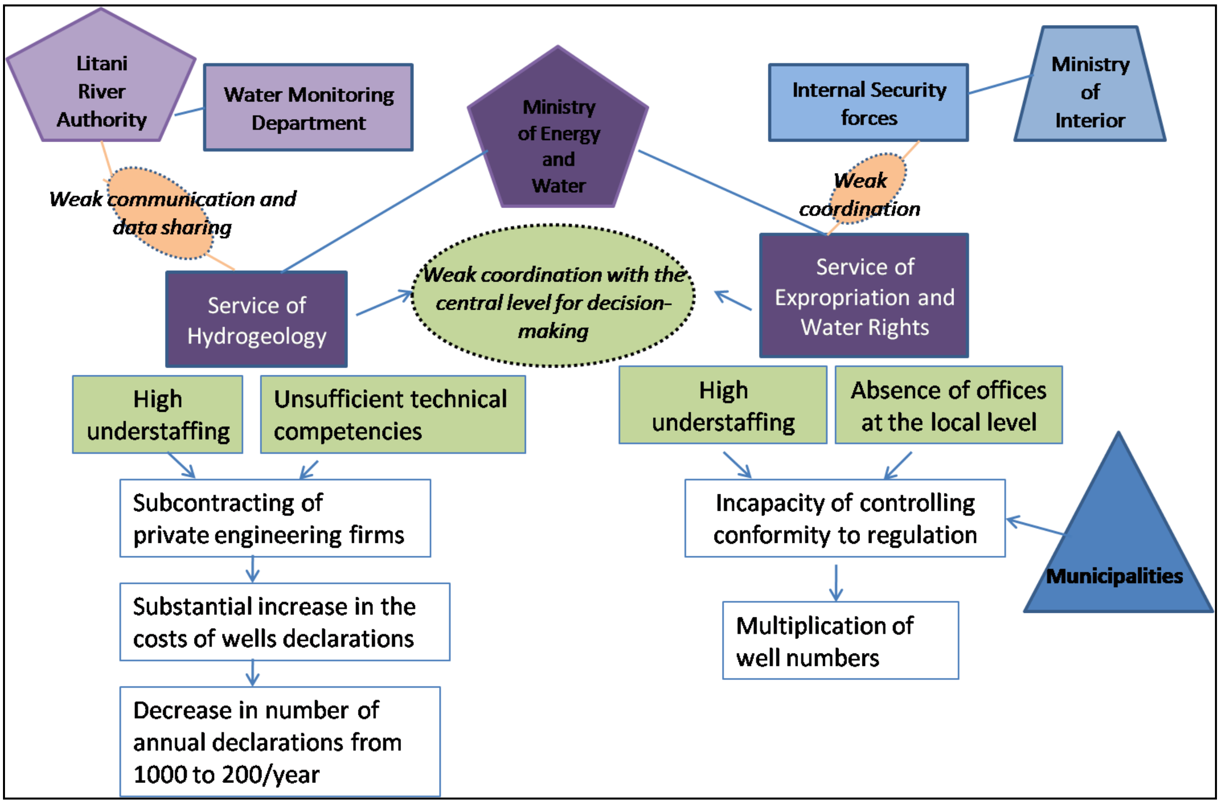
[8] "This kind of independent body which has to assess the activities of a Public institution is not very common in the Lebanon. We have independent bodies conducting financial audits that control the finances of companies and private firms, but, for regulation in general, it is the Administration that handles it, or an organization that derives its power from the Administration and depends on it" (Catafago and Jaber 2001).

redistribution of decision-making power that would empower a strong and independent regulator.

Water policy also requires coordination across ministries and other relevant administrative bodies because water affects all sectors and its finite nature requires a planning process that makes demand compatible with the resource, in terms of quantity, quality, risk and costs. This translates into the common recommendation to set up a national interministerial water council (NWC) at the highest political level (UNDP 2013). This is proposed by the draft Water Code of 2005[9]. In practice, establishing such a Council might not necessarily result in better coordination because possible power imbalances between ministries might remain. It is therefore a possibly useful but not sufficient mechanism. It must also be noted that sound policy, but also the identification of possible policy contradictions, can only arise if there is a sound and shared hydrologic knowledge, so that projects may be assessed against the reality of the water resource.

Overall, it is apparent that at the moment bureaucratic power is too fragmented, responsibilities are unclear and/or overlap, with severe implications on the groundwater licensing process and information flows (UNDP 2014).

Figure 5. Institutions and their weaknesses (Nassif 2016)



4.1.2 Licensing criteria

It is mandatory to go through a licensing process to obtain a drilling permit for wells exceeding depths of 150 m. A withdrawal permit is also required for any well with a use exceeding 100 m^3/day (= with a capacity over 1.16 l/s).

[9] "In 1972, a decree created the Higher Council for Water, but this council has never operated" (IRG, 2010).

It is a sound disposition to define limits above which wells need to be licensed. Limits are frequently defined based on the well depth or abstraction volumes (per day or per year), but there are cases where exemptions depend on the projected use (e.g. watering cattle), the area irrigated (e.g. less than 2.5 ha in Saudi Arabia), the horse power of the pumping equipment (e.g. under 5 horse power in Portugal), whether the well is dug or drilled (Turkey), or the diameter of the tubewell.

The above rules[10] date back to 1926, during the French Mandate, and have been reinstated in 1970 and then in 2010, but are unanimously considered to be obsolete[11]. Yet, for some unclear reasons, they have resisted redefinition. Our case study suggests that: 1) the rule should depend on the type of aquifer, and possibly on the type of use, and that 2) the depth/volume limit should be revised according to policy priorities (see below).

Three main situations can be distinguished: coastal aquifers, the inland quaternary aquifers (principally that of the Beqaa), and karstic aquifers. Regarding the Quaternary aquifer of the Beqaa, the low transmissivity limits the discharge of the wells to around 5 LPS (with some localized exceptions). There is a degree of self-regulation in the sense that wells too close to each other tend to have impact on neighbours and drilling deep is costly, with limited reward in terms of added available water. Regulation is also less needed because there are no major public domestic wells using this aquifer. It could be decided that wells in the Quaternary aquifer do not need licenses, or to fix a limit in terms of depth (50 or 100 m, for example) or diameter.

With regard to karstic aquifers, because yields are always much higher and are not often correlated with the well depth, and because of the central importance of those aquifers for domestic supply and for those who already tap associated springs, all wells would need to be registered, or a limit could be fixed in terms of well diameter, for example. This has to be further discussed based on sound hydrogeological knowledge. As will be discussed in section 4.2 the criteria must be designed based on the proportion of groundwater users who would be concerned (high enough to capture the bulk of groundwater abstraction but low enough to minimize administrative burden) and financial concerns.

4.1.3 Licensing process

Decree 118 of 2010 establishes that licensing processes should be handled by private engineering firms (3 have been selected) directly paid by users for providing the technical reports needed and ensuring the post-drilling verifications.

According to senior officials in the MEW, the recently modified administrative procedure led to a dramatic decrease in the numbers of people registering their wells with the ministry. The main reasons are a longer and complicated administrative procedure, the substantially higher fee that users have to pay to the private companies, and the subsequent requirement, for licensed wells, to pay a user fee to the ministry. As a result, the number of applications has fallen from 2,000 to 500 applications/year, precisely in a period (2014) where observations from the field suggested that the drought triggered massive well drilling.

[10] The law also includes rules regarding distances between wells or drilling near springs or public well fields, but they are not enforced (Comair 2007).

[11] According to one ministerial official these rules were those applied in the region around Paris in the 1920s and were 'imported' wholesale…

It must be noted that the full registration fee accrues to the private companies, with no financial contribution to the MEW, even though the Ministry still assesses and reviews the applications. The cost of this procedure is a clear disincentive to users to register their well (and/or apply for a permit), since in the past users only had to pay around US$200 for registering a well. This system is therefore counterproductive when one thinks that it is crucial for the ministry 1) to gain knowledge about well abstraction in the country, 2) to earn some revenue from the user-pays fees.

The question is also raised as to whether the central services of the MEW have the capacity to handle the registration process. The problem is that, being far from the fields, the MEW central administration is also not in a position to fully control independent initiatives by NGOs, CDR or even the BWE, the latter being reported to sometimes still drill wells without formal authorization from its own Ministry. The ministry also does not have the technical capacity to assess the microlevel conditions which govern whether a particular projected abstraction is sound or not. This difficulty was expected to be bypassed by resorting to private companies but this system also has its drawbacks. The rationale behind such a choice was mainly financial: that the cost of licensing should be shouldered by water users (through their hiring of private companies) rather than by a Ministry whose staff has been dramatically reduced rather than increased in line with what would be needed to sustain an in-home knowledge of the country's water status and to keep control of demand.

4.1.4 Handling of illegal well drilling or use

If the MEW finds an illegal well, it should send a letter to the police of the Province so that the owner be summoned to register, failing what the well would be closed, and also to the Office of the Cadastre so that the land plot is marked as not conforming to regulation.

Many wells, three out of four in order of magnitude (UNDP 2014), are dug without registration or permits. It is an open secret that the police and municipalities routinely turn a blind eye to these illegal practices, whether these involves bribing or not (Farajalla et al. 2015; Nassif 2016). Officials from the MEW do not have the right to enter a private property to control wells without permission from the Ministry of Interior and being accompanied by police officers. Reportedly, such control visits are only carried out when the administration has solid information about an unlicensed well that is intensively used for industry, producing bottle water, or filling up tankers; or when a complaint is filed by a neighbor who is severely impacted by the new well.

When asked whether they could help controlling illegal drilling, municipalities point out that they do not have the right to control, that it is the duty of the Ministry, and that they are socially too close to people to be in a position to control them.

One must also remember that the drilling of wells by militias, political parties and their factions has long been a mean of creating new allegiances, or consolidating old ones (Ghiotti and Riachi 2013). "From drilling wells and supplying cisterns to constructing large dams, war and post-war actors have used and are still using water as a socio-communitarian service to reinforce their political and social legitimacy" (Riachi 2013).

Given the prevailing political conditions in Lebanon, and for lack of a dedicated water police, acting through the armed forces has clear limits. And it is therefore unlikely that illegality can be tackled, except in case of blatant violation or heavy third-party impact.

Another way to control illegal drilling is to license drillers and seize equipment being used without permission. This provision should be incorporated into the next legal text to be enacted.

4.1.5 Water rights

Domestic water supply has been given priority over all other uses. As a result it is considered that any water source can be tapped to increase water supply even if it generates third-party impacts on people who are already using the same source (BEW 2015).

The most convenient sources of water to be tapped for water supply are karstic aquifers, especially in the vicinity of existing major springs (which testify to the presence of abundant water). However these main water springs are most of the time also used for irrigation of nearby lands. New diversions are tantamount to expropriation, whether this is legal or not, compensated for or not. Wherever this process has been gradual, like in the case of irrigation schemes around Zahle which divert water from the Berdaouni river that is also tapped for domestic supply, farmers will usually adjust by tapping groundwater (at their own cost). A more substantial and brutal new abstraction, however, with clear impacts on existing irrigated agriculture, is likely to be met with social protests, irrespective of what the law says about ownership.

4.1.6 Safeguard or prohibition zones

At the moment, there is no particular disposition to restrict or ban the drilling of wells in areas declared as under threat or overexploited.

It is a standard policy tools adopted by most countries, and included without further details in the draft Water Code. Although such a tool provides the possibility to intervene into a specific problem area, it of course does not make sense if it is not paralleled by a capacity to control illegal drilling. In the current situation of Lebanon, this is the step that must be achieved first and the absence of prohibition zones is therefore so far not decisive. Any new water law, however, should include it as a principle.

4.1.7 Planning process

RWEs have the mandate to draw regional master plans under the supervision of the MEW.

In practice these master plans are largely focused on extending and creating new local public networks for domestic water supply. Until very recently many water resource development plans were based on outdated data, such as the 1970 UNDP groundwater survey, or very crude information related to spring flows and water tables. Moreover, these plans poorly take into consideration current uses, especially irrigation as mentioned before, the recently published 'Water Supply and Wastewater Systems Master Plan' by the BWE (2015), for example, was found to plan the reallocation of water from specific spring systems without properly taking into account the current problems of both surface water and groundwater over-allocation and overexploitation in their vicinity.

New diversions are planned, for example, from the Hala Yahfoufa catchment, which is already over-allocated, or from the Chamsine Spring, that is already insufficient for the planned service area. With regard to the Anjar Spring, it was shown that the projected water discharge to be reallocated for domestic supply would lead to a situation of over-allocation, where domestic supply would compete with existing irrigation needs (Nassif 2016). Aside from the problems that the BWE would face in terms of cancelling water rights, the only alternative for farmers currently using the Anjar Spring would be to rely –through wells– on the same and already overexploited water of the Cretaceous aquifer, compounding its overall status.

As part of the on-going project implemented by the CDR (and included in the BWE Master Plan), the supply of domestic water in the Caza of Zahle and West Beqaa is expected to be provided by the Chamsine Spring together with existing wells drilled in its vicinity. Additionally, more wells are projected to be drilled in the upcoming years, along with three storage tanks located in Anjar and Terbol, to serve domestic water networks. This would increase the total amount of towns supplied by the Chamsine Spring and wells to 24 towns, representing a total water demand of 625 LPS by year 2030 (BEW 2015: p.75). This does not seem to be consistent with the fact that discharge in summer months frequently varies between 200 and 400 LPS only.

This clearly shows that the BWE Master Plan must be revised, better taking into account these actual and future situations of surface and groundwater overexploitation. But this also sorely exposes the lack of up-to-date adequate hydrologic information. The new irrigation master plan in the Beqaa needs to incorporate these dynamics and acknowledge the interactions between resource, uses, and users highlighted by this project (Nassif 2016).

Last, it must be also underlined that management (controlling illegal tapping, providing good operation and maintenance for new projects) and institutional problems (understaffing and limited technical capabilities of the BWE) are poorly addressed in the planning process. Although stated as recommendations in the Master Plan, solutions to these problems are lacking and this will likely affect implementation.

4.1.8 Monitoring and technical capacity

In the ULRB, prior to 2011, there was no groundwater monitoring network in the basin. Knowledge on the evolution of spring discharge, river baseflows, wells yields or aquifer levels is extremely patchy, with associated water balances that are at best cursory.

According to UNDP (2014), out of the 842 public water supply wells, only 20 wells are equipped with continuous groundwater monitoring devices. It is not known how many are fitted with working meters. The MEW has only recently established a few groundwater monitoring wells through the last UNDP Project, of which only four are in the Beqaa (and none in our study area). Not knowing the resource in sufficient detail is a critical impediment to a rational planning that aims at balancing demand and withdrawals with existing resources.

As recommended by UNDP, groundwater monitoring at the national level should be substantially developed for a better management of the resource. All studies actually emphasize the importance of better knowing the resource as pressure on these resources increases. As yet no allocation of public fund at the level of this challenge has been announced, suggesting that political awareness and will are still inadequate.

4.1.9 Information flows

Information flows between concerned administrations are needed but the current lack of such exchange is a sign of ineffective coordination between them.

In the ULRB, measurements of surface water flows and groundwater levels are the task of the LRA and not of the MEW. Data is archived and stored at the LRA, and is transmitted to this Ministry's departments only upon request. Improving data sharing between LRA and the Department of Groundwater and Hydrogeology, but also the BWE, is much needed.

Permit applications (including the recent technical reports) were reported to be reviewed based on the old hydrogeologic maps produced by the 1970 UNDP study. The recent National Groundwater Assessment conducted in cooperation with UNDP (2014) provided updated maps and groundwater data, but oddly enough reports were only very recently transmitted to the Department of Groundwater and Hydrogeology (around 2 years after the end of the UNDP Project). This means that from 1970 to 2016 permits were largely issued based on outdated technical data. Furthermore, it is apparent that the complete data base is still not available to this department. Another example of limited data dissemination is the 2012 Agricultural Census conducted under the supervision of FAO, which are only available at aggregated levels. Accessing official reports even within the Ministry that has commissioned them is reportedly an uphill battle (Farajalla et al. 2015). This sometimes even extends to PhD theses and other kinds of documents. According to USAID-LRBMS (2012), "Information remains a source of power for government officials and is hidden, toyed with, or ignored as suitable; decisions are taken at central level in an opaque manner".

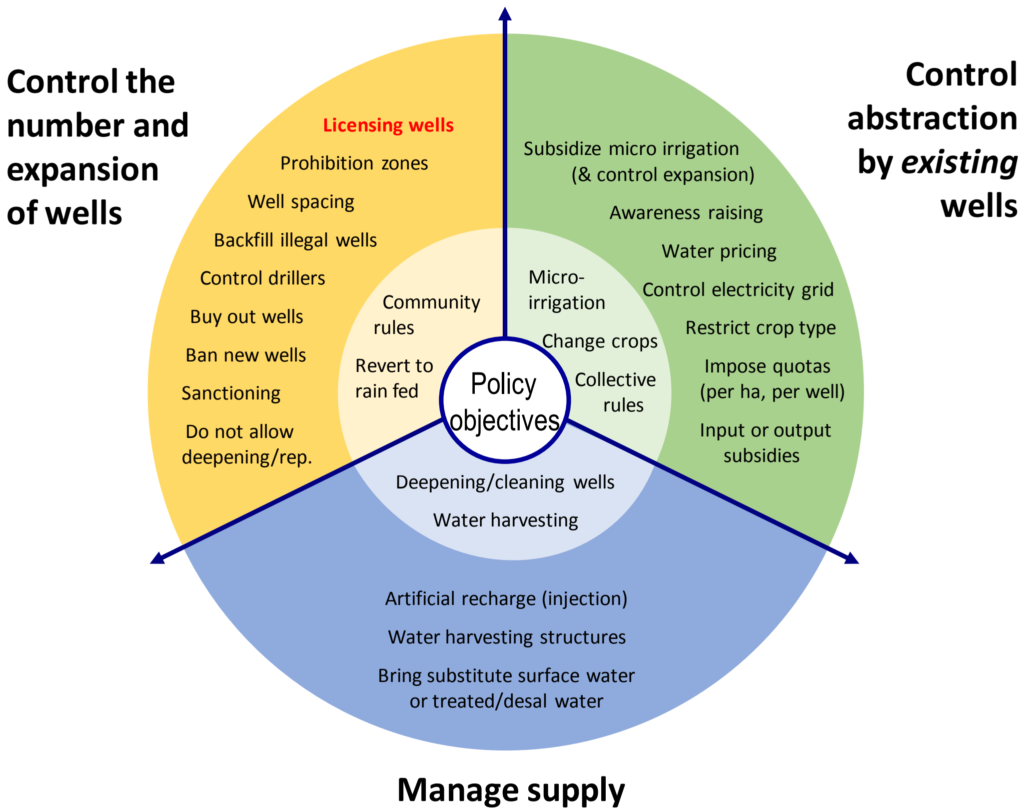
4.2 Policy Opportunities and Constraints

Groundwater governance is one of the most vexing problems of water management in general. In contrast with surface water, where the state is generally in control of the main controlling distribution points, groundwater use is diffuse, partly invisible, and largely driven by individual investments of users who tend to see this resource as theirs after they have invested to access it.

The problem posed by groundwater varies according to the relative contribution of groundwater in water use, the degree of overexploitation, the local climate and hydrology, and the type of aquifer, to name just a few important contextual elements. Although there are many commonalities across groundwater policies and laws, policy tools will differ according to the situation. The extremely critical status of groundwater in Jordan, for example, warrants the implementation of measures that are inappropriate for a country like Lebanon, which has different types of aquifer and more abundant water resources in general.

Leaving aside the question of water quality and contamination of groundwater resources (although relevant to Lebanon, it is not addressed in this report), the three main groundwater policy objectives are summarized in Figure 6. The first objective refers to managing supply, that is, increasing the availability of groundwater: this can be done, for example, by increasing natural recharge through water harvesting, practicing artificial recharge, or substituting surface water for groundwater. The second objective is to control the number and the expansion of wells. The third objective is the control of/reduction in abstraction by existing wells. Managing supply is capital-intensive but is often the politically preferred solution because it is perceived as not affecting existing uses. The latter two objectives come under demand management policies. It is crucial to understand that controlling existing abstraction is a much thornier issue than controlling the number and the expansion of wells (which is itself a very difficult issue). Controlling/reducing actual abstraction is extremely data intensive, very costly, comes with substantial social and political costs, and in practice very hard to implement with limited results. It requires in particular information on the volumes abstracted by users through metering or other proxies. In a country with close to 100,000 wells and a negligible number of water meters this is considered here as a far-fetched objective. We therefore limit ourselves to discussing the second objective, which focuses on controlling the number and the expansion of wells, that is, allowing for expansion only where available resources allow it, and freezing/reducing the number of wells where groundwater is overexploited.

Figure 6. Main groundwater policy objectives and tools



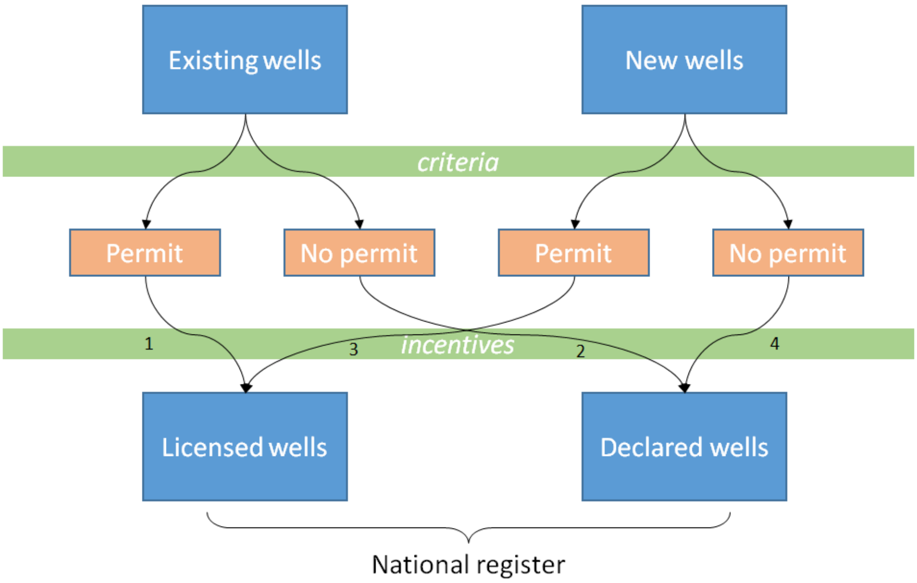
As emphasized earlier, a more rational management of groundwater resources includes developing a better knowledge of *both* supply and demand. The need for more sophisticated hydrologic knowledge has already been underlined and is not further discussed here. Knowing and controlling actual demand or use, boils down to *first* identifying abstraction points. This is why we focus here our discussion on the registration process already commented upon earlier, without which no direct policy measure can be implemented. (We will discuss indirect policies at the end of this section).

4.2.1 Registering wells and monitoring their use

Most if not all countries which find themselves, at a given point in time, forced to strengthen their process of registration of groundwater abstraction points have to contend with a large number of existing wells which have not been registered (either because this was not required, or because nobody bothered). In practice international experience shows that it is extremely difficult and takes considerable time and public funds to go back to a situation where not all but at least a large majority (say over 80%) of the wells are inventoried. Lebanon's situation is, in numerical terms, similar to that of Morocco, where the number of wells (probably understated) is roughly put at around 100,000 (Kuper et al., 2016). Between 1997 and 2015, Morocco has established several deadlines by which farmers were requested to register their wells, with hardly any success until registration came to be a prerequisite for accessing 100% subsidies for drip irrigation... Even though, a minority of wells have been registered. Another example is that of Spain, which also struggled during 30 years to raise its rate of registered wells, despite using all types of 'carrots and sticks' (see Closas et al. 2017). Yet another relevant example is that of Jordan, where the number of (working) wells is however much more limited –around 3,200– (because of stricter control and much higher drilling depths and costs), which is employing unprecedented pressure to root out illegal wells (see Al-Naber and Molle, 2017) and prevent their proliferation.

For both existing wells and those to be drilled in the future, the questions of 1) which wells need a permit, and 2) which wells are to be taxed for their use have to be addressed. This requires a pragmatic approach whereby the criteria chosen (Figure 7) allows to capture the bulk of groundwater abstraction, while minimizing the number of wells which have to be licensed. An additional issue is whether all wells need to be *declared*, even if they do not need permits. This is currently the case in Lebanon. But the most important issue to tackle is that of incentives: the system has to be designed in such a way that: 1) users with *existing* wells not registered will be encouraged to register; 2) land owners drilling a new well will go through the established procedure and request permits if their intended well meets the defined criteria (Figure 7).

Figure 7. Main pathways of the registration process



Well regularization: Encouraging owners of existing wells to declare and register their wells is the most difficult part. Some people may have inherited a well from their father and have long considered it as family property; they will not see any good reason to go through a bureaucratic process to register their well, especially if it falls under the criteria of wells requiring an abstraction permit. Farmers generally are fearful of taxation or future volumetric monitoring/pricing and if in addition this process is burdensome and/or costly there should be no expectation that wells will be registered.[12] In all cases, experience shows that wells will not be registered in the absence of 'carrots', possibly associated with 'sticks'. Looking at the international experience, carrots may include a possibility to connect to the electricity grid (high voltage, e.g. Tunisia), accessing subsidies (EU, Morocco), discounted prices (of electricity), or

[12] Note that if only a small portion of the 60,000+ non-registered existing wells is registered then there is also limited interest in having new wells going through the process. The two processes are linked and if one is not successfully achieved then there is little interest in striving to achieve the other one.

credit. Sticks may include a perceptible threat that the well could be backfilled or administrative sanctions.

In the case of Lebanon it is not easy to identify incentives for the registration of existing wells to happen. One possibility would be not to allow a land transaction if it contains an unregistered well (although sellers/buyers might chose not to mention the existence of a well). Another possibility could be the granting of a collective bonus. For example mayors could be required, under supervision of the MEW, to establish an inventory of existing wells in exchange of what the village would see its water[13] or electricity bill reduced (or the debt frequently inherited from war times cancelled). More classically, an inventory could be made by companies hired by the Ministry. The cost of such an inventory has been estimated by UNDP (2014) at around US$3 million.[14] This is actually much cheaper than providing positive incentives/subsidies and attempting to attract/coerce well owners into regularizing their wells; it should be the preferred option, even if the inventory will never be exhaustive.[15]

So far the ministry has only used 'sticks', whereby the few well owners willing to declare their wells have been actually asked to go through the private companies (and pay them). It is also not attractive for the owners of wells over the depth and/or volume thresholds[16] to come forth: they will have to pay for water and to go to the Ministry of Finance to settle their bills annually. Since the volumetric threshold, in particular, is very low, virtually all agricultural wells would in theory need to pay for using groundwater.

A few undeclared industrial or big users have been summoned by the police (mandated by the MEW) to register. This is of course very difficult to implement because the motivation of local authorities and police has to be secured. So far, according to MEW officials only 110 wells have been regularized, the MEW focusing on industrial wells. A safe conclusion is that in practice it will be impossible, under present conditions, to do more than regularizing (licensing) major domestic/industrial wells.

It must be added that the Ministry has been selective in its targeting of illegal users. For example some owners of deep wells used who abstract groundwater and distribute it through tankers to particulars have been identified but the Ministry ended up not taking action. Selective application of the law clearly invites its violation.

New wells to be drilled: With regard to wells to be drilled, the registration process (licensing or declaration) should be made the easiest possible. The process can be improved if scientific knowledge and updated information on existing wells are available to the administration and translated into a zoning of groundwater resources based on actual well density and level of exploitation. The Ministry should probably have deconcentrated offices in the field which would facilitate the processing of applications. The current solution, whereby the technical work is done by private operators reflects a general policy to downsize ministries and divest administration costs onto the users. If this may work for specific public procedures it is clearly inappropriate for well licensing, where users have no identified interest in the procedure and can just ignore it.

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[13] This would need fee recovery to be improved first. In the Beqaa it is currently at around 25%.

[14] One Ministry official asserted that internal security forces has a precise knowledge of illegal wells, and another that they could be in charge of the inventory. To introduce check and balances this could be done through the associations of several ministries.

[15] Some wells are within private precincts or not easily accessible. Some owners may find ways not to be registered.

[16] In practice it is the well capacity criteria which is decisive, since it is unlikely that a well with a depth over 150 m would have a discharge below 1.16 l/s.

Well information: How can the information on new wells being planned or drilled reach the Ministry and feed a public register? Information can be channeled in three different ways: by the well owner, by the administration, or by well drillers. In the first case, the well owner has to have an incentive for approaching the administration and we are in the situation discussed above [this must be cheap and burdensome, preferably to local offices of the MEW, if possible with some benefits attached (rather than having to pay US$935) and/or credible sanctions for not doing it]. In the second case, local administrations that are likely to know about the projected (or already drilled) well should have an obligation to report to the local office of the MEW. One could imagine that mayors could be entrusted with this responsibility, if possible also in exchange of some benefit and/or with the loss of some benefit if not complying. In the third case, drillers should first be officially registered and certified and would have the obligation to report all operations, failing what their equipment could be frozen (at their cost) or their accreditation withdrawn. These three solutions can be combined but in all cases it is important to have local offices with enough staff and means to expedite a process that should be as smooth as possible.

Two thorny issues remain. The first one has to do with whether and how much licensed groundwater users should pay (Figure 8). At present, people declaring their well have to pay US$935 to the private company to process their application, regardless of whether they will have to license their well or not. They will have to pay a lump fee if their well is deeper than 150 m (drilling license) *and* a volumetric fee for the water abstracted if the capacity exceeds 100 m^3/day (use license) (the volume used is determined by yearly field visits from the Ministry's staff). This is of course a clear disincentive to licensing, except maybe for big and/or bulk users like municipalities or industries. Since all wells with a capacity above 100 m^3/day, or 1.16 l/s, are subject to volumetric fees, virtually all agricultural tube wells fall in this category. This suggests that the limit is too low. Low threshold and high fees maximize revenue to the state but impact the rate of voluntary registration. There is therefore a trade-off to be managed.

The second issue concerns how much volumetric information on groundwater use is conveyed through the licensing process. Licensed wells are associated with actual volumetric information[17] (according to Ministry officials this concerns only 300 wells), while wells that are only registered are characterized by the (maximum) capacity of the well at a given point in time, unless this capacity is higher than 100 m^3/day. In this case, consumption is also to be measured and taxed. Licensing more wells (by having such a low abstraction limit) provides more volumetric information but comes with a higher administrative burden and, more importantly, a high reluctance from well owners to regularize. With such a low limit, well owners (expectedly) rarely ask for a use permit, which defeats the system. A type of Pareto principle, whereby only the 20% of the wells that correspond to 80% of the use would have to be licensed could be followed. This requires statistic information on the number of wells, depth, capacity, type and use and aquifers.

For practical and strategic reasons there is therefore a need to rationalize the depth and use thresholds. This is summarized in Table 1.

An alternative to metering is the indirect control of groundwater-irrigated areas through satellite and monitoring systems (e.g. Jordan). This system comes with minimal intrusion although results need to be calibrated and validated on the ground. This measure however also requires training and available staff at the ministry to process and analyze the images, and agents on the field to enforce the law. It is adapted to dry countries such as Jordan or Gulf countries where irrigated vegetation contrasts with the environment, but not to Lebanon where such a contrast is much less salient.

[17] This assumes that meters are working, that the information is collected, and that it is not distorted by bribery.

Figure 8. Current criteria for drilling and use permits.

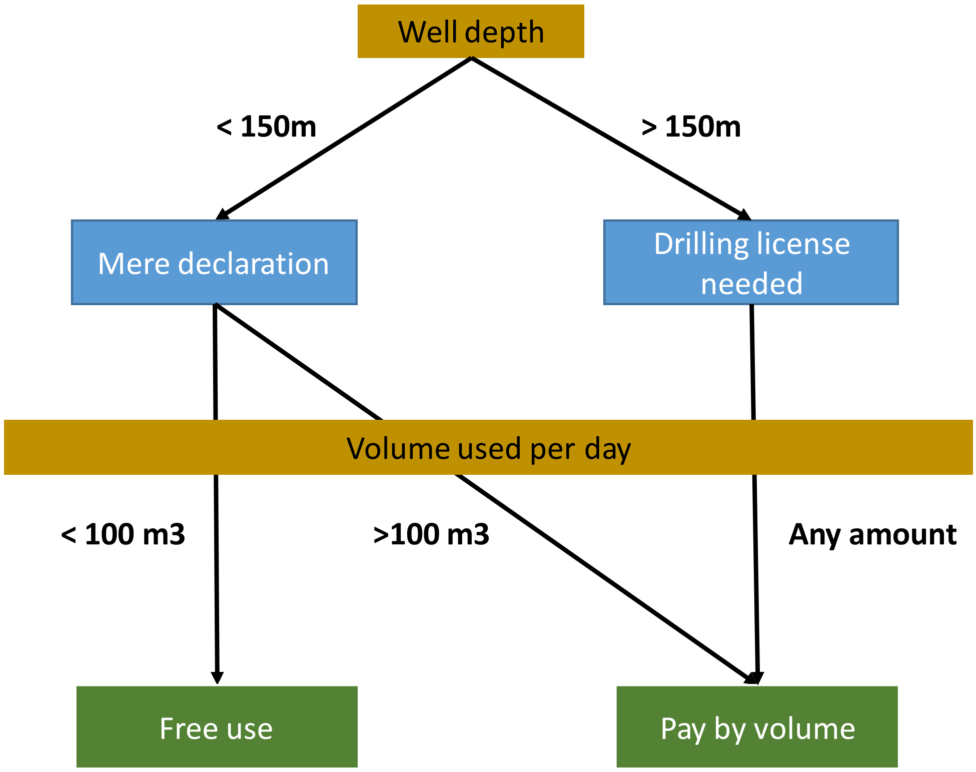


Table 1. Tradeoffs between licensing criteria and groundwater user fees

	Low licensing depth/volume thresholds	High licensing depth/volume thresholds
Low user fee threshold	Many licenses and fees to be administered; fees can be lowered, better knowledge of actual use. High reluctance to register.	Fewer licensed users and reduced administration costs. Poorer volumetric management and lower revenue. Higher incentive to licensing
High user fee threshold	Very high revenue but administrative burden; good volumetric control but unlikely adherence to regulation and extreme reluctance to register that defeats the system	Few licensed users and poor volumetric management but better revenue. Mixed incentive to licensing

We may now turn to examining the possibility of indirect management measures. Groundwater pricing as a demand management tool only makes sense for volumetric use. Metered licensed wells are therefore amenable to incentives through administered prices, but they only total 300 wells at present. However, the fee for agricultural use is US$0.066/m3 (100 L.L/$m^3$), a relatively low price.[18] Licensed agricultural users only make around 20% of these 300 wells and, reportedly,

[18] According to MEW officials, a committee within MEW has recently been considering setting a price of 300 L.L/m^3 for water sold to tankers, 400 L.L/m^3 for industrial use, and 800 L.L/m^3 for mineral water bottlers. It was agreed that water

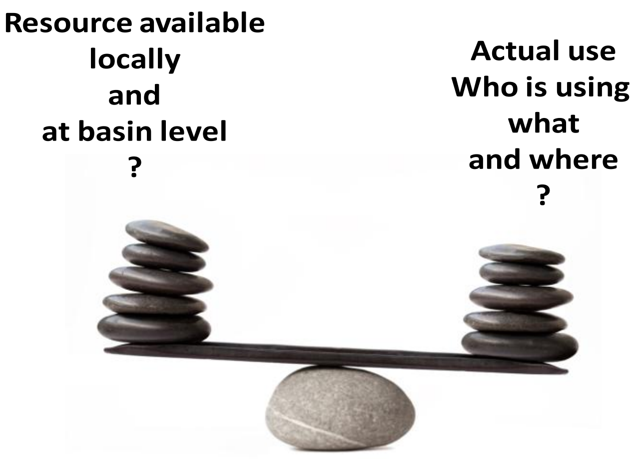
few do pay their bill. Meters are read once a year by the Ministry's staff and it is hard to envision how The Ministry could take care of thousands of wells (possibly licensed) with their dwindling staff number. In any case there is no documented case worldwide of country having raised fees of agricultural licensed wells[19] to such a level that use would be reduced or discouraged.[20] The reason for this is that such levels would result in substantial loss of income and no government is in a position to inflict this on to farmers for a resource that costs nothing (to the government) to produce.

However, prices may work in an indirect (and generally involuntary) way. Because energy costs for pumping are often substantial (and of course increase with the depth of the well), higher energy prices may work to encourage a reduction in abstraction, a return to rain fed conditions (Spain), or lead to bankruptcy (pre-crisis Syria).

4.2.2 Institutional setting

The two key weaknesses identified earlier – the limited knowledge on both the available resource and actual use – are fundamental deterrents to rational planning (Figure 9). They reflect a lack of means and of political will, but also question the current institutional setting and information flows.

Figure 9. The two key weaknesses of water management in Lebanon



As mentioned earlier, most studies on water resources in Lebanon underline the paucity of existing data, the difficulty to access data, and the near-absence of monitoring of the hydrology (notably spring and river flows and groundwater levels). The LRA has historically been entrusted with this monitoring task (for surface water) despite its limited official geographical mandate and lack of means. It is also undertaking some groundwater monitoring although this is not included in its mandate and merely reflects the continuation of activities started as part of the USAID LRBMSP program. The MEW has minimal hydrological offices at the level of the 8 Governorates but they are deprived of resources. Even internally, between departments or organizations belonging to the same Ministry (MEW), technical and hydrologic data do not circulate well. It is desirable to centralize data collection and analysis on both surface and groundwater in one

prices could not undermine the viability of economic activities and prices for agriculture have been reduced from 100 to 50 L.L/m^3.

[19] An exception is Jordan, but the high discouraging fees are only applied to *illegal* wells (see Al-Naber and Molle, 2017).

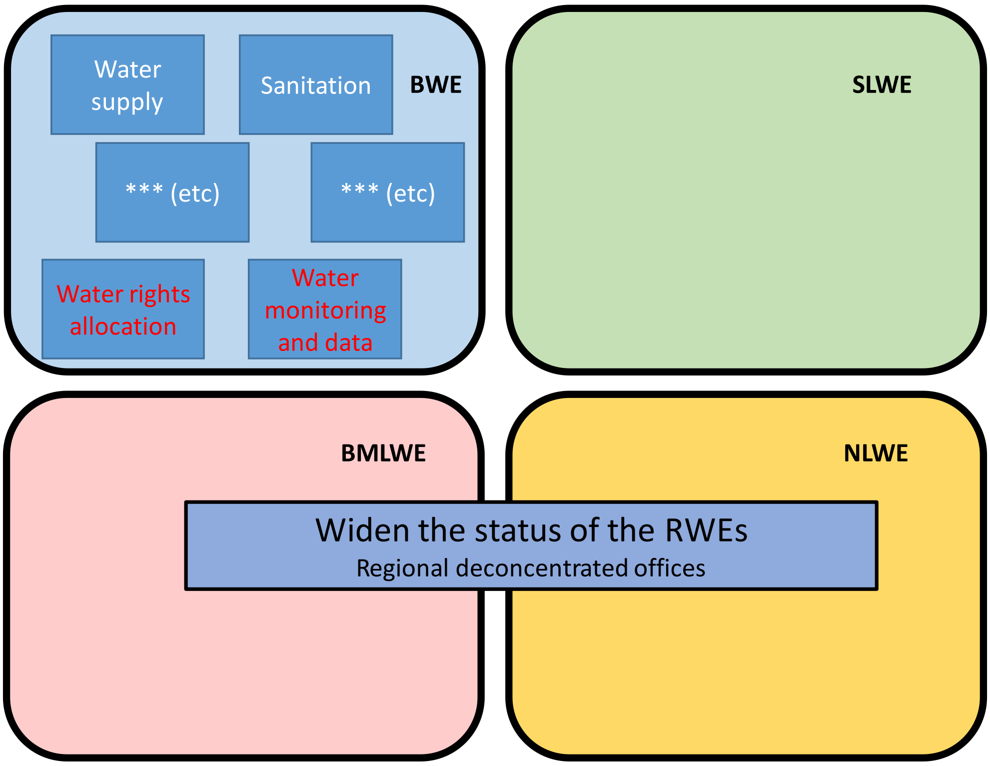
[20] This does not mean that, for revenue purposes, commercial use of groundwater should not be taxed.

strong dedicated service, with regional branches located within each RWE and endowed with adequate resources. Specific tasks entrusted to the LRA (or domestic water suppliers) would be organically put under the authority of this central service.

With regard to the second issue, that of knowing actual abstraction, it is believed that the registration service should be carried out by the Ministry itself, with deconcentrated branches also at the level of REWs. This would further strengthen the role of the four regional organizations and ease controls in the field by officials.

This implicitly questions whether the conventional river basin management model promoted by donors or the EU is appropriate for Lebanon. Because all of its 13 river basins are small, with the exception of the Litani, they could be grouped under the responsibility of one of the four RWE, just like small Mediterranean basins in France are pooled under the Rhône-Méditerrannée Basin Agency. RWEs, although initially defined based on administrative boundaries, would then become responsible for corresponding river basin master plans[21] and supervise possible multi-institutional management plans in the future. The LRA could be either absorbed into the MEW structure or kept as a Department with specific functions not overlapping with those of other Departments. Others (USAID-LRBMS 2014) also envision that it could become a fully-fledged River Basin Authority but since future development plans are limited in scope it is unclear whether a special Authority is really justified [22] (Figure 10).

Figure 10. Regional deconcentration of MEW and strengthening of the four RWEs



[21] A specificity of Lebanese river basin is that they are not coterminous with (karstic) aquifers. This presents a clear challenge to the conventional river basin management approach.

[22] The LRA is a remnant of the TVA approach ubiquitous in the 1960s and represents a river basin agency tasked to develop water resources. Its area of responsibility does not include the upper part of the Litani River basin (north of the Beirut-Damascus road) but extends to the adjacent Awali basin. A functionalist approach of course neglects the political dimension of those organizations within Lebanon's context.

5 Conclusions

Lebanon distinguishes itself by its relatively abundant water resources, the importance of snow, and the prevalence of a karstic geology. Main groundwater resources are to be found along the coast, in the alluvial formations of the central Beqaa plain, and in the numerous karstic formations of the country that are associated with springs which, in the central Beqaa, make up around half of the runoff.

Despite the growing importance taken by groundwater in both domestic water supply and irrigation, Lebanon has a relatively little developed groundwater regulation and policy. This reflects the fact that water resources are not usually seen as being overexploited and also a public administration weakened by the Civil War and stricken by fiscal drought.

May be partly as a result of this state of affair, but also due to the complexity of the country's hydrogeology, Lebanon' hydrologic knowledge is admittedly weak, particularly with regard to groundwater, the monitoring of which is incipient. The uncertainty with regard to the resource available is paralleled by a lack of knowledge regarding actual use. It is believed that there are over 80,000 wells in the country, a fourth of which are registered, and a very small part of these (300) are licensed and metered (of which approximately 60% are industrial wells and 20% agricultural wells).

The main current control point of groundwater resources is the licensing process. But the criteria used to define which wells are to be licensed and which ones are to be declared only are obsolete. Licensing criteria need to be based on the scientific knowledge of the resource, linked to groundwater use and not administratively and arbitrarily decided. Such criteria should distinguish between alluvial and karstic aquifers and be set up at a level that maximizes the fraction of groundwater use to be volumetrically monitored, while maintaining a cost to users which is both high enough to generate revenue (to the Ministry) and low enough to limit the reluctance of well owners to register. This is a difficult trade-off that has to be carefully dealt with. Any kind of improved regulation, however, will not be effective without enhancing law enforcement and making sanctions credible. It is not apparent that the needed political will is forthcoming. As a result, under prevailing conditions, any necessary addition to the policy, such as the possibility to define safeguard or prohibition zones where the drilling of wells is strictly regulated or banned, would likely remain cosmetic. A corollary is that no attempt to consider more complex policy tools such as generalized metering or volumetric water pricing should be envisaged before a certain degree of certainty about, if not control upon, actual use is achieved.

But Lebanon finds itself in the common situation where any more systematic well registration process would first have to deal with a massive number of *existing* unregistered wells (60,000 at a minimum according to recent accounts). Regularizing such a huge number of wells is an uphill battle and international experience shows that it cannot be fought without considerable time and public money. The second challenge is to define an incentive structure and a mechanism to ensure that the information on newly or to-be-drilled wells is reported, and that the wells are registered (and licensed if need be). It is unrealistic to expect individuals to accept to register their wells without clear benefits. In all cases it could be envisaged to associate municipalities and drilling companies which could also be requested to transmit information under respective sets of carrots/sticks incentives.

Institution fragmentation is apparent from the scattered nature of responsibilities (LRA monitors the resource at national level and manages infrastructures in a part of the Litani Basin, BWE is in charge of planning and management of water supply and sanitation, CDR has a parallel line of decision-making, the licensing process is centralized in the ministry (MEW) contracted out to private companies). At the moment individuals, NGOs, industries and even the CDR or the RWEs are, reportedly, still finding ways to drill wells while bypassing the ministry registration process.

The main conclusion is that both knowing the resource and administrating its allocation are indispensable tasks that can only be handled by the Ministry at public cost. Applying general principles to the contrary has not served Lebanon well, as illustrated in this report. Not recognizing this fact will sustain a situation of free-for-all and anarchic access to water resources with public institutions unable to even make sense of the situation, for lack of information on both actual supply and demand.

Main messages

- Data, information, monitoring and analyses. We can only reinstate and underline the often made recommendation that Lebanon should invest in hydrologic data collection and analysis in order to better know its resources and plan its use. Such data must be made accessible and available to the public, researchers, and donor agencies.
- The same applies to allocation and the needed inventory of abstraction points. The current process that resorts to private companies and shifts all costs to users is unrealistic. Lebanon cannot manage its resource without investing public money in this process.
- Thresholds for well drilling authorizations (150 m depth) and for groundwater use fees (100 m^3/day of well capacity) need to be revised based on the type of aquifer, the type of use (agriculture/non-agriculture), and a scientific approach to identified tradeoffs. Currently, the 100 m^3/day limit (1.16 l/s) is unrealistic and undermines the whole registration system by creating a very high reluctance to register, since this would entail taxation (notably for agricultural users).
- Drillers should be licensed and any drilling equipment used without permission seized. This is one more possible measure to help control illegal drilling.
- It is unrealistic to think that Lebanon will be able to register all its wells. An inventory through direct survey is the best way ahead to establish a better vision of the situation. Positive incentives to convince 80,000+ well owners to regularize their wells would be more costly. Negative incentives (police action, fines, etc.) are unrealistic under present circumstances, except for domestic/industrial wells.
- Registration of new wells must be made easy and cheap, and some threat or risk must be associated with not-registering, in order to minimize reluctance to registration. The current system, which has dramatically reduced the number of applications, is not sustainable and is counter-productive since it does not give any incentives to users to register their wells.
- More generally, the power of the state to govern through formal laws or regulations should not be overestimated, since enforcement capacity is weak. Policies must therefore be realistic and pragmatic rather than formally exemplary and/or relying too much on 'stick instruments'. As Elinor Ostrom (2000) put it: "The worst of all worlds may be one where external authorities impose rules but are only able to achieve weak monitoring and sanctioning".
- Water users in the Beqaa have been able to withdraw water from several surface and groundwater sources and to shift from one to the other depending on their respective status and level of exploitation. Conjunctive use strategies, however, come at a cost because of the investments needed to access these different sources. Meanwhile, public interventions and donor projects affect these arrangements. Planning and management in

the Beqaa need to understand and take into consideration the complexity of multiple surface water/groundwater uses.

- There is a lack of understanding in Lebanon that many water sources are already overexploited: this translates into polluted waterways (e.g. the Litani River) and dropping water tables. Although a high recharge obscures this state of overexploitation and deepening wells offers a short-term response, limits will be reached at some points. Since one year dry spell in 2014 already had severe negative impacts, a longer one would likely wreck havoc.
- Coordination between ministries and within the MEW is widely seen as problematic. Clarification of roles and prerogatives is needed, in particular with regard to the generation of data and flow of information. RWEs should be strengthened as regional 'arms' of the Ministry and incorporate bureaus in charge of data collection and of the registration or regularisation of wells (and more generally water abstraction/diversions).

النتائج و الرسائل الرئيسية

- من المجدي إعادة التأكيد على حاجة لبنان للإستثمار في الأبحاث الهيدرولوجية، وجمع المعلومات المتوفرة، وتحليلها بدقة؛ وذلك بهدف تحسين المعرفة بالنسبة لمصادر لبنان المائية، والتوصل إلى خطط سليمة لاستخدامها. كما وينبغي جعل هذه الأبحاث والبيانات متاحة ومتوفرة للرأي العام والباحثين والوكالات المانحة.

- التوصية نفسها تنطبق على موضوع إحصاء كميات المياه الجوفية المستخدمة، وتحديد النقاط الجغرافية التي يتم فيها الضخ والاستخدام. ينبغي الإشارة إلى أن العملية الحالية المتبعة للقيام بتسجيل أو ترخيص الآبار السابقة أو الجديدة هي غير منطقية؛ وذلك يكمن في اللجوء إلى شركات القطاع الخاص التي يغطي كلفة خدماتها المستخدم . ليس بوسع لبنان أن يؤمن إدارة موارده المائية دون تخصيص استثمارات من المال العام في هذه العملية.

- ضروري إعادة النظر في المعاييرالمحددة للحصول على تراخيص حفر الأبار (عتبة الـ ١٥٠ م المتعلقة بعمق البئر) واستخدامها (عتبة ال١٠٠ م ^{3}يومياً المتعلقة بقدرة ضخ البئر) ، من أجل وضع معايير جديدة يتم تحديدها حسب نوع الطبقة الجوفية، وغرض إستخدام البئر (زراعي /غير زراعي) كما وإستناداً على دراسة جدوى تهدف إلى تحديد تلك المعايير بطريقة علمية. وينبغي الإضاءة على أن معيار الـ١٠٠ م ^{3}يومياً المتعلق بقدرة البئر هو غير واقعي، وينسف عملية التسجيل بكاملها عبر خلق تردد عالٍ لدى المستخدمين، إذ إنه يستتبع وجوب تسديد الضرائب لأغلبيتجم (لا سيما للمزارعين منهم).

- ينبغي تزويد الحفارين برخصة عمل، على أن تكون جميع الاليات والمعدات المستخدمة في حفر الآبار حائزة على إذن للإستخدام ؛ أما خلافاً لذلك فيتم مصادرتها. يمكن إعتماد الإجراء الموصوف أعلاه للسعي في مراقبة عمليات حفر الآبار غير القانونية.

- الظن بأن لبنان سيكون قادراً على تسجيل جميع الآبار الواقعة على اراضيه هو أمرٌ غير واقعي. لذا فالطريقة المثلى لتكوين رؤية جيدة عن الواقع الحالي تكمن في القيام بمسح مباشر وشامل لهذه الآبار، بحيثأن إقناع ٨٠،٠٠٠ مستخدماً تسوية وضع آبارهم عبر نشر حوافز إيجابية سوف يكون عملية باهظة الكلفة، كما وأن وضع الحوافز السلبية (عمل الشرطة، والغرامات، الخ) يعتبر غير عملي ضمن الظروف الحالية (باستثناء الآبار المنزلية والصناعية).

- على عملية تسجيل الآبار أن تكون سهلة وغير مكلفة. كما وينبغي خلق إجراءات تكون نتائجها سلبية على المستخدم في حال عزوفه عن التسجيل. فإن النظام المتبع حالياً أدى إلى تخفيض عدد طلبات التسجيل او الترخيص بشكل هائل (دون تخفيض عدد الآبار المحفورة فعلياً) وهو إذاً غير قابل للإستمرار كونه يأتي بنتائج عكسية، لعدم تقديمه أية حوافز إيجابية للمستخدمين.

- على المستوى العام ، لا يجب المبالغة في قدرة الدولة على تطبيق سلطتها من خلال القوانين والأنظمة الرسمية; لا سيما نظراً إلى ضعف الأجهزة التنفيذية على أرض الواقع. لذا نقترح أن تكون السياسات واقعية وبرجماتية على أن تكون مثالية ورسمية . فكما كتبت إلينور استروم (٢٠٠٠) : " إن أسوأ الأنظمة العلمية الممكنة هي التي تقوم بفرض قوانين دون أن تكون قادرة على تطبيقها".

- لطالما نجح مستخدمو المياه في البقاع بالإستفادة من مصادر مائية متعددة، سطحية كانت أو جوفية، وفي الإنتقال من مصدر إلى آخر تبعاً لعدة عوامل (جغرافية، إدارية، إجتماعية)؛ كما استخدام تلك الطرق المختلفة يتطلب في أحيان كثيرة كلفة مالية مرتفعة لاسيما في الوضع الحالي للمصادر المائية. من ناحية أخرى، إن المشاريع والبنى التحتية الموضوعة من قبل الدولة والجهات المانحة يمكنها التأثير سلباً على هذه الترتيبات. لذا يجب على عمليات التخطيط والإدارة أخذ تلك الاستخدامات بعين الإعتبار، كما فهم التدخلات ما بين الاستخدامات والمصادر المائية المختلفة.

- اليوم العديد من المصادر المائية في لبنان مستنزفة. ما يترجم بتلوث مجاري المياه (كوضع نهر الليطاني) و بتدهور الجداول المائية. بالرغم أن نسبة التغذية العالية تحجب واقع الإستنزاف الحالي، كما أن تعميق الأبار يوفر حلاً مؤقتاً، فوضع الإستنزاف سوف يبلغ ذروته عاجلاً أم أجلاً. من المعلوم أن موسم الجفاف الذي اختبره لبنان سنة ٢٠١٤ كانت له ارتدادات قاسية: مرحلة أطول أو أشد من الجفاف تؤدي إلى نتائج خطيرة.

- التنسيق بين المؤسسات المعنية المختلفة وحتى بين الإدارات المختلفة ضمن وزارة الطاقة والمياه يعتبر ناقصاً إلى حدٍ كبير; إذ يجب توضيح الأدوار والمسؤوليات، لا سيما في ما يتعلق بوضع الدراسات وتبادل المعلومات. وفي هذا الإطار يمكننا الإقتراح التالي: تعزيز دور مؤسسات المياه في مناطقها وجعلها " الذراع الأيمن" لوزارة الطاقة والمياه ، لتصبح مسؤولة عن جمع المعلومات المتعلقة بالمصادر و أيضاً عن تسجيل الآبار و وتسوية ادارتها في مناطقها.

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