Chapter

Rivers of Lebanon: Significant Water Resources under Threats

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Abstract

Lebanon is known by tremendous water resources, and this has been often viewed from the considerable number of rivers (i.e. 14 rivers). These rivers are characterized by small catchments and short length. The estimated average annual discharge from these rivers is approximately 2800 million m^3. Due to the sloping terrain of Lebanon; however, it was estimated that more than 75% of water from rivers is unexploited it mainly outlets into the sea. The majority of water use from the Lebanese rivers implies domestic, agriculture, as well as some other rivers are used for hydro-power generation where they contribute by about 20% of electricity needed for Lebanon. Lately, and added to water pollution, there is abrupt decline in the discharge from these rivers estimated to more than 60% of their average annual discharge. This unfavorable situation is attributed, in addition to the changing climate, to the anthropogenic interference is the most affecting one and it is represented by over pumping from these rivers and form the recharge zone for groundwater and springs that feed these rivers. This chapter aims at introducing a discussion on the existed challenges on the Lebanese rivers and the proposed and their impact.

Keywords: stream flow, over pumping, climate change, pollution, dams

1. Introduction

Rivers in Lebanon are usually considered as the most significant water resources, as well as they are one of the known heritage sites and distinguished landscape. They show dense networks since there are 14 rivers located in the area of 10,452 km^2. Therefore, the estimated total annual discharge is about 3452 million m^3 where there is about 20% of this discharge goes into the Transboundary Rivers, therefore, the net discharge from the Lebanese rivers is approximately 2800 million m^3/year.

The average annual discharge from these rivers is about 247 million m^3, which is low enough if compared with international rivers, as an example, this volume of water is equivalent to the discharge from the Nile River in one day. There is also an argument about the exact number of rivers in Lebanon notably that not all of the 14 rivers, which are discharging water all year long as it was the case in the past, and this gives the first indicator about the current bad status on these rivers. Thus, the adoption of this number (i.e. 14) has been derived from the morphometric characterization basis and catchment shapes of the existing perennial watercourses, even though this conflicts with their hydrology where water flow is now almost intermittent.

There is remarkable hydrologic feature that characterizes the Lebanese rivers where all of them are almost controlled by the rugged topography, and then distributed within the three geomorphological units of Lebanon (i.e. Mount-Lebanon, Bekaa Plain and the Anti-Lebanon). Hence, Lebanon with its small area represents as a regional hydrologic junction where water flows into three regional directions. These are regional flows: 1) northward to comprise a tributary of the Orates River Flow System, 2) southward forming a major tributary for Jordan River Flow System and 3) eastward where the Lebanese Coastal Rivers System flow to the Mediterranean Sea [1].

Rivers in Lebanon have diverse orientations of distribution on terrain surfaces, and more specifically they are characterized by different flow directions and dimensions. Therefore, these rivers can be classified as follows:

1. Coastal Rivers: These are 10 rivers in Lebanon span along Mount-Lebanon where they have originated from, and then trending from east and discharge in the Mediterranean Sea (**Figure 1**), and then described as "Coastal rivers". These rivers are essentially fed from the snowmelt. The coastal rivers are relatively short where the longest one is El-Awali River which is about 61 km (curved). In addition, these rivers have nearly similar basin characteristics where the channel slope is relatively high and averages at 35–40 m/km, and this makes water flows rapidly between 5- and 10 km/hour in average [2]. This in turn results water loss into the sea.

2. Inner Rivers: Other than the 10 coastal rivers, there are 4 rivers in Lebanon that are characterized by diverse catchment morphometry and hydrology including mainly the flow direction and discharge regime. One of these rivers (i.e. El-Kabir River) is originated from the most northern part of Lebanon and outlets into the Mediterranean Sea (**Figure 1**); another two rivers (i.e. Al-Assi River and Litani River) are originated from the Bekaa Plain where the first one flows northward to Syria and the second flows southward and then diverted

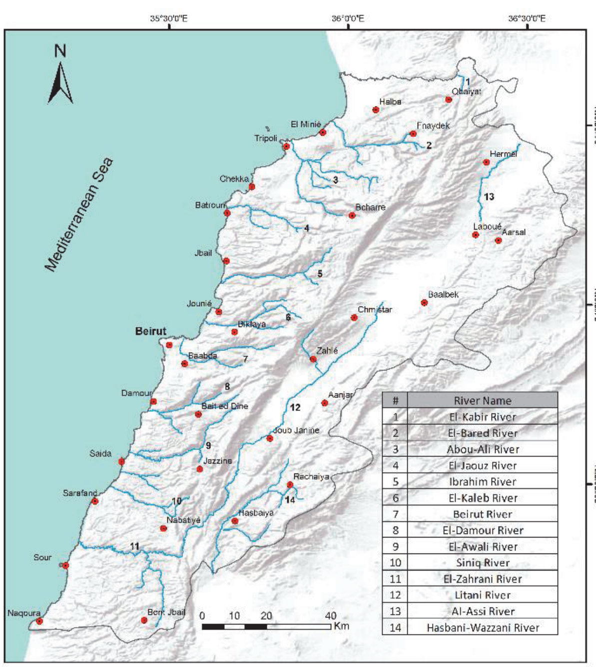

Figure 1.
Rivers of Lebanon [1].

towards the sea within the Lebanese territory. The fourth river (i.e. Hasbani-Wazzani River) is originated from Jabal Hermoun and then spans southward comprising the highest channel slope (40 m/km) of the four rivers. Except the Litani River, the other three rivers are Transboundary water resources.

2. Watersheds of the Lebanese Rivers

Elaborating the dimensions and mapping of drainage systems, including the catchment and the streams inside, is usually applied as a primary phase for detailed hydrological analysis and surface water assessment. Therefore, the geometric and morphometric analysis are utmost significant in watershed management to presume, for example, site suitability for surface water accumulation and harvesting, agricultural projects, dams' construction, hydro-power sites, etc.

Drainage systems of Lebanon including rivers were extracted directly from the stereoscopic satellite images (i.e. SRTM DEM) where digital elevation models were generated by magnifying the pixel details, and then slopes were extracted to determine flow directions and then stream delineation. Therefore, the digital extraction of drainage systems enabled calculating a number of geometric and morphometric measurements.

2.1 Geometry of the Lebanese rivers

Geometric measurements represent the calculations of the variables for the boundary of watershed (or catchment), and this will be totally separated from the properties of the streams (primary or secondary) included in the catchment. In this view, catchments with relatively large areas are usually subdivided into sub-catchments, which is dependent of the purpose of study applied.

For Lebanon, the area of rivers catchments is small and averaging about 250 km^2 for the coastal rivers if excluding the Litani River, which is an inner-coastal river. Hence, the largest area belongs to this river (i.e. Litani) and the smallest one belongs to Siniq River (**Figure 1** and **Table 1**).

1. Basin maximum length (B_l): This represents the maximum straight length of the catchment where it extends almost parallel to the primary watercourse, and it reflects the topographic orientation of a catchment

   B_L is a function of water arrival time to reach the outlet, and thus it controls the time of leakage, evaporation, and transpiration **Table 1** shows the maximum length of catchments of the Lebanese rivers

2. Basin width (B_w): The ratio of length of a catchment to its width significantly affects water flow to the outlet, thus when the difference between the length and width of a catchment is relatively low, that means the flow will be more regular and takes more time than it when this difference is high. For Lebanon, the B_w of rivers catchments are shown in **Table 1**.

3. Elongation Index (E_i): This represents the ratio between the diameter of the circle with the same area (A) as the catchment, and the distance between the maximum two points (B_l) in the catchment [3]. It is expressed by the formula:

$$E_i = \frac{2\sqrt{A}}{B_l\sqrt{\pi}} \tag{1}$$

No.	Catchment	A (km^2)	B_l (km)	B_w (km)	E_i	F_f	R_r
1	El-Kabir R.	303*	43	7.5	0.35	0.10	0.34
2	El-Bared R.	284	27	11	0.70	0.38	0.25
3	Abou-Ali R.	482	35	16	0.69	0.38	0.46
4	El-Jaouz R.	196	32	6.5	0.49	0.20	0.42
5	Ibrahim R.	326	40	8.5	0.57	0.20	0.47
6	El-Kaleb R.	237	36	12	0.48	0.18	0.57
7	Beirut R.	216	31	9	0.44	0.22	0.53
8	Ed-Damour R.	333	32	10	0.65	036	0.51
9	El-Awali R. R.	291	33	9.5	0.58	0.27	0.33
10	Siniq R.	102	19	5.5	0.60	0.28	0.26
11	El-Zahrani R.	140	28	6.5	0.48	0.18	0.28
12	Litani R.	2110	145	16	0.36	0.10	0.21
13	Al-Assi R.	1930*	51	31	0.98	0.76	0.25
14	Hasbani-Wazzani R.	645*	52	11	0.55	0.24	0.27

**Catchment area within Lebanon.*
R = River.

Table 1.
Geometric measurements of the Lebanese rivers' catchments [1].

Table 1 shows the calculated E_i for the catchments of the Lebanese rivers. According to Schumm [3], E_i is: < 0.5, 0.5–0.7, 0.7–0.8, 0.8–0.9 and 0.9–1 for more elongated, elongated, less elongated, oval and circular; respectively.

4. Form Factor (F_f): It is the numerical index used to determine ratio of the basin area to square of the basin length [1]. It is a function of the flow energy in the catchment. Thus, form factors for the catchments of the Lebanese rivers are shown in **Table 1**.

Hence, F_f must be less than 0.7854 [4]. Therefore, smaller F_f value indicates more elongated, while high F_f value experience larger peak flows of shorter duration. According to Horton (1932) form factor is expressed as:

$$F_f = \frac{A}{L^2} \tag{2}$$

5. Relief gradient (R_r): This is the ratio between the altitude at the highest and lowest points on the catchment, and it is calculated according to following formula [5]:

$$E = \frac{\text{Mean Elevation–Minimum Elevation}}{\text{Maximum Elevation–Minimum elevation}} \tag{3}$$

2.2 Morphometry of the Lebanese Rivers

These represent measurements for the dimensions, orientation and the connection between different streams in a catchment [6]. Thus stream morphometry evidences the origin and evolution of drainage networks, geomorphology and

No	Catchment	Length (km)		S_s	C_s	D_d	M_r	T_t
		Straight	Curved	m/km	—	S/km^2	%	—
1	El-Kabir R.	46	59	17	25	3.00	78	3.77
2	Al-Bared R.	37	49	13	14	1.00	76	2.75
3	Abou-Ali R.	42	54	54	46	1.75	78	6.95
4	Ej-Jouz R.	33	37	27	44	2.40	89	5.51
5	Ibrahim R.	44	50	63	45	5.30	88	16.30
6	El-Kaleb R.	35	41	66	45	6.10	85	17.25
7	Beirut R.	48	58	52	50	5.80	83	14.89
8	Ed-Damour R.	45	54	51	46	5.30	83	18.15
9	El-Awali R.	50	61	36	44	4.35	82	10.90
10	Siniq R.	18	21	7	9	2.35	86	7.54
11	Ez-Zahrani R.	36	41	8	13	2.10	88	8.16
12	Litani R.	163	174	5	8	0.84	83	0.54
13	Al-Assi R.	31	33	19	21	1.27	94	13.03
14	Hasbani-Wazzani R.	22	25	14	11	1.14	88	5.06

Table 2.
Major morphometric measurements of the Lebanese rivers' catchments [1].

geology of the underlying stratum. For this reason, stream morphometry controls water flow regime and mainly the flow energy. **Table 2** shows the main morphometric calculations for the streams (primary and secondary) in the Lebanese rivers' catchments.

1. Mean stream slope (S_s): It is the difference between the altitude at the source and the altitude at the outlet with respect to the total stream length. Thus, higher S_s results high flow rate along the primary stream in the catchment and vice versa. The following formula represents S_s [7]:

$$S_s = \frac{\text{Elevation at source–Elevation at outlet point}}{\text{Length of stream}} \quad (4)$$

2. Mean catchment slope (C_s): This is calculated by dividing the difference in elevation between points at defined lengths of the catchment (e.g. 0.85 L towards the upper and 0.10 L near the lower part of the catchment) over the length of the catchment. Hence, C_s is expressed by the following formula [8]:

$$S_b = \frac{\text{(Elevation at 0.85 L)–(Elevation at 0.10 L)}}{\text{Elevation at 0.75 L}} \quad (5)$$

3. Drainage density (D_d): This represents the degree of streams congestion in an identified area of the catchment. Thus, it is calculated by dividing the total length of streams within the identified area in the catchment. Hence, streams with high density indicate lower permeability of terrain surface if compared with lower density stream [9]. D_s is calculated according to the following formula:

$$D_d = \frac{\Sigma \text{L (total of all stream segments)}}{A \text{ (area of the basin)}} \tag{6}$$

4. Meandering ratio (M_r): It is ratio between straight and curved length of the primary stream in the catchment [2]. Therefore, higher M_r ratio reflects low run-off energy and higher sedimentation rate. M_r can be calculated as follows:

$$M_r = \frac{\text{L (straight)}}{L \text{ (curved)}} \tag{7}$$

5. Texture topography (T_t): This evidences the ability of a terrain to infiltrate water as it is controlled by rock types and structures in the catchment. It is calculated as the total number of streams (N_s) of all order in a basin per perimeter (B_p) of the basin [10]. Hence, T_t is calculated by the following equation [11]

$$T_t = \sum N_s / B_p \tag{8}$$

Smith [11] classified the texture topography as: very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8).

3. Volumetric measures of the Lebanese rivers

It is significant to calculate the volume of water that enters the drainage system of rivers. This assists in characterizing the catchment ability to capture and outlet water. This requires elaborating quantitative analysis in the each catchment, where the volume of precipitated water and discharged water are measured.

For the precipitated water, data were collected from the available meteorological ground stations, as well as form remotely sensed products, with emphasis to Tropical Rainfall Mapping Mission - TRMM [12]; Climate Hazards group Infrared Precipitation with Stations - CHIRPS [13]; and from National Oceanographic Data Center – NOAA [14]. While, the discharge from the Lebanese rivers is periodically measured by the Litani River Authority (LRA) [15]. Therefore, water volume enters and outlet, along rivers, from each watershed was calculated as shown in **Table 3**.

Table 3 shows that the average volume water enters the catchments is about 480 million m^3/year, and the average discharge is approximately

No.	Catchment	Area (*A*)	Rainfall (*R*)	Discharge (*D*)	*D/R*	*R/A*
		km^2	Mm^3/year		%	Mm^3/km^2
1	El-Kabir R.*	303	260	222	—	0.38
2	Al-Bared R.	284	225	165	73	0.79
3	Abou-Ali R.	482	505	365	72	1.04
4	Ej-Jouz R.	196	125	80	64	0.64
5	Ibrahim R.	326	380	495	131	1.16
6	El-Kaleb R.	237	330	225	66	1.39
7	Beirut R.	216	260	100	38	1.20
8	Ed-Damour R.	333	335	255	76	1.00
9	El-Awali R.	291	320	280	88	1.09

No.	Catchment	Area (A)	Rainfall (R)	Discharge (D)	D/R	R/A
		km^2	Mm^3/year		%	Mm^3/km^2
10	Siniq R.	102	100	60	60	0.98
11	Ez-Zahrani R.	140	145	200	137	1.03
12	Litani R.	2110	2078	360	17	0.98
13	Al-Assi R.*	1930	1254	420	—	0.65
14	Hasbani-Wazzani R.*	645	598	225	—	0.89

**Transboundary River*

Table 3.
Volume of precipitated water discharged water from the Lebanese rivers' catchments [1].

247 million m^3/year. This indicates that the Lebanese rivers are discharging only about 51% of the precipitated where the rest 49% goes to the evapotranspiration and for groundwater recharge [1].

4. Water pollution in rivers

It is estimated that in Lebanon, more than 50% of water resources are under physiochemical and biological contamination, and rarely a source of water in Lebanon is pure [16]. Lately, the problem of water quality deterioration has become one of the major is striking challenges that acts on the national level, and it severely hurts human life. This includes mainly the pollution of surface and then followed by groundwater resources.

This unfavorable problem is being increased by the absence of the controls and therefore, disposal of liquid and solid wastes (i.e. industrial, municipal and agronomical wastes) is widespread, notably in river courses and streams. Hence, the bad geo-environmental situation, due to water pollution, added a challenging issue for the water sector in Lebanon, while it is surprising that no effective actions have been taken by the concerned governmental bodies and even there is unethical behavior by some inhabitants in different regions of the country.

The Litani River, the largest river in Lebanon, gives a typical example on water pollution in the country. This rivers, which includes more than 370.000 people in 246 towns and encompasses 174 km length, has been lately witnessing intensive pollution pressure. This implies the river Couse and its reservoir (i.e. Qaraaoun Reservoir). Therefore, it was described as "Death of a River" [17]. In this respect, pollution sources were determined including direct dumping of huge amounts of solid wastes and high volume of sewage water into the river course and its tributaries, excessive use of fertilizers and well as the presence of many landfills within the catchment of the river and thus acting on groundwater purity.

Many surveys and studies have been done to investigate water quality in Lebanon where some of them aimed also at identifying the sources of pollution. The largest number of these studies were either applied to selective regions, or sometime they were applied for a limited time period specific, while other studies investigated only one aspect of pollution (e.g. microbiological pollution).

It is still a paradox that even with the large number of studies, nothing has been improved yet in regard to water quality in all resources; besides the pollution level in being continuously increased. Moreover, no effective management plans have been addressed to resolve the problem, and if they are proposed/exist, they remain propositions or without creditable implementation.

There are many examples can be illustrated to expose the current situation on the deteriorated water quality in Lebanon. Below are some example [18]:

1. The analysis of selective water samples from the Litani River shows:

    - Nitrite (NO_2) 19 ppm (max. 0.1 ppm)
    - Chromium (Cr^{3+}) 0.27 (max. 0.05 ppm)
    - Staphylococcus 8750 (0 in 100 ml)
    - Total coliform 183,000 (0 in 100 ml)
    - Fecal coliform 180,000 (0 in 250 ml).

2. The analysis of water quality the Qaraaoun Reservoir shows [19–21]:

    Sodium (Na): 10 mg/l (WHO max. 200 mg/l)

    - Chromium (Cr) 0.02 mg/l (WHO max. 0.05 mg/l)
    - Zinc (Zn) 0.09 mg/l (WHO max. 3 mg/l)
    - Copper (Cu) 0.019 mg/l (WHO max. 2 mg/l)
    - Cylindrospermopsin toxin 1.7 μg/L (WHO guidelines 0.7 μg/l)
    - Cyanobacteria up to 200 μg/l (WHO limits 10 μg/l)
    - Carlson trophic state index 66 to 84 (CTSI max. 40).

3. The analyzed samples of groundwater analysis in different boreholes located in the Bekaa Plain showed that Nitrate (NO_3) concentration exceeded 300 mg L^{-1} [22].

4. The analyzed bottled water which were taken form 48 major water companies in Lebanon showed that approximately 80% were contaminated either chemically or biologically or combination of both [23].

Due to its significance and the resulted severe impact on human health and even life, there are some implementations done for waste disposal management, and thus several national and international projects were applied. Moreover, field campaigns, capacity building, inter-ministerial committees and business plans were established to identify the required measures and secure water quality and the existing ecosystems, but no enhancement in this concern could be touched yet [17].

5. Uncontrolled water pumping

In the view of shortened water supply besides an exacerbated demand, inhabitants are always searching for any available sources of water to compensate the difference between supply and demand. This primarily accounts the ease and the low-cost of exploitation of these sources. Hence, rivers are the most applicable resources to be invested in Lebanon, notably that these rivers and their major tributaries are widespread over short distances between urban clusters and among the arable lands where water is competitive. Hence, many rivers' tributaries are only few kilometers from each other.

In addition to this geographic aspect of the Lebanese rivers, there is no consolidated and effective environmental controls to regulate the behavior of people towards the exploitation of water from rivers. This can be also attributed to many other reasons including mainly the political situation in the country. Therefore, unfavorable works are widespread in all the Lebanese rivers, and illegal water abstraction from rivers plus dumping of liquid and solid wastes are commonly observed. These works can be summarized as follows:

1. Direct water pumping from rivers and the surrounding springs where this pumping does not follow and control or measuring approaches (i.e. illegal), and this is very common in upstream regions of the Lebanese rivers. The largest part (>90%) of the pumped water goes to irrigation (Example in **Figure 2**).

2. Uncontrolled water use from rivers where several private water systems are connected with rivers, and then conveying water along private-owned canals for irrigation. These canals can be for hundreds of meters long.

3. Chaotic water abstraction whether from the recharge zones of rivers, where rivers receive their water from, or from the recharge zones of springs and groundwater aquifers which in turn replenish rivers.

Figure 2.
Illegal pumping of water from rivers in Lebanon, a common observation.

6. Transboundary rivers

In spite of the small surface area of Lebanon (i.e. 10,452 km^2), the geography of the country makes its water resources shared with the neighboring regions. Therefore, about 2631 km^2 of Lebanon's surface area constitutes shared groundwater reservoirs with the neighboring regions, and this is equal to approximately 25% of the Lebanese area [2]. In addition, there are approximately 2878 km^2 (27.5%) of Lebanon's surface area comprises basins for transboundary rivers with the riparian regions. Thus, Lebanon contributes with major tributaries for three transboundary rivers [2]:

1. Al-Kabir River (222 million m^3/year from Lebanon): It almost represents the northern international boundary of Lebanon with Syria, and it encompasses a catchment area of 972 km^2 where 303 km^2 are in Lebanon.

2. Orontes River (420 million m^3/year from Lebanon): One of its major tributaries is originated from Lebanon and then named as Al Assi River. It is shared with Syria and Turkey with a total catchment area of 25,300 km^2 where 1930 km^2 are located in Lebanon.

3. Jordan Rivers (225 million m^3/year from Lebanon): In Lebanon the Hasbani-Wazzani River represents one of the primary tributaries of Jordan River which is shared with Syria, Jordan and Israel. The river, which is under frequent geo-political conflicts, has a total catchment area of about 18,425 km^2, only 645 km^2 of them are in Lebanon.

There are only 210 million m^3 of water which is used by Lebanon from shared water resources of the country [2], and this volume constitutes water pumped from transboundary rivers, as well as the estimated water abstracted from dug wells in shared groundwater aquifers). This volume represents only about 15% of the total volume of these resources.

In the lack to proper management of these shared water resources; however, Lebanon loses a significant portion of its water. According to Shaban and Hamzé [2], if Lebanon adopted integrated and appropriate management approaches for its shared water resources, and then work in the direction of utilizing around 50% of these resources; thus, a water volume of about 700 million m^3 can be added to the budget of water in Lebanon.

If this volume is allocated to consumers in the country; therefore, approximately 175 m^3 per capita (i.e. equivalent to about 80% of water demand per capita) will be added to water supply. Whereas, the benefit of about 60% of shared water in Lebanon; will totally provide the water demand per capita. This in turn catalysis the adoption of these resources which can be done by following integrated management strategies of these resources.

7. Dispute on dams construction

Lebanon is characterized by mountain topography where acute sloping terrain is dominant, and the majority of precipitation (rainfall and snow) accumulates on the elevated areas and then water rapidly flows along these slopes. The journey of water flow from mountains to the sea takes short time interval which was estimated approximately as few hours, notably that the average distance of flow does not exceed few tens of kilometers.

Therefore, the flow of water from the Lebanese mountains is considered as a major aspect of water loss and water outlet into the sea before any significant investment. Therefore, water harvesting should adopted as an alternative solution to tap water along the Lebanese rivers instead of water loss. Hence, construction of dams will be an optimal solution.

There are dams constructed in Lebanon along some rivers and major tributaries, but they are still of small-scale dams, except the ones of Qaraaoun and Shabrouh dams, which have capacity of 220 and 11 million m^3; respectively. In this regard, the

Ministry of Energy and Water (MoEW) obtained a long-term plan for surface water development within the horizon of 2030 where 18 dams are proposed.

It is unlikely that the Lebanese administration and public finance can accomplish the planned long-term plan for constructing the proposed dams and lakes before 2030. Reasons behind postpone/or obstruction of dams construction in Lebanon are tremendous. One of these reasons is the dispute on dams' construction, and more certainly the believe that the topography and geology of Lebanon are not suitable for dam's construction; in particular the seismic setting of Lebanon does not assure the stability of dams [1]. Therefore, there is always debate on dams' construction in Lebanon. Lately, a problem has been existed even on the political level where the two proposed dams of Bisri and Janeh regions have been come to the implementation phase. Thus, there is of postponing to start working on these dams due to the existed conflicts about their location suitability.

8. Conclusion

Rivers in Lebanon are compose the veins of agricultural development, notably that the largest portion of water supply is delivered from rivers, as well as rivers constitute about 42% of water resources in Lebanon besides 32% from groundwater and the rest 26% is from other sources and mainly springs. However, these estimates are still rough and the water cycle in Lebanon can be considered as a comprehensive cycle where all elements of water journey are included. Thus, rivers feed groundwater, and the later replenish spring and so on.

Rivers in Lebanon discharge about 2800 million m^3 per year, which a significant part of the water balance in Lebanon. Nevertheless, only 25% (or even less) of this amount is exploited and the rest is either lost to sea or shared with the neighboring regions.

The exploitation of water from these rivers is almost chaotic and illegal, notably for irrigation which consumes more than 70% of water in Lebanon. In addition to domestic and industrial uses, water from rivers is also used for hydro-power generation and it contributes to approximately 20% of electricity needs for the entire country.

There are several threats existed lately on these rivers and they include natural and man-made threats. Hence, the average annual discharge rate in rivers has been sharply decreased and some rivers showed decline in the discharge reach up to 60% of its normal discharge rate. This is attributed either to the direct pumping from these rivers or the over pumping form the feeding zone for springs and groundwater aquifers. In addition, the changing hydrologic regimes of the terrain surface plays a major role in controlling the amount of water in rivers [1].

Moreover, pollution is a major problem in all Lebanese rivers and rarely a river in Lebanon is found with pure water. Thus, outfalls from wastewater (e.g. sewages, domestic, etc.) sources and delivered towards rivers. This made some rivers, like the Litani River, as a source of contamination and diseases became widespread in the proximity of its tributaries. In addition, the physiochemical and bacteriological analysis of water and sediments in many of these rivers showed contamination exceeds several times the accepted standards.

The solution for the Lebanese rivers implies adopted an integrated management of river' water. This can be built in the context of a national water strategy where assessment and monitoring must be continuously applied, and this can be consolidated by creating environmental legislations and laws devoted for water in rivers of Lebanon.

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