Land-Water Linkages in Rural Watersheds Electronic Workshop

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Case Study 15

Environmental impacts and vulnerability of water resources in the Berdawni rural watershed, Bekaa, Lebanon

T. Darwish, M. Khawlie, I. Jomaa and R. Chihny
National Center for Remote Sensing of NCSR
Beirut, Lebanon
email: rsensing@cnrs.edu.lb

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, Italy

THE BERDAWNI WATERSHED

The area lies at the footsteps of the eastern slopes of Mount Lebanon, overlapping downhill with the Bekaa Plain, covering about 14000 ha. Steep to moderate slopes dominate the west, and they grade towards the plain eastward through a succession of hills (Fig.1). It spans sub-humid to semi arid environments with precipitation varying between 500-700mm, and temperatures of 2°C-38°C over the year. The higher and hilly reaches are mostly occupied by the city of Zahlé and its suburbs, though the last two decades witnessed a chaotic urban expansion downstream and also scattered growth of near-by settlements in the plain at the expanse of agricultural land. This meant a rapid rate of change in population density from an estimated 800/km^2 in 1980 to more than around 2150/km^2 now.

This central area in Bekaa, around Zahlé, is the most industrialized, therefore witnesses sources of industrial pollution. It also plays a very significant agricultural role. It is characterized by fertile soil and abundance of both surface and groundwater. This allows the production of consequent cash field crops like wheat, potato, sugar beet, fruit trees and vegetables. High crop water demands used to be satisfied, but recent water shortages made farmers use non-conventional sources of irrigation water with hazards of contamination of soil and water resources. The increase in demographic pressure through dense and scattered urbanization resulted also in domestic solid and sewage wastes dumped into the open lands or water streams. Land use in the area is not based upon adequate requirements and planning. Industrial effluents, agrochemicals, solid waste disposal, animal husbandry, land degradation and soil erosion in the upper areas have caused substantial changes in the quality of the downstream shallow water table and soil resources. The complex nature of the soil-water pollutant interaction downstream imposes serious problems threatening the quality of life, which needs proper integrated approaches.

DOWNSTREAM WATER IMPACTS AND ASSESSMENT

In the plain downstream, where agro-practices increase, irrigation consumes almost 80% of the water that mostly came from surficial sources. These have become more polluted. That led to increasing demand on less polluted water from the subsurface. Farmers started putting more pressure by exploiting water wells for irrigation. Now, hundreds of private wells exist in the area that are uncontrolled. The hydraulic level in the wells is between 10 and 150m depth (Hobler & Rajab, 2000). Shallow ground water is more common in less exploited areas. Nevertheless, some wells downstream show an artesian nature. The statically high level of the ground water, i.e. its shallowness, makes it vulnerable to bacteriological and chemical pollution originating from liquid, human and industrial wastes, etc.

Chemical analysis were done of the water branches nourishing the Litani River (Fig.1). The branches are the Berdawni with a varied industry including paper, tannery, construction materials, and hospitals, and the Ghouzaiel branch with sugar, glass, ceramic and aluminium industries as well as the Litani itself and the Qaraoune Lake (further downstream of Litani). The analysis revealed pollution levels exceeding the norms, i.e. WHO standards for drinking water. As a result, swimming and fishing were forbidden in the lake. Analysis showed some accumulation of Cr in well water (Table 1). Ni and Cr in the Litani River, Pb in the Berdawni River, exceeding the values of tolerance set by the German Act on Soil protection. These water resources, among others, are nourishing the lake.

Obviously, wherever water is polluted, soil is polluted, and vice-versa. The characteristics of the surface cover, i.e. parent material/soil, and the hydraulic character, i.e. how facilitated is the water flow laterally and vertically, will determine the rate of transfer and, therefore, the extent and duration of pollution. The vulnerability of the two resources, soil and water, is pretty much the same. But, and until further specific information is available, the surficial spatial pollution correlation between the two is more likely to be positive than the deep subsurface one. This was

proved by the analysis of the O_2 and heavy metals content in both water sources undertaken by fieldwork. The O2 concentration showed a value of only 0.15mg/l (Table 1) in the downstream of Berdawni river after receiving the wastewater. The value increased until 1.47-2.9mg/l in the deep water well and reached normal values by ISO standards in the open reservoir, whose water is obtained from the seepage of shallow water table, and used for irrigation. In the absence of natural sources of soil and water salinization, the EC values of water sources downstream slightly exceed those of the FAO standards for optimal irrigation water quality, i.e. they represent a slight use restriction in clay soils, which are rich in active clay, as salt buildup in the soil can cause possible problems for salt sensible crops.

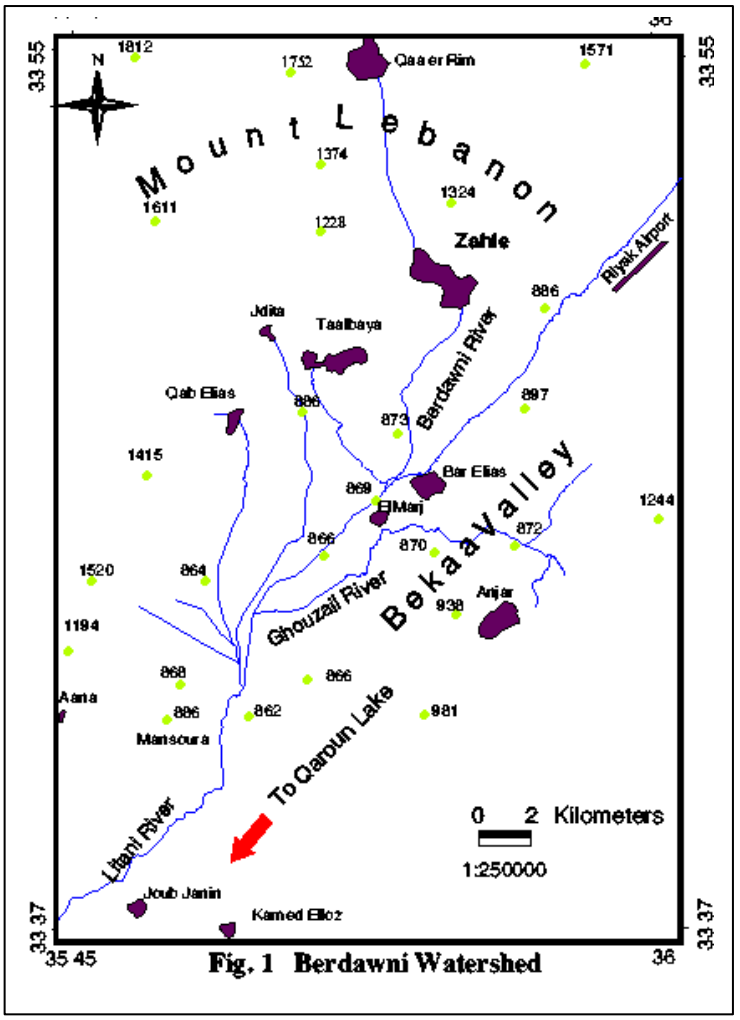

Fig. 1 Berdawni Watershed

Cr and Ni accumulate yearly with irrigation water derived from the Litani River (Table 1) and reservoirs collecting water from below the surface near the Saadnael and Marj villages. The annual input varies from 125 to 153g/ha and from 1152 to 2195g/ha for Ni and Zn, respectively.

TABLE 1
Preliminary analysis of water resources downstream in the study area
(Assessment is done according to the German Act on Soil Protection)

Source@	pH	TC°	EC ds/m	NO_3* mg/l	O_2 mg/l	Ni (µg/l)	Cr (µg/l)	Cd (µg/l)	Pb (µg/l)
Shallow open water reservoir 2m	7.64	13.7	0.87	-	7.03	13.9	6.4	0.06	0.86
Berdawni River	7.43	13.3	0.88	>200	0.15	6.8	3.8	0.16	14.7
Litani River	-	-	-	-	-	15.3	10	0.2	6.3
Deep well 70m	7.21	16.6	0.84	270	2.9	5	4	0.02	0.4
Shallow well 8m, El-Marj	7.0	17.4	1.13	-	1.47	12.5	5	0.03	0.95
Level of tolerance	-	-	<0.75	40	-	<15	<1	<1.5	<15
Level of intervention**	-	-	-	-	-	15-37	1-26	1.5-6	Not available

@ Sources are presented according to their position in the watershed-from upstream to downstream
* Analysis values are still being verified
** Level above which a management measure is needed to alleviate the impact and prevent hazards

APPLICATION OF REGULATORY MEASURES

In view of the preceding picture, it is obvious that the quality of living is deteriorating in the area, particularly downstream. The vulnerability of both water and soil to pollution in the area and surrounding is considerably high. The vulnerability is taken to imply the ease of deterioration due to the overall character of the resource, its potential plus actual contamination by the different studied polluting parameters, and its closeness to level of intervention mentioned above. It is estimated as follows:

Vulnerability Category:	Low	Medium	High
Water*	60	30	10
Soil* (land)	45	40	15

* values are estimated percentages of area coverage

Regulatory measures are a must, and they must be taken now. The nature of the problem, its extent, and stakeholders involved call for both top-bottom and more important bottom-top approaches, especially participatory procedures. Any environmental impact affecting land-water interaction in a watershed area and surrounding must take into consideration the following tri-procedural operational measures:

Prioritization

Management Level: Both the central and local authorities (C & LA) must define and implement relevant strategies and policies to assure quality of living of all stakeholders and sectoral needs through imposing water values and instream values, i.e. allocate an adequate costing for water use and secure that the quality of stream water allows in-stream activities such as swimming, fishing, … etc. Ascertaining local participation priorities must also be defined.

Control Level: Again the C & LA must monitor and secure updated databases, standards, supply/demand allocations, quality assurance and human plus ecosystem health compliance. It is crucial that the LA cooperate in a participatory manner with the community.

Technical Level: The C & LA must go through routine institutional upgrading and capacity building. They should implement a continuous Impact Assessment Program (IAP) through the different watershed components, especially land use and natural resources utilization. Again here, public participation is an utmost necessity.

Environmental Impact Assessment

Because there are some projects of scale, e.g. industrial, waste disposal, hospitals, sewage treatment, agricultural activities, irrigation … etc., it is imperative that the C & LA impose an EIA commissioning studies for these projects. As a minimum, those EIA studies should include:

a. Total physico-environmental characterization of the area
b. A detailed project evaluation and quality control
c. Define potential environmental impacts
d. Estimate cost of requirements to reduce or eliminate negative consequences

Integration and Performance

1. Focus strategies and policies on quality performance (C & LA)
2. Follow total watershed management, i.e. the whole upstream and downstream terrain with interactive land-water-socio-economic aspects on a resource sustainability basis (all included)
3. Control water sources, uses and sinks (C & LA + others)
4. Adopt appropriate technologies
5. Capacitate networks and upgrade personnel including special programs for public participation (C & LA).