Irrigation Planning in Lebanon: Challenges and Opportunities

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Hydrological and agricultural background

The French Mandate authority started modern irrigation planning in the early 1930s, when it helped build small earth dams, a few mountain lakes and other irrigation infrastructure. Shortly after its independence, in 1943, Lebanon paid particular attention to the agricultural sector, including irrigation, because of the country's comparative advantage in ample arable land, temperate climate, moderate to high precipitation, and strategic location, close to natural markets in the desert states of the Middle East.

Lebanon's Mediterranean climate limits precipitation to the winter season. In fact, Lebanon's precipitation occurs within 80–90 days every year. In Beirut and the Bekaa Valley, the temperatures average 7.0°C and 5.5°C in winter and 27°C and 24°C in summer (Jaber 1997). Significant spatial variation occurs in precipitation over the various parts of Lebanon, especially in the vast fertile plain of the Bekaa (Table 1).

Table 1.

Precipitation in the Bekaa Valley			
Geographic Regions of the Bekaa Valley	**Millimeters a year**	**Site of precipitation measuring station**	**Land classification**
Northern Bekaa	250–275	Qa'a	Arid
Central Bekaa	500–600	Reyak	Semi-arid
Southern Bekaa	700–750	Karoun	Non-arid

Source: Adapted from Nimee (1998).

The cultivable area is an estimated 36 000 ha, or 36% of total area. In 1992–94, the cultivated area was an estimated 189 206 ha, of which 104 120 ha was in annual crops and 85 086 ha was in permanent crops, the latter comprising mainly orchards and olive trees.

The potentially irrigable area, based on soil type and water resources, is an estimated 177 500 ha (FAO 1997), requiring 1700 × 10^6 m^3/year of water (Jaber 1997). A full 67 500 ha receive irrigation perennially, and 20 000 ha, seasonally. All the irrigated areas together amount to 46% of the cultivated land (FAO 1997) and consume more than 900 × 10^6 m^3 of water annually, or 68% of water consumption in all sectors of the economy. Calculations of agricultural water use are based on an estimated 11 200 m^3/ha a year from surface water and 8575 m^3/ha a year from groundwater (FAO 1997).

According to Shatila (1996), Lebanon has 30 aquifers, with 12 in the interior (Bekaa Valley) and 18 along the coast. Its freshwater supplies comprise 2500 × 10^6 m^3 of surface water, 600 × 10^6 m^3 of renewable groundwater, 1.7 × 10^6 m^3 of desalinated water and 2 × 10^6 m^3 of treated wastewater and drainage. Lebanon consumes 240 × 10^6 m^3 of groundwater every year and uses 1225 × 10^6 m^3 of water annually in all sectors of its economy and society (ESCWA 1998).

The greatest concentration of the Shia population is in the south, north, and northeast. The central government has traditionally neglected these regions, and so they are the most underdeveloped and deprived. This minority, once a marginalized sect, has organized and galvanized itself politically and become the largest religious sect, surpassing the Maronites and Sunnis. This is particularly significant because Lebanon's confessional political structure allocates political power and representation to the national sects according to the size of their population.

Some of the factors triggering the civil war were the low standard of living, government negligence of economic development in the south and northeast, and the low-intensity conflict in southern Lebanon since 1970 that had led to a massive movement of Shia refugees to Beirut. More recently, a peaceful "revolt of the hungry" in northeastern Lebanon, in 1997, deteriorated into a violent confrontation. The revolt's leader demanded the government give greater attention to economic development, including irrigation projects in the long-neglected region.

This paper surveys Lebanon's irrigation-planning strategies and argues that irrigating the south, north, and northeastern parts of the country would be critical to the national (re)integration process that the country embarked on after its protracted civil war. Also, exporting "virtual water" (that is, exports of food with all the water embedded in it) to water-stressed states in the region would have political and economic benefits for Lebanon and hydrological rewards for the importing states.

Irrigation planning

The main sources of water for irrigation are the Litani-Awali river system and subsurface waters. According to the most recent data, from 1993, 54.3% of all lands were irrigated from surface-water sources; and 45.7%, from groundwater sources (FAO 1997).

Surface irrigation is widely practiced in Lebanon. In 1993, farmers irrigated 53 500 ha, using furrow and basin methods, comprising diversion structures or simple intakes on streams or springs, open concrete main canals, and earthen or concrete secondary canals (FAO 1997). They used sprinklers to irrigate 21 000 ha, primarily potato and sugar-beet crops in the Bekaa central plain, and microirrigation techniques to irrigate 13 000 ha in the northern (Qa'a) region, central Bekaa, and the coastal plain (FAO 1997).

Rehabilitating the agricultural sector and rebuilding of the irrigation system were not high priorities of the Lebanese government during the early years following its civil war. As a result, individual farmers relied more on groundwater, and thus between 1992 and 1995, they added 2000 wells to the existing stock of more than 10 000 wells to augment the farmers' water supply (FAO 1997).

Irrigating 1 ha of land consumes an estimated 10 000–18 000 m^3 of water in Egypt, Iraq, Jordan, and Syria. That volume drops to 5000–10 000 m^3 in Lebanon, Oman, and Saudi Arabia (ESCWA 1998). The Food and Agriculture Organization of the United Nations (FAO) estimated that irrigating 1 ha of land requires 11 200 m^3/year from surface water and 8575 m^3/year from groundwater (FAO 1997). The volume of water depends on the irrigation method and the types of crop and soil. Lebanon's glaring low water-use efficiency in irrigation weakens its hydrological sustainability and constrains its food production. According to the FAO, "the average yield for irrigated wheat and barley was estimated at 5 tons/ha, as against 2.2 tons/ha for rain fed wheat and barley" (FAO 1997, p. 9). Farmers have, then, conspicuous economic incentives that will continually entice them to convert rainfed fields to irrigated farms, with all the attendant hydrological, environmental, and economic consequences.

It is useful to put these figures into relative perspective: 100 nomadic bedouins and 450 head of cattle for 3 years could use 15 000 m^3 of water needed to irrigate 1 ha. Alternatively, that volume would meet the needs of 100 urban families for 2 years or 100 hotel guests for 55 days (ESCWA 1998).

The country's drive to achieve larger and larger irrigation coverage faced the spatial "sectarian challenges" concerning which areas to irrigate and at what elevations ("levels"). An implicit question has been whether the politically and economically disadvantaged Shia have as much access to irrigation as the more advantaged Maronites and Sunnis? This challenge — as well as other factors, such as difficulties in financing some of the projects, corruption, and political instability — greatly slow the country's progress in meeting its agricultural objectives.

Lebanon established the National Authority for the Litani River (NALR), effective 14 August 1954. Its objectives were to implement the Litani project, drain and irrigate lands, and provide potable water and electricity within a comprehensive water-planning strategy for Lebanon. In 1955, the government applied for, and received, a $24 million loan from the World Bank to initiate work of this project (Sayigh 1978) (US dollars throughout). This included construction of hydroelectric-power plants in Markaba and Awali (96 MW), Jun (48 MW), and Awali (36 MW) and the irrigation of 15 000 ha (Sharaf ad-Din 1994).

The project Irrigating the South was first studied in 1964 and had its economic-feasibility study completed in 1965. However, delays resulted from disagreement over the elevation to irrigate and, later, the instability prevailing after the Israeli bombardment and occupation in southern Lebanon.

In 1964, NALR conducted a study to reclaim and irrigate 5000 ha between Qab Illyas and Jib Janeen. The project straightened and deepened the channel of the Litani River north of Karoun between 1965 and 1970. In the mid- to late 1990s, some environmental organizations started to demand protection for the natural wetlands near Qab Illyas and Bir Illyas, because of their biodiversity, aquatic life, and role in regulating hydrological dynamics (Srour and

Sleiman 1998).

On the 29th August 1973, the Council of Ministers agreed to implement the first phase of Jabal A'mil irrigation project, by building the infrastructure needed to provide water to areas located up to 800 m asl. In 1974, the parliament voted to allocate 191 million Lebanese lira to implement the project (Assafir 1994) (conversion estimated at 61 million United States dollars). These decisions put an end to what had been dubbed, then, the "war over elevations."

In 1994, 4 years after the civil war, Lebanon secured from the World Bank a low-interest (8%) $57-million loan to help rehabilitate and expand Lebanon's existing irrigation projects (Iktissadiat 1994). All in all, Lebanon has committed, had promised, or borrowed a total of $1 billion to invest in phases from the mid-1990s until around 2006. This financing will help rehabilitate much of the irrigation infrastructure and revive long-suspended projects throughout the country.

On 12 December 1992, Lebanon established the southern Litani Water Authority and Southern Water Authority, by decrees 9630 and 9628, respectively. Their mandates were to implement, oversee (regulate), and operate potable-water sources and wastewater discharge networks (Srour and Sleiman 1998).

Local farmers of the upper Litani River use some 100×10^6 m^3 of water to irrigate their fields. Another 100×10^6 m^3 comes from the lower Litani, for the same purpose. The central and western Bekaa region is the location of the Bekaa irrigation project, which will cover 121 000 ha at a cost of $300 million (Younis 1997). The following section outlines some of the major irrigation projects.

Qasmiyah-Ras al-Ein

In 1974, NALR took over the management of the small Qasimyah irrigation scheme, completed under the French Mandate, only to discover the scheme's gross economic mismanagement (Sayigh 1978).

The project irrigates the coastal areas between Zahrani and al-Mansouri on the Lebanese-Israeli border. The various Israeli invasions, as well as the Lebanese civil war, damaged much of the infrastructure, including pumping stations. When fully operational, the project will irrigate 4000 ha and have 40 km of lined canals and 6 km of tunnels and pipelines. The government will spend $7.98 million of the World Bank's loan on rehabilitating and expanding this project (Iktissadiat 1994; Younis 1997).

In addition, the Yamouneh project aims to rehabilitate the waterfall and canals, store 8×10^6 m^3 of water, and construct mountain "lakes" (holding ponds) to store 17×10^6 m^3. When the project is fully operational, the area under irrigation will reach 5000 ha. This project received $6.27 million in funding in 1994 (Assafir 1994; Iktissadiat 1994).

The Thineyaa irrigation project will cover 1700 ha at a cost of $5 million, and the A'kar-al-Barid project will cover 1600 ha at a cost of $1.86 million.

Irrigation dams

Dams are tools of economic development. They allow countries to use their "natural capital" for economic development, by generating more hydroelectricity and increasing the agricultural yields (of lucrative crops) per hectare of irrigated land. For Lebanon, building dams has an added advantage: the more the country captures and uses its surface water, the better positioned it will be to deflect calls and international pressure to share its "surplus" water, which is currently referred to as "wasted," simply because it flows into the sea. According to Srour and Sleiman (1998), an estimated 900×10^6 m^3 of surface fresh water discharges into the Mediterranean Sea every year. This water cannot be stored because of the location of the water, steep topography, narrow river channel, and perhaps most significantly the high cost of building appropriate reservoirs. As well, the country discharges 880×10^6 m^3 of subterranean fresh water into the sea (Srour and Sleiman 1998). Most of this large volume of freshwater currently goes unused, but Lebanon could use it if it significantly expanded its irrigation schemes and initiated new ones, particularly in the water-deficient but fertile plains in the south and northeast. Irrigation is after all a huge consumer of water, and a substantial area of Lebanon's arable lands remains without irrigation.

Lebanon has always been averse to selling its water to other countries in the region. This is a politically and socially explosive issue. However, the country can get around this by capitalizing on its comparative advantage in temperate climate, moderate to high precipitation levels, arable, fertile lands (much of them currently without cultivation or without irrigation), moderately skilled agricultural labour force, and an existing moderate level of mechanization in farming. It can significantly boost its export of water-intensive crops like citrus and vegetables to lucrative markets in water-deficient states in the Middle East. With intensive farming and irrigation-driven agricultural yields, Lebanon could become the food-basket of the Middle East. If Lebanon began to expand and modernize its agricultural sector, its neighbouring water-deficient countries would begin to import its water-intensive crops while phasing them out in their own states. Because huge amounts of water go to irrigation, redirecting even a fairly small percentage of this to the domestic and industrial sectors would immensely relieve the stress these sectors have experienced in some Middle Eastern countries. However, exporting virtual water would revitalize Lebanon's long-neglected rural periphery and significantly elevate the standard of living in most economically impoverished but agriculturally very fertile parts of the country.

Technical studies recommend that Lebanon build 16–20 dams in various parts of the country (Table 2) and identify the locations for 106 mountain ponds (Table 3) (Younis 1997).

Among existing dams, the Karoun Dam, more accurately the Albert Naqash Dam, is Lebanon's largest and essentially only dam. Its reservoir can store 220×10^6 m^3. It is located on the upper Litani River, near the town of Karoun. Engineer Salim Lahoud, the general manager in charge of building the Karoun Dam, proposed building it to withstand a military strike. The dam regulates downstream flow of the river to generate power and irrigate the upper and lower reaches of the Litani and can release water at a rate of 500 m^3/second. The Abd al-A'l hydroelectric plant, commonly known as the Markaba plant, uses 22 m^3/second of water from Lake Karoun through a 6400-m-long tunnel, which takes the water to power plants and then to the Awali River.

Table 2.

Rivers on which Dams are Proposed in Coastal Area	
River Names	**Storage capacity ($\times 10^6$ m^3)**
Khardali Nahr	70
Zhgarta Nahr	8
Al-Barid Nahr	40
A'rka Nahr	20
Al-Ustwan Nahr	15
Al-Kabeer Nahr	60
Ibrahim Nahr	35
Ad-Damour Nahr	5
Nahr Bisri	35

Source: Shatila (1996).

Table 3.

Areas earmarked for mountain ponds		
Province	**Caza (administrative unit)**	**Number of ponds**
Bekaa	Ba'albeck	12
	Zahle	2
	Jib Janeen	3
	Rashaya	6
North Lebanon	Al-Batroun	1
Mount Lebanon	Beit ad-Din	1
South Lebanon	Hasbaya	1
	Jezin	1

Source: Annahar (1995).

A number of dams are proposed, primarily for irrigation and urban domestic water supply. One such dam would be on the Damour River south of Beirut, with a capacity of 175×10^6 m^3. The Damour River is 38 km long and originates from Dahr al-Bayder at an elevation of 1510 m asl. The river's average water discharge is 306×10^6 m^3/year, and the area of its watershed is 288 km^2. The reservoir behind a dam on the Damour River would (1) supply metropolitan Beirut; (2) irrigate the Damour and other nearby coastal plains; and (3) provide the water needed for the industrial and recreational-tourist industries south of Beirut (Annahar 1997).

The Bisri Dam on the Awali River is in its final design stage. Its storage capacity will be 128×10^6 m^3, and it is intended primarily to supply water to metropolitan Beirut.

The Khardale Dam on the lower-middle reach of the Litani River has a storage capacity of 128×10^6 m^3. Work on the Khardali Dam was suspended in the 1960s, because of the war of the irrigation levels, the civil war, and the

dam's precarious location on the edge of the Israeli-occupied strip in southern Lebanon, which the Israeli army was evacuating in June–July 2000, having kept it under military control for 22 years.
Since the early 1960s Lebanon has been helping farmers construct dirt reservoirs, primarily in the mountains, to collect rain and flood water during winter. The stored water would then be of use to farmers for irrigation and watering animals during the dry summer, as well as to others for recreation, tourism, and household consumption. NALR was in charge of the ponds project in the late 1970s. The capacity of each dirt reservoir ranges from 1000–10 000 m^3. Between 1965 and 1985, the ponds captured 3.605×10^6 m^3 of water throughout the state. NALR built an additional capacity of 0.394×10^6 m^3 between 1991 and 1992 (Assafir 1994). After NALR took charge of this project, it built the Kfar-Houne Lake near Dahr ad-Daraje in southern Lebanon. This is a natural lake with a storage capacity of $150\,000 \times 10^6$ m^3. It loses 110 000 m^3 of water as a result of seepage and evaporation, thus making only 40 000 m^3 available.

Al-Kawashera Lake (A'kar) is an artificial lake, with a dirt dam and an original storage capacity of 120 000 m^3 of water for irrigation and herding. This lake is under management by NALR.
Al-Mrouj Lake is near al-Ballout in the upper Matn. Cement covers the dirt dam and the lake floor. The lake can store 380 000 m^3 of potable water (Annahar 1995).
The Green Plan (Le Plan Vert) is a state institution, established in 1963, to improve farm and state lands and develop water reservoirs for agriculture. Specifically, its mandate is to help landowners, especially those with small plots and meagre means, clear their properties of stones, build terracing, obtain cheap tractor services, intensify tree-planting from nurseries run by the Green Plan, and dig wells, or otherwise obtain and use water for irrigation. During the period of 1964–92, the Green Plan developed hundreds of earthen and concrete water-storage ponds, the former containing 3.5×10^6 m^3; and the latter, 0.35×10^6 m^3. The maximum per-unit capacity of each pond is 0.2×10^6 m^3 (FAO 1997).
The technical- and economic-feasibility studies for the new dams have been ready for sometime. Lebanon's challenge now, however, is to secure funding for these projects, without which, officials argue, the country is heading for serious shortages. A rapidly creeping "new" (or long-neglected) challenge for water and irrigation development is water quality.

Water quality and irrigation

The Bekaa is Lebanon's largest province and has by far the largest area of arable land. It is also fairly arid, with near-desert precipitation near the historic city of Ba'albek. Consequently, threats to its water supplies would severely hamper the economy of the province.
Most towns and villages in the Bekaa Valley have no sewer systems, and many that have them empty their waste water completely untreated into a nearby valley and, more likely, the Litani River (Table 4). The town of Jib Janeen, around 10 km north of Lake Karoun, had a sewer system installed in the early 1990s, but its waste flows, untreated, into the adjacent Litani River. The problem becomes magnified during the summer, when the river's flow slows to a trickle, but not that of the sewer system. Furthermore, some unscrupulous farmers near Jin Janeen (and further up stream, near the city of Zahle) are known to draw water from the river to irrigate their summer crops, which they market locally and in Beirut. The impacts on people's health as a result of the farmers' use of contaminated irrigation water remain undocumented.
Over the decades, I have made countless visits to Lake Karoun and have been noticing the water is green, rather than its natural blue colour. By the end of November, at the end of the long dry season, when the lake is at its lowest point, more than 10% of its volume is waste water discharged into the upper Litani or directly into the lake from surrounding villages (Comair 1998; see also Srour and Sleiman 1998).
A "cocktail of toxic chemicals" contained in 15 800 barrels and 20 containers was exported to Lebanon, primarily from Italy, in 1987. The chemicals came from industrial processes and waste from research laboratories and consisted of heavy metals, such as Ag, CN, CN_2, Hg, $CdCN_2$, dioxin, and PCBs.
Although Lebanon eventually returned some of the barrels, more than 10 000 of them remain. People emptied some of the barrels and used them to store food or water (Annahar 1995). They emptied some into the Mediterranean Sea and others in the Kesrouan Mountains, the recharge area of a significant coastal aquifer northeast of Beirut (Hamdan 1995). Consequently, this dumping endangers groundwater and local farmers' irrigation water on their fertile coastal plain.

Table 4.

Wastewater discharge into the upper Litani, May–Nov (L/second)		
Region	**Volume (L/second)**	**Location**
Ba’albek	50	Litani headwaters
Zahle	300	Lower headwaters
Western Bekaa	70	Upper Litani, near Karoun
Total	**420**	**Up to Lake Karoun**

Source: Comair (1998) (see also Srour and Sleiman 1998).

The Litani watershed has 96 quarries; a mere 19 of them have government licences (Srour and Sleiman 1998). Their activities increase soil erosion and water turbidity and harm the quality of water, thus adversely affecting aquatic life and the purity of the river water.

In the Kesrouan town of Shnanir, the government has closed a massive quarry numerous times, only to have it return to normal operations a short time later. This is largely owing to the fact that the current and former officials have been part owners (Al-Azar 2000) of this lucrative enterprise. This quarry was a dump site for toxic waste from Europe, and some of it was set on fire back in 1987. The site was never decontaminated. In 2000, gravel and sand from the quarry was being used to build the Beirut-Jounieh highway, thereby spreading the contamination even farther along the coastal plain and aquifer.

Discussion and conclusions

S. Tufaili, the former secretary-general of the Hizbullah (“Party of God”), led the 1997–98 revolt of the hungry, which demanded that the central government improve the standard of living for people by initiating development projects, such as irrigation schemes in the long-neglected Hirmil-Ba’albeck region of northern Bekaa. Although the revolt was to be peaceful, it deteriorated into a violent confrontation, with people being killed or injured. This region was the heartland for the hashish and cocaine industries until the early 1990s. With American help, the government eradicated these lucrative crops but failed to supply a replacement crop or create any jobs for the displaced or impoverished workers. A mere 2 years after Tufaili launched his campaign of civil disobedience, the government initiated a project to rehabilitate and expand Lake Kawashra, built in the 1970s, so that now it stores up to 350 000 m^3 of water. This will allow the government to pipe water to 13 villages in Jabal Akroum in the A’kar region (Abullah 1999).

With the liberation of south Lebanon, after 22 years of occupation, the area urgently needs a “Marshal Plan” to uplift its residents’ quality of life to national levels. Irrigation projects would very likely be high on the agenda of government officials, as a key step to enticing people to remain in the region or return to it. Would governmental neglect of the south lead to civil tensions in war-weary Lebanon?

The country could more efficiently manage its water resources in the short term, which would “create” water for other more needy parts of the country. In 1998, NALR provided some western Bekaa farmers with equipment to efficiently irrigate 900 ha. This helped to drop water use per ha from 15 000 m^3/year, as in the Qasimyah-Ras al-Ain project, to 6500 m^3/year (Wimmen 1999). In the Qasimyah-Ras al-Ain project, most farmers rely on furrow irrigation.

The drip, or microirrigation, technique appeared in the 1960s, and now farmers use it primarily in water-stressed countries like Australia, Israel, Jordan, New Zealand, and some regions of the United States. Drip irrigation delivers water to individual plants via plastic tubes. Thus it uses 30–50% less water than surface irrigation (Tuijil 1993). Although drip irrigation is efficient, it is energy and capital intensive and requires fairly clean water so that its fine delivery tubes do not clog up.

Planting trees to shelter crops reduces evaporation and transpiration from the planted ecosystem by 13–20% during the growing season. This increases crop yields for corn by 10–74% (Gregersen et al. 1989). Sheltering crops also reduces wind soil erosion. Controlling erosion helps conserve water by reducing rapid runoff. As Pimentel et al. (1997, p. 104) remarked, “protecting forests and other biological resources facilitates effective use of water resources and helps maintain the hydrological cycle.”

Lebanon should take immediate steps to conserve water. This would provide more water and more time to pursue funding for some of its urgently needed water-development schemes for, among other things, extensive irrigation and urban water supply. The human and physical–natural resources make agricultural development through irrigation a sensible approach to improving the quality of life for people in the long-neglected northeastern and southern regions. This would cement their identity and loyalty to the central government and, in turn, enhance national unity and civil harmony and stability.

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