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PARTICIPATORY WATER SAVING MANAGEMENT AND WATER CULTURAL HERITAGE: LEBANON COUNTRY REPORT

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SUMMARY – The Lebanese experience in participatory water management is recent and undeveloped. The small size irrigation schemes and the weakness of water management services have left a gap in water saving policy. The main experience related to local water saving issues derived from specific cases of scheme rehabilitation and construction. Private irrigation from wells has developed its own experience in irrigation techniques. Recent results about underground water table monitoring showed a drop of 15 m in level in South Bekaa Valley, this is mainly due to uncontrolled proliferation of private wells. The irrigated areas in Lebanon consist of 90,000 ha. It consists of 73% of schemed and 27% of private irrigation. There are actually 67 medium and small schemes, two of them are pressurized. Average farm size is generally small (1.8 ha). Post-war period has featured increasing concern about water saving issues. Beside research activities on farm level, water saving policy in Lebanon consists of water management reorganization, water harvesting, schemes rehabilitation, and individual initiatives. In 2000, the government has reorganized the water management sector which includes irrigation, potable and sewage waters. Along the LRA and under the sponsorship of the MOEW, all water bodies were merged in four water authorities. The aim was to attain a better level of management, maintenance and efficiency. In 1999, the MOEW has lunched a 10 years master plan envisaging the construction of a series of mountain ponds and dams. Once implemented the plan will afford a storage capacity of 625 MCM. The Lebanese government has rehabilitated 24 irrigation schemes (5 medium and 19 small size), totalizing an irrigated area of 28,000 ha. Research activity in water use matters has focused chiefly on improving on-farm water use efficiency. An active player in this field is the Lebanese Agricultural Research Institute (LARI). However, the dissemination of new results and techniques at farm level is actually insufficient.

Key words: water saving policy, irrigation schemes, rehabilitated schemes evaluation, on-farm efficiency research.

WATER MANAGEMENT STRATEGIES AND ACTIVITIES IN LEBANON

Introduction

In Lebanon, water saving is a result of an applied policy at different levels (national, scheme and farms), with technical approach like water harvesting, network distribution, on farm equipment and refining by legislation, water management and water pricing. The role of researches is important and essential when results can be practically applied.

Lebanese experience in Participatory Water Saving Management is recent and modest. Small scale schemes and irrigation management weakness on administration and farmers' association levels have left a gap in water saving policy at the schemed irrigation level. Private irrigation from wells has developed its own experience in irrigation techniques. Actual Lebanese experience in water saving is coming from schemes rehabilitation at water distribution level and from private small irrigation scheme at farm level.

Lebanese Researches have developed many activities in the irrigation field, but those activities were not followed by extension activities at the farm level.

To avoid water scarcity, the Lebanese Government has started since the nineties a new policy based on:

- Rehabilitation of existing irrigation schemes (since 1994)
- Reorganization of water sector (since 2000)
- Ten year plan for water harvesting by dams and ponds construction starting in 2002.
- Implementation of new irrigation schemes with new technology pressurized water distribution systems.

Historical background

Before the seventies, all Lebanese irrigation schemes were open channel systems with gravity irrigation techniques at farm level. Since 1968, Litani River Authority (LRA) has designed and implemented its irrigation projects with a new conception in distribution network and in on-farm irrigation techniques. The first project with a pressurized system was Saida-Jezzine pilot sector, (sector for Hydro-agricultural Development Project in South Lebanon), followed by South Bekaa Scheme phase One. LRA has executed the main structures for the two schemes and equipped with distribution networks an area of 280 Ha, in the pilot sector and 2000 ha in South Bekaa scheme. In the pilot sector, LRA introduced sprinkler technique at farm level.

Lebanon war has stopped new collective irrigation projects and destructed a big part of implemented schemes. After the end of the war in 1990, rehabilitation and implementation were reactivated. Taking into consideration the water resources limitation, Lebanese water management authorities designed all new irrigation projects with pressurized water distribution system, using new water saving irrigation technologies at farm level.

Irrigation in Lebanon

The total equipped irrigation area in Lebanon is actually estimated to about 90,000 ha, shared between collective irrigation schemes and private small irrigation farms as shown in Table 1.

Table 1. Equipped irrigation area and effectively irrigated area

Category	*Collective Irrigation Schemes [ha]*	*Private small irrigation farms [ha]*	*Total area [ha]*
Equipped Area	65,600	24,400	90,000
Net irrigated area	59,070	21,960	81,030

Schemed irrigation
(Exploitation et entretien des projets d'irrigation au Liban - Study executed by Cadres Bureau for Ministry of Energy and Water in 1998)

Schemed irrigation consists of 67 small and medium schemes irrigated by surface water except the two LRA schemes cited before. Figure 1 shows irrigation schemes repartition at the national level. Table 2 gives the repartition of existing Irrigation Schemes by size.

As shown in Figure 1 and Table 2, these schemes are:

- Geographically dispersed around the national territory;
- Small to medium size, 60 (89.55%) of these schemes have an area smaller than 2000 ha and represent 53.75% of equipped area.

Only 41.65% of irrigation schemes area is fully irrigate in summer season. For the remaining area (58.35%) water resources permit to irrigate 56.5% in summer, 37.8% in winter spring season and 5.7 still without irrigation. Traditionally, majority of schemes has two irrigation seasons, spring-winter and

summer; intensification rate is relatively low (Equal to unit for the two season).
Table 2. Classification by size of existing Collective Irrigation Schemes

Size Class in ha	Number of Schemes	Equipped area [ha]	Net Irrigated Area [ha]
80-200	17	2,260	2,040
201-500	19	6,770	6,110
501-1000	13	10,040	9,040
1001-2000	11	16,190	14,570
2001-5000	5	16,740	15,070
5001-8000	2	13,600	12,240
Total	67	65,600	59,070

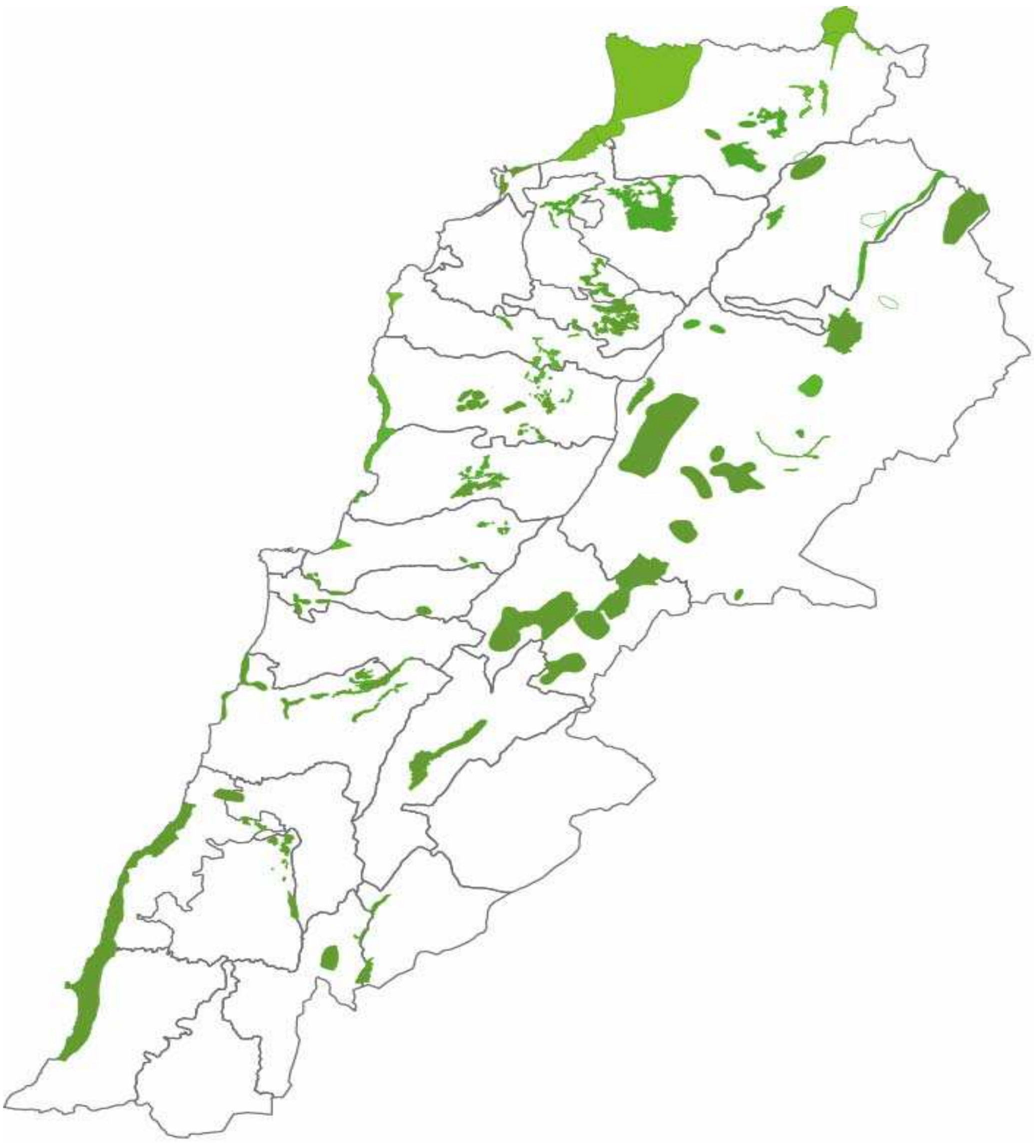


Fig. 1. Existing Irrigation Schemes in Lebanon

About 26% of the area is irrigated until June. Table 3 summarizes the main crops growing in winter and summer irrigation season.

Table 3. Main crops (in ha and %) growing in winter and summer irrigation season

	Winter Irrigation	Summer Irrigation			Total area
	Cereals Wheat	Fruit Trees	Vegetables	Partial total	
Area in ha	15,277	21,136	22,657	43,793	59,070
Percentage of total area	25.86	35.78	38.36	74.14	100.00

Farmers in these schemes are small owners: 60% of owners have parcels fewer than two ha size. The average farm size for all schemes is 1.8 ha.

Small private irrigation

Small private irrigation farms are mainly sited in Bekaa Valley and partially in coastal plain area and Akkar plain. The underground water provided by private wells is the main water resource. As shown in Table 1, total irrigated area is about 22,000 ha.

LRA has monitored underground table level for 12 wells in the South Bekaa region. Results for two years (LRA archives) shows a decrease of 15 meters in South Bekaa Valley and some wells dry up early during irrigation season. The management of these wells needs to be revised in a way to control and regularize underground water exploitation.

In Bekaa valley, 95% of irrigated area is dedicated to annual crops especially potatoes and vegetables with bi annual rotation alternating wheat with previous crops. In the coastal area, land use is divided between citrus orchards and vegetables in field or under green houses.

Water Sector Authorities and their responsibilities

In 2000, the Lebanese government has reorganized the water management in Lebanon. Along with the Litani River Authority, which is responsible of the water projects on Litani basin, the government has created four new water management authorities. These are in charge of drinking, irrigation and sewage water. All the water authorities are functioning under sponsorship of the Ministry of Energy and Water (MEW). New Authorities structure is shown in table 4.

Table 4. New Water Authorities Structure

New Water Authority	Previous Regional Water Authority	Local Committees		
		Potable	Irrigation	Total
North Lebanon	8	8	51	64
Beirut& Mount Lebanon	6	11	52	70
South Lebanon	5	5	6	17
Bekaa	3	14	44	58
Total	22	38	153	209

Ministry of Energy and Water (MoEW) responsibilities are:
- General water policy including streams responsibility and underground water recharging;.
- Main structures construction: dams , lacks, ponds ,etc.;
- Water quality and legislation;
- Water Authorities control.

Water Authorities responsibilities:
- Study, rehabilitation, execution and management of water projects(adduction and distribution

network);
- Water quality control and water pricing.

Litani River Authority responsibilities (LRA):
- Litani Watershed development: Hydroelectric power plant, Irrigation schemes including main structures construction and South Lebanon domestic water provision;
- The management of south Bekaa and South Lebanon irrigation schemes sited outside the Litani watershed;
- Surface water measurements in total national territory.

Actually, the water sector undergoes a transitional period; new organization is under implementation and will replace an old system grouping 22 water regional authorities, 209 committees and some municipalities.

Before year 2000, the management of these schemes was done by diverse organisms as shown in table 4: Ministerial committees, municipalities, water authorities, farmers committees, cooperatives or farmers associations. Ministerial committees are constituted by decision of minister or general director of Energy and Water Ministry.

In general, committees, cooperatives and farmers association cannot assume maintenance because of:
- Small size of schemes and high number of committees.
- Distance between schemes does not help to associate management of several schemes.
- Low farmers revenues does not encourage to investment in maintenance.
- Farmers mentality consider water as haven gift and don't accept any fees related to water management particularly in regions where schemes are very old.

In general, maintenance is limited to very important needs. Main maintenance budgets is allocating by the Ministry of Energy and Water (MoEW). Operation in these organizations is limited to water distribution control. Water is distributed in time-share relative to irrigated area. One or more persons (Shawi) are hired by irrigation season to execute the schedule. Maintenance is better when management is the responsibility of municipalities or water authorities.

The new organization assembles regional water authorities and committees in a new powerful organism capable to have efficiency in water management and especially in maintenance. It is sure that new system organization will assure water saving. Parallel to this structure, many other ministries and institutions are partially involved in water management:
- Ministry of agriculture: Responsible for agricultural extension services and creation of small schemes and water ponds.
- Ministry of environment is involving in water quality.
- Green plan is constructing ponds, small water reservoirs.
- Lebanese Agricultural Researches institute acting in researches.
- National Meteorological Service, which is managing climatic data.
- National Center for Scientific Researches including Remote Sensing Center
- Four Agricultural Faculties: Lebanese university, American university of Beirut, Kaslik University and Saint Joseph university.
- NGO organizations: Abdel Aal Association is the most important.

WATER SAVING POLICY

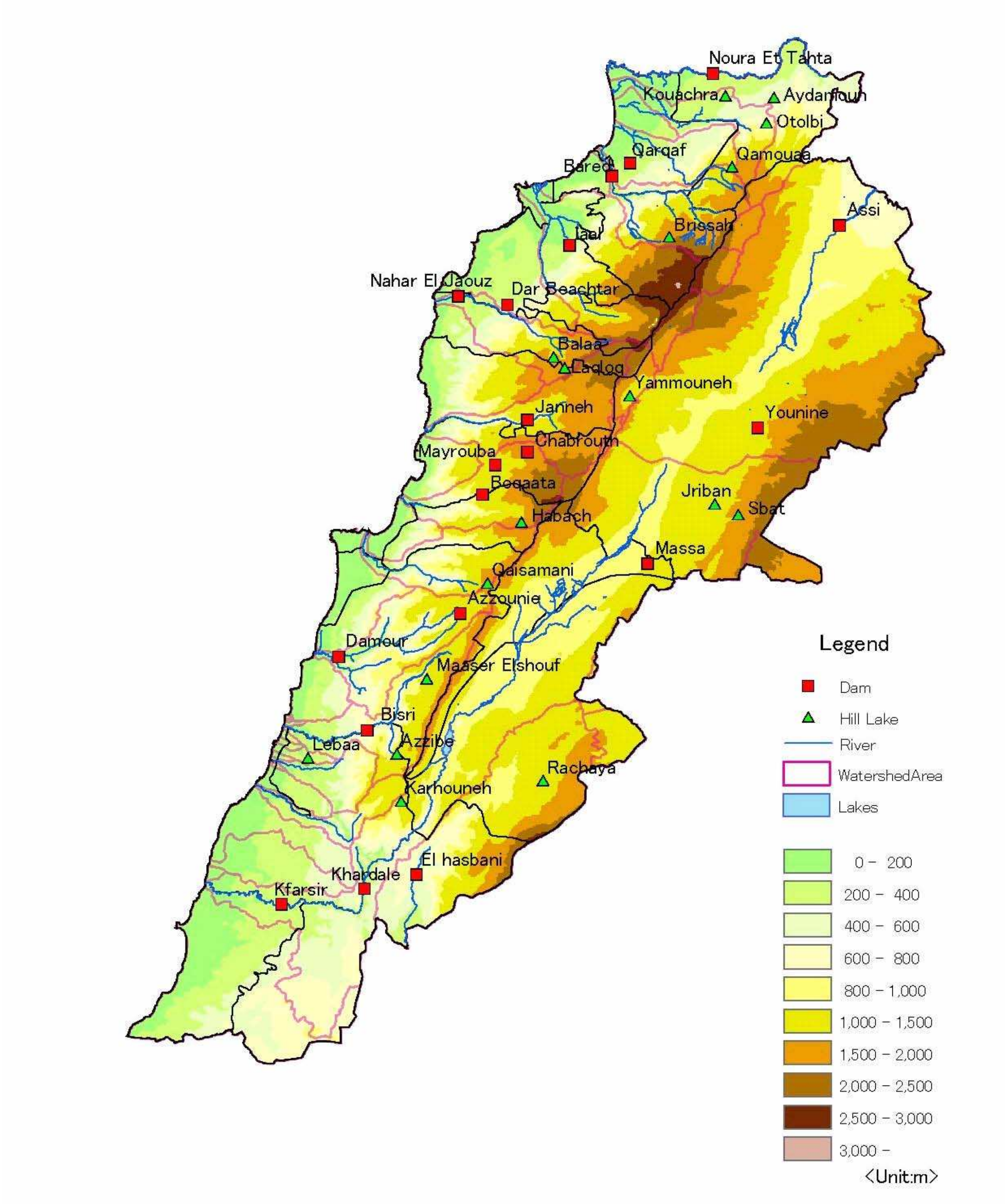
Many activities contribute to overall water saving policy including water harvesting and increase of water storage capacity, schemes rehabilitation, on-farm water management research programs, etc.

Water harvesting and increase of water storage capacity

Water harvesting is a very old practice beginning with small and medium irrigation schemes implementation: Civil structure on springs, diversion dams on rivers, small pounds and reservoirs. The most important dam is Qaraaoun constructed in 1959 with a storage capacity of 220 MCM. To increase water capacity storage, a Ten Years Master Plan, prepared by the Ministry of Energy and Water, was approved by the council of ministers in November 1999 to construct:

- 17 dams with total storage capacity of 625 MCM;
- 25 ponds of which 13 have a storage capacity of 10.68 MCM and 12 ponds with an estimated capacity of 5 MCM.

A law in 2002 has approved the allocation of construction budget and execution is previewed between 2004 and end of 2011. Figure 2 gives sites of these new storage structures and Table 5 gives details on capacities. Study and execution are the responsibility of MEW and LRA.



Fig, 2. Sites of the Master Plan's main storage structures

Table 5. Ten Years Master Plan for Dams and ponds construction

Dam	*Volume in MCM*	*Pond*	*Volume in MCM*
Noura Et Tahta	70	Qasmaneh	0.55
Qarqaf/ Wadi Jamous	20	Yammouneh	1.5
El Bared	40	Atlebi	0.7
Iaal	10	Kwachra	0.23
Dar Beachtar	55	Balaa	1
Nahar El Jaouz/Mousailah	9	Laklouk	0.8
Bisri	120	Maasser el chouf	1
Janneh	30	Wadi Sbat	1
Chabrouth	8	Wadi Jraibane	1
Boqaata	7	Brissa	1
Azzounie	4	Habach - Zaarour	0.5
Damour	60	Lebaa	0.8
Younine	7	Aazbyeh	0.6
Assi	37		
Massa	8		
Ibl el saki	20		
Khardale	120		
Total volume in MCM	*625*	*Total volume in MCM*	*10.68*

Schemes rehabilitation (Litani River Authority exploitation archives (1990-2002)

The Litani River Authority exploitation archives (1990-2002) indicate two rehabilitated schemes that have sufficient registered data allowing to estimate water saving and socio-economic improvement.

Qasmieh scheme

Is a gravity system scheme sited in southern coastal area. The works carried out on this scheme have resulted in the rehabilitation of the main canal, equipped with automatic gates and limited flow distributors (modules á masques), and the construction of regulating reservoir. After rehabilitation, water consumption decreased from 16700 to 11575 CM/year/ha, saving about 33.08% of resources. Total saving water is estimated to 20.25MCM for a subscribed area of approximately 3600 ha.

LRA has adopted a differential water pricing, according a reduction of 33,33% for users of drip or sprinkler irrigation techniques. In two years, 503.5 ha (15.67% for subscripted area)were converted to drip irrigation. Saving water per ha is estimated at 28.42%. With such a progress in saving water resulting from rehabilitation and water pricing policy, a supplementary 2100 ha is now not so far to implement.

South Bekaa irrigation phase1 Scheme (Karaa, 2002)

South Bekaa irrigation scheme is a pressurized system with the main objectives of underground water control and saving. Water consumption before project implementation was estimated to 6100 CM/ha/year (WB CDR, 2002). After project implementation, data are available for one year of exploitation (2002). Consumption per ha is 5534 CM/ha/year, which means that consumption has decreased by 9.28% for the first year. It must be noticed that 2002 was a free year water pricing, therefore, it is expected that the decreasing in water consumption could be larger in the next years.

One of project targets is to cut the monopoly of wells owners in water matter and decrease water fees which is a heavy charge on land exploitation under irrigation before project. After Project, average farm size was considerably decreased for Qaraaoun sector (60.19%), meaning that owner did not rent theirs parcels but use them directly.

In the first year of scheme exploitation, total profit has increased by 17.51% between 2001 and 2002. In the second year of exploitation, the profit per ha has increased by 24.17%, between 2002 and 2003 (Karaa, 2003).

On Farm Level

In small private irrigation, the cost paid by farmers to extract water, pushes them to use adequate equipments making possible saving water. Farmers have adopted sprinkler irrigation for wheat, potatoes, sugar beets, forages and drip irrigation for trees and vegetables. Black mulch is commonly used in vegetables plantation to reduce water losses and economizing weeds control.

Role of the Research

The challenge in water resource management is to make sustainable the agricultural production for the long run. In Lebanon, an action plan aiming at improving on-farm water use efficiency has been recently developed at the Lebanese Agricultural Research Institute (LARI). Such plan includes

(i) conserving and using natural water resources efficiently and safely;
(ii) increasing agricultural water use efficiency to meet future food requirements; and
(iii) use of unconventional water in irrigation.

This part of the paper will focus on the efforts which have been made to improve the efficient use of water for irrigation purposes in Lebanon in the period prior to water, and the supplemented steps in the period post-water, taking into account agronomic, technical and socio-economic aspects. It will also constitute a comprehensive tool to the integration of natural water resources in the sustainable development of agriculture with respect to the local experience in participatory irrigation management and water saving policies. Finally, the recent achievements of the concerned research institutions, mainly public; in the process of irrigation development and technology transfer to additional irrigated areas will be discussed.

The pre-war period (1955-1975)

The first irrigation trials were initiated at the Agricultural Research and Educational Center (AREC) of the American University of Beirut and dated to mid fifties. At this stage, only technical reports on water delivery at farm level were issued. The first irrigation studies at Master degree were produced in the sixty's dealt with the irrigation of apple and other fruit trees in the foothills of the Mount-Lebanon and the effect of wind on sprinkler performance for some herbaceous crops in the Bekaa Valley and the cost of irrigation water using sprinkler systems (Mutayrah, 1964; Hanbali, 1964; Jalili, 1967; Nimah, 1968; Asfur, 1969; Fiuzat, 1972; Ali 1975 and Azar, 1975). The major part of these studies were published but no consistent steps were taken in order to transfer information and technology to the farmer level, mainly because the extension services at that time were not as well as organized and structured to cope with these jobs, especially technical assistance of the farmers.

In the sixties and late seventies, field irrigation experiments were initiated at Tal Amara and Terbol Stations of the Lebanese Agricultural Research Institute (LARI) in the central Bekaa Valley (Aboukhaled et al., 1969; Aboukhaled and Sarraf, 1970; Aboukhaled et al., 1970; Aboukhaled et al., 1971). The outputs were presented in annual reports until the appearance of the first issues of the official LARI's scientific and technical journal: Magon Science and Magon Technique. In the first issues, Sarraf (1965), Sarraf et al., (1969), Sarraf and Aboukhaled (1970), Sarraf et al., (1971) and Sarraf and Dannaoui (1972) reported on the crop water requirements and irrigation duties of the major cultivated crops in the Bekaa Valley and on the Lebanese coastal strip. At this stage potential evapotranspiration (ETp) values were only estimated by the use of various standard formulas from USA, West Europe and Eastern countries (Sarraf, 1973). The results of the estimation of the potential evapotranspiration showed significant discrepancies exceeding sometimes 30% on monthly basis, thus causing difficulties for irrigation planners and designers. Klaimé (1965) reported on the effect of temperature and irrigation on wheat maturity, while salinity toxicity effects were described by Lamouroux et al. (1967). By that time, the methodology used started evolving rapidly from simple conventional techniques to more scientific instruments, namely neutron probes, improved gypsum block meters, tensiometers, various types of lysimeters, complete agro-meteorological stations and soil physics laboratory equipment. This helped in determining with relatively high accuracy the soil water content, which permitted to better determine the irrigation water needs of the crops, and consequently the quantity of water being evapotranspirated by the plants.

The Land and Water Division of Food and Agriculture Organization of the United Nations (FAO) and the Soil and Water Division of the International Agency of Atomic Energy (IAAE) of the United Nations provided technical assistance and advanced equipments through specific projects to AREC and LARI. In addition to the neutron probes (Hanbali, 1964) isotopes (N_{15}) were provided for tracing nitrogen in fertilizer experiments of irrigated crops (Macksoud, 1972; Barrada, 1972).

Results on water use and irrigation efficiency from hydraulic lysimeters installed at AREC of the American University of Beirut led to comparing the use efficiency of different irrigation methods, with the aim to save water and increase crop productivity in water-limited environments (Chodratnama, 1966; Jalili, 1967; Asfur, 1969; Chaudhry, 1978; Nasr 1979 and Halimi, 1981). Many studies covered sprinkler distribution systems and their performance in windy environments, while others treated drip irrigation systems and improved leveled surface irrigation, mainly furrow irrigation for row grown crops (Baasiri and Ryan, 1986).

At Abdé experimental station of the Lebanese Agricultural Research Institute, situated on the Northern Coast, sprinkler tests and performance evaluation were carried above and below citrus canopy using drag hose systems (Aboukhaled et al., 1971). Distribution uniformity (DU) was found to be good enough to reduce evaporation losses from larger wet soil surfaces. As for below canopy irrigated crops, called differently intercropping of irrigated summer vegetables with orchards, sprinkler movement was naturally easier. The system performance and cost were very acceptable. A large sprinkler unit was then introduced at Terbol Station in the Bekaa Valley for irrigation of forage crops when intercropped with fruit trees, mainly pistachio and almonds, typical for the eastern central Bekaa Valley. The system consisted in a hand-move ABC quick-coupling Al-tube system. It served also for demonstration purposes in pilot areas. But in the early seventies, most of the farmers were still reluctant to adopt sprinkler irrigation, despite the experimental works that have been made at AREC and LARI. This revealed the absence of links and coordination between research and farmers. At present, most of the wheat, potato and sugar beet fields were sprinkler irrigated in the Bekaa area.

For drip irrigation, five demonstration systems were introduced by LARI at Tal Amara in the Bekaa Valley, at Abdé in the northern coast, at Choueifate in the central coast and at Dahr El Baidar in the Mount Lebanon, where two private apple orchards were used for drip irrigation and for demonstration purposes. Furthermore, two irrigated drip units were installed in greenhouses in 1972 and 1973 at Fanar Station near Beirut for vegetables grown greenhouses. However, it took several years for sprinkler and drip systems to gain grounds from the side of the farmers, due to the lack of the Extension Services, which were supposed to transfer and train farmers to become familiar with these new irrigation techniques. Add to this the war situation, which extremely limited the expansion of the irrigation technologies and lowered the irrigated areas. However, it should be recognized that irrigation equipment dealers had a major role, later on, in promoting the spread of sprinkler and drip systems all over the country. Nowadays, thousands of hectares of open field crops, mainly potatoes and fruit trees, and greenhouse grown vegetables, mainly tomatoes and cucumber, on the Coast and in the inlands are irrigated with drip systems.

Of particular importance was the direct measurement by LARI researchers of potential evapotranspiration using pairs of grass-covered lysimeters, 4 m^2 each (2m $\times$ 2m), surround by a 2 ha-buffer area in the Bekaa Valley and on the coastal strip. This was essential to put limits to the Coast and to account for the effect of advection dominating during summer period in the Bekaa Valley. This also was essential to put limits to the discrepancies of estimated values, when using various formulas as postulated by researchers and engineers all over the world. This has led to a re-evaluation of the main formulas being used at that time by many researchers over the world, and highlighted the need of their adjustments. This work has been done in collaboration with the group of agro-meteorologists of Davis, California and FAO experts (FAO, 1976). Reliable measured potential evapotranspiration (ETp) and crop coefficients (Kc) became thus available for irrigation management and scheduling (Sarraf, 1973). To complete this research line, an advanced mechanical precision weighing lysimeter of 16 m^2 (4m $\times$ 4m), comparable to the unit of Davis of the University of California, was installed at Tal Amara in 1972-1973 within a 2-ha buffer area. Unfortunately very limited measurements (daily and hourly basis) were possible, as the unit was heavily damaged and vandalized during the period of the war in 1975 and afterwards. Data published by Karam et al., (2003) reported on the reuse plan of the weighing lysimeter to accomplish the scientific works that have been done in early seventies, with emphasis to the new crops and cultivars that have been recently introduced in the country.

Post-war period

After the war period (1990-till present), LARI had to go through a long process of infrastructure rehabilitation, recruitment of new staff and acquisitions of laboratory and field equipments. This had to be done within limitations of budget routine administrative procedures. Few years elapsed before the basic requirements were met to launch research, including irrigation works. LARI's 1994 annual report reflected the first steps towards the re-establishment of the Department of Irrigation and Agro-Meteorology (DIAM). A concrete water reservoir of 4000 m^3 capacity was constructed to replace the damaged old buty1-rubber-lined reservoir at Tal Amara station. The water reservoir dominates an irrigated experimental area of 10 hectares, used for research and demonstrations within delimited pilot plots. The soil laboratory became functional for soil and water analysis. The Agronomy Department carried comparative work on 40 varieties of potatoes (110-125 days) and 14 varieties of sugar beets (mainly 187 days). The Irrigation Department followed-up and obtained automatic agro-meteorological stations, which were installed at all LARI stations. LARI's 1995 annual report reflected a research strategy based on:

1. Supplementary irrigation experiment on some local durum wheat cultivars, mainly Waha, Stork and Hourani, combined with six levels of nitrogen fertilizers ranking from 50 to 250 kg N/ha. It was concluded that the cultivars under test responded differently to different application of supplementary irrigation for a recommended fertilizer level of 150 kg N/ha.
2. Testing and comparison of different in-line dripper sources (41/h) showed acceptable performance for local made emitters according to CEMAGREF criteria of classification. The in-line drippers were experimented for some vegetables (potatoes, lettuce and onion), field crops (corn, soybean, cotton, and sunflower) and fruit trees (apple, cherry, apricot and peach). This research line was accompanied with a test on the efficiency use and recovery of fertilizers, especially nitrate and potassium, to study the effects of drip systems on crop productivity, water saving and benefit cost of the fertilizing systems.
3. Estimation of potential evapotranspiration using 1980-1995 agro-meteorological data from AREC, by four ETp formulas showed large discrepancies, especially between the radiation-method and the evaporation method. However, the radiation method compared with temperature-method showed less deviation. FAO CROPWAT and CLIMWAT software were used for this purpose.

The research major lines aimed to cover during this period irrigation technology and links to poor farmer's sources and the crop water requirements and irrigation duties of the major field and protected crops. A parallel axis aimed at evaluating the use of reclaimed wastewater for irrigating of some of the selected crops.

Results of the research on irrigation efficiency and water saving

This component includes mainly irrigation amount and timing, use of agrochemicals and fertilizer application, and different agricultural practices. Supplementary irrigation, deficit irrigation and stress treatments make also a part of this investigations.

Real time irrigation scheduling of drip irrigated potato cultivars differing in maturity with sprinkler and surface drip systems was studied and reported for a five-year period (1998-2003) at Tal Amara Research Station (Darido, 2000; Dirani, 2003). The results of this study will be presented during the next meeting the European Association of Potato Research (EAPR) which will be held at the University of Tuscia in Viterbo, Italy in June 2004, jointly with the International Society of Horticultural Science (ISHS). Drip irrigated potatoes have been shown to have higher potassium use efficiency (KUE) with respect to sprinkler irrigated potatoes. However, fresh tubers per hectare did not seem to differ notably between sprinkler and drip treatments (Karam et al., 2004).

A scheduling computer program is available at the Department of Irrigation and Agro-Meteorology (Mounzer and Karam, unpublished) since 1999 based on daily crop coefficients inputs to determine actual evapotranspiration and irrigation duties of the most cultivated field crops in the Bekaa Valley. The program is based on a weather generator, which calculated at daily step potential evapotranspiration (ETp) using the 24 hr FAO Penman-Monteith method (Allen et al., 1994). Ambient weather data (solar radiation, air temperature, wind speed at 2 m height, air temperature at dew point and relative humidity) used by the computer program were daily recorded from an automated weather station (AURIA 12E), 50 m apart from the experimental sites. Then, ETp was multiplied by the crop coefficient (Kc) computed at daily scale. The obtained actual evapotranspiration ETc was then used to determine the net irrigation requirements, and consequently the gross irrigation requirements by dividing the net irrigation requirements on the efficiency of the irrigation system.

Sugar beet is one of the most potential crops in the central Bekaa Valley. Its water use varies between 800 mm and 900 mm. Sugar beet is a sprinkler irrigated crop, where the losses due to wind drift are consistently high. The response of sugar beet (*Beta vulgaris*) to planned deficit irrigation and nitrogen application rates was studied at Tal Amara. It was concluded that sugar beet yield was higher and sugar content was lower under well-irrigated conditions, with comparison to the deficit-irrigated treatment (Karam et al., 2002). A two-year experiment (1998-1999) on drip irrigated corn in the central Bekaa Valley showed that full irrigation corn was managed for high productivity, whereas deficit-irrigated corn showed yield reductions (Karam et al., 2003). However, water use efficiency (WUE) of the fully-irrigated corn was lower than the less irrigated corn. Yield and nitrogen recovery of drip irrigated lettuce under non limiting soil N conditions was undertaken by Sarkis (1999) and reported by Karam et al., (2000). This study showed that water stress caused by the deficit irrigations reduced significantly final fresh weight. Further, nitrogen inputs from groundwater were found to be considerable and increased the potential of N loss with leaching as a source of point pollution.

Evapotranspiration and seed yield of field grown soybean under deficit irrigation was also studied at Tal Amara by Sfeir (2001) and reported by Karam et al., (in press). Average soybean evapotranspiration (ETc) as measured by drainage and weighing lysimeters totaled 800 mm. Another experiment carried out during the period 2001-2002 on drip irrigation with cotton showed that cotton yield was extremely dependent on water stress timing. Higher yields were obtained in the less irrigated treatments (Daccash, 2002).

When rainfall is prevented from reaching the soil, as in the case of covered greenhouses, the irrigation requirements must include a leaching fraction, or a seasonal leaching must be carried out to avoid soil salinization. Crop water and leaching requirements of greenhouses grown vegetables on the coast were largely studied by Nimah et al., (1993), Attalah et al., (1996) and Nachar, (1998) in relation to water use and sustainable productivity. In general, greenhouses are provided with drip irrigation and fertigation systems. With lower water quality and high fertilizer inputs the salinity naturally increases and should be leached in due time.

The basic justification of water saving research program is the conservation of water quantity and quality. The old concept of irrigation efficiency, most important at the farm level, should be well understood to undertake the necessary measurements accordingly. Improving the storage efficiency and water distribution uniformity implies improvements of the uniformities of water application. High application efficiency is not always synonymous with good irrigation. High and very high water application efficiencies can be simply the result of water storage or deficit irrigation. For adequacy of irrigation, the storage efficiency and the uniformity of water application become essential. The objective is to apply uniformly adequate water (i.e. the water needed in the root zone) throughout the field. This implies controlled water application associated with good land preparation and leveling. Adequate design of head and field ditches with appropriate flow rates also remain essential in surface irrigation. For sprinkler and drip systems, good design, operation and maintenance of performing equipment are key factors to be evaluated.

The irrigation research program was focused on tertiary off-takes and field inlets and to determine the application efficiency, storage efficiency and water distribution uniformity at on-farm level in a demonstration area, which was established in 1998 to cope with these objectives. Traditional versus modern irrigation systems were tested and compared with data from selected private farms and constituted guidelines for farmers. However, the question remain how flexible are actual and future schemes with respect to water delivery in order to meet farmers effective needs "On-demand" water supply systems with the Litani River Authority would respond fully to this concern, while rotational supply schemes are rigid an lack this flexibility. In this case farmers have to accommodate themselves and make the best use of the water when it is provided. Matching cropping systems to available supply becomes the answer. In general, the pressurized irrigation systems and individual wells provide good flexibility. The rotational water supply systems are not really suitable for new irrigation technology; specially drip irrigation unless individual on-farm reservoirs are constructed. The efficiency of conventional schemes is usually low. But, the recoverable water losses include seepage or leaks from conveyance and distribution systems, operational spills, surface runoff from fields and reduced percolation beyond the root zone. The re-use of field runoff is known as tail water-recovery. Off-farm-water management aspects are beyond the scope of this consultancy. Water users associations (WUAs) are essential links between water supply institutions and the farmers.

FINAL REMARKS

At the on-farm level, the recommended steps have to be undertaken for a better future links between research and the farmers:

- Consolidate the water quality control in different parts of the water delivery systems in the irrigated areas;
- A more rationalized policy for agricultural water uses, including water management and water saving techniques;
- Transformation of tertiary canals to pressurized pipes, i.e. from the pumping stations to the irrigated farms;
- Support of the collective irrigation networks through public irrigation projects;
- Provision of pressurized water outlets (hydrants) at the farms, and disposition of flow-meters and flow-limiters;
- Supervision and control of water abstraction at farm level;
- Commitment by the farmers to accurately deliver water duty and irrigation requirements;More active and fruitful collaboration between farmers and the technical staff. In that sense, field days are important;
- Farmer’s involvement in data filling-up, readings and measurements related to irrigation networks;
- Confirming the extension aspect and continuing farmer’s education via field days, seminars and other media forms.

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