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# Modernization of irrigation systems: measures to reduce pressure on water demand in Lebanon

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**Abstract.** In Lebanon water balance will reach its limits by 2020. Agriculture sector is the main consumer of water (around 70% of the total needs). In order to support water saving, the Lebanese government is applying a long term plan aimed at rehabilitating and modernizing the water sector. The policy adopted includes a number of strategies: institutional reforms, new legislation and administrative structure, application of an integrated water management plan, rehabilitation of existing schemes, water storage capacity improvement. This policy must be completed and further actions should be envisaged. The application of this new policy is encountering many difficulties which need to be solved. The present paper aims to give an overview of these problems considering some case studies and to outline the measures that should be adopted in order to improve water use efficiency. Many recommendations are given but the involvement of farmers in the processes, through water user associations, is still the main goal to achieve in order to obtain significant results.

**Keywords.** Integrated water management – Water policy – Water saving – Irrigation efficiency – Modern irrigation techniques – Water user association – Extension.

## **Modernisation des systèmes d'irrigation: Mesures pour réduire la pression sur la demande en eau au Liban**

**Résumé.** Au Liban, on prévoit qu'avant 2020 de fortes contraintes pèseront sur le bilan hydrique. Actuellement, le secteur agricole reste le principal consommateur d'eau (environ 70% des besoins totaux). Afin de promouvoir une stratégie pour l'économie d'eau, le gouvernement libanais a lancé un programme à long terme, qui vise à dynamiser et à moderniser la gestion de l'eau dans son ensemble. La politique adoptée repose sur différentes stratégies: des réformes institutionnelles, une nouvelle législation et une nouvelle structure administrative, l'application d'un programme de gestion intégrée, la réhabilitation des périmètres existants, l'amélioration de la capacité de stockage de l'eau. Cette politique nécessite aussi des actions d'accompagnement qui doivent encore être définies. L'application de cette nouvelle politique se heurte à de nombreuses difficultés auxquelles il faut faire face. Le but de ce travail est donc de donner une vue d'ensemble de ces problèmes en s'appuyant sur des cas d'étude et de passer en revue les mesures qui devraient être mises en œuvre en vue d'améliorer l'efficacité d'utilisation de l'eau. Plusieurs recommandations sont aussi présentées bien que la mobilisation des producteurs, à travers les associations des usagers de l'eau, reste encore l'objectif principal pour atteindre des résultats significatifs.

**Mots-clés.** Gestion intégrée de l'eau – Politique de l'eau – Économie d'eau – Efficacité de l'irrigation – Techniques d'irrigation modernes – Association des usagers de l'eau – Vulgarisation.

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## **I – Introduction**

The World Bank has warned the MEA region against the looming water shortages. Indeed, overuse of water resources is putting the region at high risk. The amount of water per person in the Middle East will be reduced by half by 2050. However, the crisis can be avoided provided that the regional governments take actions towards managing properly waste water, building more efficient networks and reducing water use.<sup>1</sup>

In 2020, water balance in Lebanon could become negative if all the players involved in water management do not apply water saving policy. Since the population is rapidly growing, water demand is increasing across the country. At present the agriculture sector utilises the vast majority of available water resources.

The irrigated area in Lebanon is now around 90,000 ha, of which 55,466 ha are still under traditional gravity system and only 25,564 ha are under pressurized systems. Technological inadequacy prevails both in water irrigation systems at farm level and in water conveyance and distribution systems.<sup>2</sup>

However, according to Dr. Fadi Comair, poor management is the main cause of these problems, along with political interference and misunderstanding about how to improve water delivery and sanitation services. In contrast to the region's booming growth, water infrastructure and the management capacity are lagging behind. "What Lebanon needs is better management".

Dr. Comair also highlights that we must take up the challenge of water policies, in particular, those concerning drinking water, agriculture, industry and sanitation, by adopting innovative techniques within the framework of integrated management, ensuring protection from socio-economic and environmental impacts.<sup>3</sup>

A sound management of the system and of irrigation water is as important in pollution control as proper design. In addition, a sound management almost always implies water and energy savings, thereby increasing productivity per dollar invested<sup>4</sup>.

Today the irrigated area accounts only for 42% of the total irrigation potential, with great efforts on technical improvement aimed at:

- rehabilitating and improving efficiency of the present irrigation and domestic water network;
- enhancing "on-farm" irrigation efficiency;
- limiting degradation and improving water quality;
- reusing treated wastewater.

Since 1960s, the Lebanese Agricultural Research Institute (LARI) and the Litani River Authority (LRA) have undertaken many research works, experiments and investigations in the field of irrigation. At the beginning of 1970s, the first pilot pressurized irrigation project was implemented (by LRA) in southern Lebanon. The pressurized irrigation system equipment, such as the sprinkler, began to be familiar to the farmers. Since that time modernization and water saving concepts, at governance and farmers' level, have been based on pressurized systems including scheme network and on-farm equipment. This type of equipment is increasingly adopted in the private irrigation projects of the Bekaa valley exploiting underground water. In the last few years, new management tools have been introduced to Lebanon to help decision-makers manage more properly irrigation water at field level. However, only few practical experiences are known with successful application to irrigation systems.

The objectives of this paper can be summarized as follows:

- to describe the measures taken by the Lebanese government in the framework of water management at the national level and to provide some recommendations in order to draw up an appropriate policy;
- to analyse some case studies from the South Bekaa Irrigation and Drainage Scheme and the Southern Lebanon Scheme in order to discuss the problems encountered in modernizing irrigation and propose management alternatives in the light of the knowledge gained in this field;

- to focus on the importance of shared management by stakeholders, especially the water user' associations which represent the rural communities, in modernization and water saving policies.

## II – Description of the irrigated area in Lebanon:

As shown in table 1, the irrigated area can be divided into two categories: Scheme and private Irrigation.

**Table 1. Irrigation area in Lebanon**

Description	Area in Ha			
	Equipped	Net Irrigated	Traditional Gravity System	Pressurized System
Scheme Irrigation	65,600	59,070	53,270	5800
Private irrigation	24,400	21,960	2196	19,764
Total	90,000	81,030	55,466	25,564
Actual efficiency			0.45	0.7
Potential future efficiency			0.6	0.8

### 1. Scheme Irrigation

The total irrigated area comprises 67 schemes covering approximately 59,000 hectares. All traditional irrigation schemes are open channels with low-efficiency traditional irrigation systems (Table 1), while the new schemes (Pilot sector, 1200 ha, in southern Lebanon, and South Bekaa irrigation project first phase over 2000 ha) implemented by LRA are pressurized networks allowing the application of on-farm pressurized irrigation systems.

Water saving will pursue two main objectives: shifting towards pressurized irrigation techniques and rehabilitating the already existing networks.

### 2. Private irrigation

Groundwater resources are usually extracted from individual wells, and sometimes from river basins, and the farmers support all costs. Therefore, 90% of these farmers use pressurized irrigation systems. A detailed study<sup>5</sup> has demonstrated that when farmers use private wells, 77.66 % of the area is irrigated by sprinkler, 11.58% by trickle and 10.75% by traditional techniques. Irrigation modules are excessive and many problems arise at the farm level.<sup>6</sup>

The uncontrolled rapid growth of private groundwater irrigation induces many problems affecting water quality and continuity. The excessive uptake of groundwater and the lack of artificial feeding lead to:

- seasonal and inter-annual deepening of the watershed level in the Bekaa region, inducing severe water scarcity in the wells in dry years;
- marine intrusion bringing about a progressive deterioration of the watershed water quality in the coastal plain.

Nowadays, there is not a law restricting the water amount withdrawn from the wells. Beside on-farm extension, legislation on underground water is highly needed.

### III – Modernization measures at the government level

Water balance will reach its limits in 2020. The total water needs will grow by 83% compared with the present water needs.<sup>7</sup> Of course, these figures take into account the implementation of new irrigation systems and the strengthening of the existing water projects.

To overcome the problems related to water scarcity, in the late 1990s the Lebanese Government undertook a new water management policy based on:

- the rehabilitation of the already existing irrigation schemes;
- the reorganization of the water sector;
- the launching of the ten-year Master Plan for water storage in dams and mountain ponds;
- the implementation of new irrigation schemes using advanced pressurized distribution systems.

#### 1. Institutional reform:

The law n. 221, of May 2000, reformed the water sector in Lebanon. Under the governance of the Ministry of Energy and Water (MEW), 22 water authorities were grouped in four regional authorities besides the existing Litani River Authority (LRA). As far as irrigation is concerned, the Litani River Authority controls the domain of the Litani river basin in the South Bekaa Valley, and the region of Southern Lebanon. All water authorities along with LRA are under the umbrella of the MEW.

Nowadays, LRA manages 34.1% of scheme irrigation in Lebanon and is responsible for 73.29% of the ongoing and proposed irrigation projects. The tasks subdivided between LRA and RWA are summarized in the following table.

**Table2: Subdivision of irrigation projects between LRA and RWA by surface area (ha).**

Designation	Existing Irrigation	Ongoing & Proposed irrigation projects	Total
Total Lebanese Schemes	65,600	82,000	147,600
LRA Schemes	22,370	60,100	82,470
LRA versus Lebanon (%)	34.1	73.29	55.87

The Ministry of Energy and Water is in charge of water policies whereas the Water Authorities are entrusted with the implementation of MEW master plan. The Regional Water Authorities (RWA) are responsible for integrated water management: domestic, irrigation and wastewater. RWA and LRA are involved in direct water management. On the other hand, the Ministry of Agriculture is responsible at farm level.

In accordance with the law, the MEW and the Ministry of Finance appoint a committee for the evaluation of the water authorities' procedures and work.

#### 2. Application of an integrated water management plan:

Many studies, plans and actions have been undertaken so far. A short description of the achievements and of the future goals is given below.

## **A. Rehabilitation of existing schemes**

Thanks to a loan from BIRD, approved in 1993, Lebanon could rehabilitate five medium-sized and ten small-sized schemes representing a total equipped area of 27,200 ha. The remaining areas, accounting for about 58% of the total, still need rehabilitating. These schemes are under the responsibility of RWA and LRA. The main objective of rehabilitation is to increase efficiency of the network and of water collection systems.

## **B. Water Storage Capacity improvement:**

The Lebanese government prepared and approved a ten-year action plan for the construction of dams, reservoirs and mountain ponds<sup>8</sup> in 2003. The new works aim at adding 743 MCM/year to the existing storage capacity. MEW and LRA (according to its statutory mission) are in charge of this plan.

### **a] Water Resources Quality Protection:**

Water control and monitoring are the responsibility of MEW and the Water Authorities. The main problems and the related actions for water quality protection can be summarized as follows:

- Wastewater Treatment:

The Lebanese government elaborated a master plan for second-level wastewater treatment. According to predictions, the wastewater treatment plants will serve 87.9% of the total Lebanese population and will keep operating until 2030<sup>6</sup>. This plan intends to prevent pollution of underground and surface water. At present, the Lebanese population is still connected to a sewage network or septic tanks. Raw sewerage is directly discharged into the environment, including rivers streams, dry riverbeds and underground water (through dry wells). Pollution prevents water from being used and can seriously affect the available water resources.

- Pollution from agriculture:

It is related to intensive agriculture. The main farming region concerned with this kind of pollution is the Bekaa Valley. Excessive use of fertilizers and pesticides is affecting water quality. The investigation results demonstrate that the nitrate level in groundwater is high whereas pesticides are below the detection limits.<sup>9</sup> Finding a solution to this problem is the responsibility of agricultural of the extension service.

- Solid waste:

In many regions, riverbeds, streams, dry riverbeds are frequently used as a landfill. This practice has two major effects: flooding by decreasing the flow in riverbeds and leaching problems. In many municipalities land filling can seriously damage the environment. The resulting liquid and gas emissions may pollute underground and surface water. To prevent this contamination, sewage water must be collected, controlled for quality and treated before discharge into watercourses.

- Sea-water intrusion:

Underground water use is not regulated in Lebanon. In coastal areas, the domestic water shortage brings about over-pumping from underground water. This entails the degradation of water quality due to seawater intrusion. As a result, coordinated action needs to be undertaken: a law should be issued to regulate water uptake from wells and groundwater abstraction should be limited and controlled by MEW.

- Industrial pollution:

Many factories discharge their wastewater in riverbeds or wastewater network without any treatment. To fight against industrial pollution, the Ministry of the Environment issued a law whose enforcement could help solving the problems induced so far.

## **b] Unconventional water Reuse<sup>10</sup>**

Total possible collected wastewater for treatment in Lebanon is estimated to reach 213 MCM by 2015. All treatment plants are planned to work on secondary treatment. This treated water represents 10% of the water needs in Lebanon. The topographical, demographic and urban conditions and economic considerations have paved the way to the implementation of a master plan according to which most wastewater (55%) shall be collected in the coastal area; 36% of the treated wastewater can be used in agriculture. A third treatment is required in order to recover this percentage and use it for domestic purposes.

In 2006, LRA created its Water Quality Department and launched, jointly with Abdel Aal Association (an NGO), a water quality awareness campaign for local communities.

## **c] Improving on-farm irrigation**

Special attention has been given to the enhancement of Water Economic Return at farm level: the goal is to optimize regulated deficit irrigation (RDI) practices. Some experiments and studies have been conducted or are still underway :

- in Lebaa center<sup>11</sup>, a cooperative study was carried out by LRA and the Lebanese Agricultural Research Institute (LARI) on cucumber and tomato under greenhouse conditions. The technique applied was trickle irrigation. For two years, the results demonstrated that farmers could save up to 40% of the water used;
- LRA and LARI are partners in the EU research and dissemination project “Sustainable orchard irrigation for improving fruit quality and safety”, started in July 2006. The main objective is the regulated deficit irrigation for citrus in the coastal area and peach in the inland region.

In order to improve on-farm irrigation practices, emphasis should be laid on:

- extension services improvement. Up till now, RDI research results have not been disseminated and they will be hardly accepted by the farmers. Indeed, these results must be a pillar in extension activities;
- developing applied research on practical irrigation schedules and doses for different crops. Special attention on regulated deficit irrigation research is required;
- a water tariff policy can be adopted to encourage irrigation water saving by shifting to on-farm pressurized irrigation systems in the traditional scheme. A two-tier tariff could be applied, where a fixed share per hectare is related to maintenance and a variable share is determined by the water volume used. This tariff must and can be applied in pressurized irrigation schemes.

## **IV – System Modernization**

According to data in the literature, at scheme level, overall efficiency, which is the result of storage, conveyance, network and on-farm efficiency, is between 40 and 45%<sup>12</sup>. At farm level, irrigation efficiency is on average 50% with traditional irrigation techniques, such as the basin and furrow systems, but it could reach 70%-90% when modern pressurized techniques are used.

The flexibility degree in water delivery systems is a crucial issue in any irrigation scheme<sup>13</sup>. The question remains about how flexible present and future schemes are with respect to water delivery in order to meet the farmers' effective needs. “On-demand” water supply systems would respond fully to this concern, while rotational supply schemes are rigid and lack this flexibility<sup>14</sup>. In this case farmers have to adapt and make the best use of water when it is provided. Moreover, water user associations (WUA) are the essential link between the farmers and the water supply bodies. On-demand pressurised irrigation systems generally provide good flexibility. Rotational water supply

systems are not really suitable for new irrigation technology, especially drip irrigation, unless individual on-farm reservoirs are constructed.

A significant improvement can be attained by shifting from the traditional gravity to the pressurized system by:

- converting open channel networks and distribution to pressurized pipes;
- using adapted on-field irrigation equipment;
- constructing all new irrigation projects as pressurized systems: the area which should be equipped amounts to 82,000 ha.

**Table 3. Potential water saving by shifting to pressurized systems.**

Description	Actual Efficiency	Potential Efficiency	Efficiency gain ( Related to new pressurized System)	Percentage out of the total area
Actual Gravity System	0.45	0.6	0.35	26.52
Actual pressurized system	0.7	0.8	0.1	12.22
New pressurized System (gain obtained versus gravity)			0.2	61.26
Overall Efficiency Gain			0.23	

Considering the above changes and actions, a simple calculation can give the weighted average of efficiency gain for all irrigation systems in Lebanon. Table 3 reports the data and results of this calculation which demonstrate that a 0.23 efficiency gain can be reached by applying a pressurized irrigation system.

Two experiments, run by LRA and aimed at enhancing efficiency by the pressurized system, will be analyzed: preferential tariff and implementation of a pressurized irrigation project network.

One more interesting topic to discuss is the involvement of farmers in the implementation of a new irrigation project in Southern Lebanon.

## 1. Preferential tariff

Applied in Qasmieh Ras el Ain Scheme to encourage the use of on-farm pressurized equipment and yielding the following results:

- shifting from gravity to pressurized system over about 30% of the scheme surface ( 1000 ha out of 3400ha);
- partial saving but overuse due to the distribution system:
  - Saving on-farm irrigation:
  - Lack of efficiency at the distribution system level due to:
    - Lack of efficiency at the channel level;
    - Distribution system by “Tour d’eau”: the related outlet remains open for a long time exceeding the parcel needs.

Distribution needs to be adapted by creating an individual outlet at the parcel level.

## 2. Existing Pressurized irrigation network project:

### A. South Bekaa irrigation project Phase I (2000ha) scheme

LRA carried out and still manages the South Bekaa irrigation project Phase I (2000ha) scheme. This scheme displays a wide range of irrigation conditions required for practical evaluation of water management options and their feasibility from both a technical and a socio-economic point of view.

#### a) Description:

The selected irrigation scheme is located within the South Bekaa Irrigation and Drainage Scheme (SBIDS), whose command area covers 23,500 ha, divided into three districts; the first one is located on the eastern side of the Litani River, also called the Left Bank (8700 ha), the second one is located on the western side of the Litani River, also called the Right Bank (9200 ha), and the third one is located in the northern area of the Litani River (5600 ha). The Qaraoun dam, with its average storage capacity of 220 MCM, is the main water source for irrigation in the project area. The project area lies between the two levels of the 900 m altitude curve of both the eastern and western side of the Litani River.

The scheme is located on the eastern side of the Litani River, or the Left Bank, with its 8700 ha command area; only 2000 ha are equipped with pressurized pipelines, allowing the use of modern irrigation systems such as sprinklers and trickles.

Channel "900" supplies irrigation water to the Left Bank and is located at a 900 m altitude. A main pumping station, consisting of 4 pumps, 1.5 m<sup>3</sup>/s discharge each, is located at the foot of the Qaraoun dam that feeds the channel with 30 million m<sup>3</sup> annually. Moreover, four local wells feed the "Canal 900", supplying 12 million m<sup>3</sup> per year whereas 2 million m<sup>3</sup> come from the Chamsine spring in the northern area of SBIDS.

Water is stored in 3 reservoirs, one per each district (Quaraoun I, Quaraoun II and Jebjennin). The reservoirs supply the district distribution network and the branched irrigation networks. At the end of the reservoir, there is a control unit equipped with a gate, and a recording Venturi meter. In this scheme, water is delivered to farmers on demand, by the hydrants, which are equipped with outlets containing pressure regulators, volume and flow meters. Pressure is set at 3.5-5kg/cm<sup>2</sup> and discharge is a function of the area of the land parcels equipped with those outlets. The irrigation parcel equipment uses new pressurized techniques.

#### b) Problems observed

The studies and on-the-spot checks conducted in this scheme highlighted the following problems:

- Vandalism of the outlet:
  - breaking of flow meters;
  - removal of flow and pressure regulators.
- Outlet misuse:
  - poor connection between the outlet and the parcels' irrigation system leading to severe leakage and pressure loss;
  - excessive number of sprinklers on the laterals and on the hydrant outlet;
  - connection of two outlets in order to get a higher flow on a lateral.
- Bad use of equipment: inadequate design of the irrigation system at the parcel level:
  - different types of sprinklers or drippers on the same lateral;
  - inadequate fittings.

- Inadequate irrigation schedule:
  - lack of knowledge of the irrigation module;
  - wrong ideas about irrigation practices (leaves burnt, no irrigation with temperature variation between water and soil etc...). Farmers tend to irrigate at night thus inducing a poor performance of the network, which irrigates only 30% of the area that it was designed to cover;
  - lack of incentives to save water.
- Some types of irrigation equipment, commonly used on the farm and available on the market, are not reliable:
- Lack of a shared policy for water allocation;
- Lack of cooperation between farmers.

### ***B. Southern Lebanon scheme-First phase - Pilot sector***

#### **a] Description:**

The Litani River Authority has started to evaluate the Hydro-agricultural Development Project of Southern Lebanon (35000 ha), in cooperation with UNDP and FAO, since the seventies. The first phase of this project concerned the Canal 800 (15000ha). In 1975 the Lebanese war interrupted the evaluation of details and implementation of the Canal 800 project.

In 2002, after a reviewed and updated pre-design and feasibility study, the Lebanese Government decided to start implementing the project including two main components: Irrigation and Domestic Water supply. The irrigation project is focussed now on on-demand and pressurized water irrigation with full telemetry SCADA control system.

In order to solve the different problems that can be encountered during the design and implementation phase, a pilot sector (Marjeyoun North) is selected.

The Gross Irrigated area of Marjeyoun North equals 745 ha and the Net Irrigated Area amounts to 470 ha.

The Gross irrigated area is determined considering the 1/20,000 land classification. The Net irrigated area is assumed based on a comparative study between 1/20,000 and 1/2,000 scale land classification on ability to irrigate.

The cadastral district of Marjeyoun North scheme comprises nine villages, namely Dibbine, Marjeyoun, Khyam, Boueyda, Qlaiaa, Borj El-Moulouk, Kfar Kila, Deir Mimas and Houra.

#### **b] Problems to be solved<sup>15</sup>**

- Cadastral maps: In the region of Southern Lebanon, there is an area which does not have any cadastral delineation, whereas some other areas have a temporary delineation and a few a final delineation.
- Detailed land classification for ability to irrigate: Irrigation water resources for Southern Lebanon are very limited. The decree n.14522 sets out water allocation by geographic area where only 17% of this area will be irrigated. Based on economic criteria, a land classification for ability to irrigate is made on a 1/20.000 scale. Taking into account the results of this study, combining technical and economic criteria, irrigation schemes are delineated for technical, economic and equity (between farmers) reasons. Two studies (FAO1972, LRA Dar el Handasa Chaer, 2002) show the differences between the two scales (Variable between 2 and 86%), with an average of 30%. For this reason a detailed classification is needed to determine the parcels that shall be irrigated inside the schemes.

- Land reclamation designs and works: the region of Southern Lebanon is hilly and requires land reclamation works on a scheme basis. Under the current legislation, these works must be done at the owner's request or at least upon his agreement. Two solutions can be adopted: either amending the legislation in force or involving the local civil society in facilitating the process. Setting up associations like the Water User Associations (WUAs) will prove to be very helpful.
- Network design and expropriation: the first step in distribution network is the Hydrant Implementation Plan (HIP). This plan must be drawn up in full collaboration with farmers. Parcel tenure in Southern Lebanon is very limited (on average less than 0.3 ha). Therefore, the project designer must face the following problems:
  - the high density of the tertiary network will increase the expropriation cost;
  - the expropriation for tertiary network at parcel level will decrease the irrigated area at farm level due to the high network density and the parcel size;
  - access to the hydrant: in many cases, due to economic and technical reasons, the designer has to assign one outlet to more than one user. The right of access to the outlet must be assured to the neighbours of the parcel where the hydrant is established.

The establishment of a water user association can help solving these problems because the owners concerned will be more willing to give access to:

- the irrigation scheme manager (at present the LRA, in the future the WUA) in order to facilitate the maintenance;
- the neighbour's parcels to operate their outlets.

Nowadays, the WUA has to play a decisive role during the preparation and verification of the "Hydrants plans" in order to allow each user to have a proper access to his hydrant.

The traditional concept of on-demand irrigation has always posed some problems in South Bekaa irrigation project (first phase, Scheme 2000 ha). These problems concern the misuse of the network by the farmers due to:

- the use of overdose water by farmers.
- under-use of the outlets allocated by parcel over time: farmers provide one water application per day instead of two or more.

Pressure on water demand is very high during the timing adopted by farmers: In a 24 hour-use per day, farmers irrigate 12 hours from 6pm to 6 am. All these traditional concepts limit the network capacity. More or less, fifty percent of the irrigated area can be served. The network management, extension excluded, does not have allow any intervention to re-establish the full network capacity.

The pre-programming hydrants (e.g. Aquacard) are a new generation of hydrants which can solve management problems related to the traditional hydrants, including water shortage in dry years. They can also solve the problems concerning the fees which will be collected by a pre-paid card (the same card is used for programming irrigation schedule and quantities).

## V – Measures to be adopted

### 1. Reinforcement of Extension services

- Awareness of the existing irrigation facilities: training courses, data sheets, laboratory analyses, technical assistance; meteorological information;

- Ongoing production of new technical materials to solve future problems;
- Farmers' capacity building:
- Technical assistance to farmers:
  - Establishment of a laboratory to check the performance of the different irrigation equipment brands available on the market;
  - Assistance in field equipment design, acquisition and use;
  - Application of scheduled irrigation;
  - On-farm technical assistance.

## 2. Establishment of Water User Associations

- Issue and enforce a new legislation ensuring proper performance and sustainability of WUAs: at present, there is not a legislation regulating WUAs in Lebanon;
- Actual implementation of WUAs: awareness campaigns, monitoring by social experts;
- Capacity building of WUA members at technical and administrative levels.

Integrated water resources management is a high-profile issue as it involves national governance and high-value global, socio-cultural, environmental and economic resources. The prevailing system of uncoordinated water resources management cannot sustain the ever-increasing water needs in the different expanding sectors. Therefore, it is necessary to work out a strategy to integrate the needs of the various sectors and the available water resources in order to attain both economic and environmental sustainability.

A participatory approach is needed to allow the stakeholders facing several key issues. Stakeholders capacity building in the field of water natural resources management policies, water rights and enforcement of laws would be an important input for a participatory integrated water resources management where roles and responsibilities have to be specified.

### A. Role of WUAs

In the present Lebanese legislation, two forms of associations are recognized: the Agricultural Cooperative and the "Hydraulic Syndicate Association" (Association Syndicale Hydraulique). The former has a different mandate from the Water User Association. The latter was established by decree n. 320 in 1926. The principal objective of this association is to provide protection from flood damages; irrigation is just mentioned without any detail.

WUAs are indispensable for a sound management and implementation of irrigation projects.

In addition to playing a crucial role during the irrigation project assessment and implementation phase (for instance, for the Southern Lebanon scheme), they are very important in order to:

- provide the missing cadastral information on the scheme;
- assist in drawing up a detailed land classification for ability to irrigate to ensure the fair allocation of water resources, by properly selecting the parcels which shall be irrigated;
- participate in the land reclamation process and facilitate the works implementation;
- help getting the right of access from the parcel's owners for operation and maintenance of the hydrant network.

### **a] Short and medium term role of WUAs in the existing pressurized schemes**

- Ensure the management, operation and maintenance of the tertiary network.
- In the short run:
  - Ensure the functioning of the tertiary network according to the rules;
  - Protect the tertiary network from vandalism;
- Participate in the elaboration of modernization plans;
- Replace expropriation by « right of way » for the new secondary and tertiary networks projects;
- Adopt drip irrigation technique, more suitable with respect to the crops grown and the scarce water resources.

### **b] Long-term role of the WUA**

- Take over the management, operation and maintenance of the whole scheme.
- This objective will be achieved by the establishment of a consortium of WUA's after having acquired the experience needed.

### **Role of WUAs in private irrigation**

In the absence of continuous control, the legislation alone will never be able to solve the problems related to the excessive groundwater uptake. The role of WUAs in private irrigation would mainly be to provide an extension service aimed at water saving, to control the water uptake from the wells and the collective exploitation of the wells. The exploitation sustainability could explain the collective interest in joining regional groundwater user associations.

## **3. Establishment of a river basin agency responsible for water management and the main structures in the river basin**

The river basin management entails water resources management at an integrated catchment level (including both surface and underground resources). Sustainable management of water resources is an important goal that must be pursued at national and international level in an effort to face water shortages, inequity, pollution and many other water problems. One of the introduced key innovative elements results from recognition that upstream/ downstream effects require management based on a basin approach. Accordingly, many countries are introducing new institutional patterns for water resources management, including organizations entrusted with water resources management at the basin level.

Creating new structures, or modifying the old ones, to meet the goals of integrated water resources management, is not an easy task considering that the establishment of new river basin organizations will require a great effort in many countries. As a result, it would be advisable to review the status of the existing water authorities in order to promote river basins as management entities.

## **VI – Conclusion**

Much is still to be done to achieve a rational use of water resources in Lebanon. Water infrastructure needs being upgraded to meet the modern irrigation system requirements. Integrated participatory irrigation management must be fostered through the establishment of WUAs in each irrigation districts. The water pricing policy is to be reviewed in order to encourage water saving at farm

level. Farmers' capacity building and extension services are highly needed to gain knowledge and apply crop water modules at farm level. Groundwater uptake should be monitored, socio-economic awareness campaigns should be conducted in order to make farmers assume a new attitude towards water use efficiency at farm level etc.

Moving towards an IWRM approach at national level means changing the enabling environment, the institutional roles, and the management tools. This includes a change in (water) governance, that is to say in the political, social, economic and administrative systems to develop and manage water resources and provide water services, at different levels in the society.<sup>16</sup> The creation of the High Council for water is a major step towards coordinating the decision makers' activities, sharing knowledge and exchanging experience. The role of the Council will be decisive for updating and modifying the Water National Master Plan.

"Principled pragmatism" stresses the importance of economic principles, such as ensuring that users take the financial and resource costs into account when using water, and the need to tailor solutions to specific, widely varying natural, cultural, economic and political circumstances.<sup>17</sup>

The absence of Water User Associations and extension in water management, bad maintenance and water pollution are the major causes of water losses. Legislation, law reinforcement, research and establishment of education centres, tariff policy, stakeholders' capacity building are the main factors for water management enhancement.

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