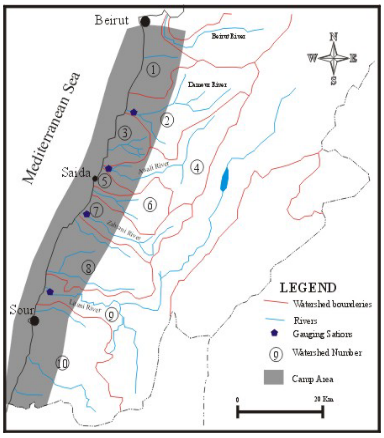
INTEGRATED WATER RESOURCES MANAGEMENT IN CAMP AREA WITH DEMONSTRATIONS IN DAMOUR, SARAFAND AND NAQOURA MUNICIPALITIES

FINAL REPORT



Submitted to:

REGIONAL ACTIVITY CENTER FOR THE PRIORITY ACTIONS PROGRAMME
SPLIT, CROATIA
&
COASTAL AREA MANAGEMENT PROGRAMME
MINISTRY OF ENVIRONMENT
ANTÉLIAS, LEBANON

OCTOBER 2003

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

TABLE .... **PAGE**

LIST OF FIGURES

FIGURE PAGE

FIGURE		**PAGE**

LIST OF PHOTOGRAPHS

LIST OF ABBREVIATIONS

ARD	Arab Resources Development
AUB	American University of Beirut
BWA	Beirut Water Authority
BWIA	Barouk Water and Irrigation Authority
CAMP	Coastal Area Management Programme
CAS	Central Administration for Statistics
CDR	Council for Development and Reconstruction
COD	Chemical Oxygen Demand
CWR	Crop Water Requirements
EERC	Environmental Engineering Research Center
EPA	Environmental Protection Agency
ETo	Reference Evapotranspiration
FAO	Food and Agricultural Organization
GIR	Gross Irrigation Requirement
ICAM	Integrated Coastal Areas Management
IWRM	Integrated Water Resources Management
LRA	Litani River Authority
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoPH	Ministry of Public Health
NGO	Non Governmental Organization
NIR	Net Irrigation Requirement
NWA	Nabaa El Tasseh Water Authority
PAP/RAC	Priority Actions Programme / Regional Activity Center
RAM	Readily Available Soil Moisture

SWA	Saida Water Authority
SLWWE	South Lebanon Water and Wastewater Establishment
SWOT	Strength, Weakness, Opportunity and Threat
TAM	Total Available Moisture
TDS	Total Dissolved Solids
TWA	Tyre Water Authority
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

γ	Psychrometric constant (kPa/°C)
°C	Degree Celsius
ea	actual vapor pressure
es – ea	saturation vapor pressure deficit
es	saturation vapor pressure
G	soil heat flux density
Hrs/d	hours per day
Kc	crop coefficient
Km/d	kilometers per day
Kpa	kilopascal
$Mj/m^2/d$	mega joules per squared meters per day
mm	millimeters
m/s	meters per second
RH	relative humidity
Rn	net radiation at the crop surface
Δ	slope vapor pressure curve
T	mean daily air temperature at 2 meters height
u2	wind speed at 2 meters height

PART I

INTRODUCTION
WORK METHODOLOGY
IWRM PRINCIPLES AND TOOLS

1. INTRODUCTION

1.1. THE CAMP PROJECT

The Coastal Area Management Programme (CAMP) aims at developing a comprehensive strategy for the harmonious reconstruction and sustainable development of the southern stretch of the Lebanese coast (extending from Khalde to Naqoura) by developing and applying Integrated Coastal Area Management (ICAM) methods and tools. As part of this strategy, and among other activities, CAMP seeks to elaborate an Integrated Water Resources Management (IWRM) plan for the 8-km wide southern strip of the coast with specific focus on three municipalities, namely Damour, Sarafand and Naqoura.

1.2. INTEGRATED WATER RESOURCES MANAGEMENT

The main objective of the IWRM component of the project is to assist in the elaboration of a water resources management strategy for the area and an action plan for each of the nominated pilot municipalities in order to ensure sustainability of water resources and cover their population's domestic, agricultural and industrial needs while preserving fresh and seawater quality. Objectives of the strategy are to be developed in close coordination with the municipalities in a participatory approach. The main output of this activity will be practical recommendations that incorporate IWRM principles and will assist the target municipalities in shifting towards a more sustainable management of their water resources.

1.3. OBJECTIVES OF THE REPORT

This final report provides the background on IWRM principles and tools necessary to develop a sound and sustainable strategy. It also provides a comprehensive review of the legal and institutional frameworks governing the water resources sector in the CAMP area, which need to be considered to ensure that recommendations do not conflict with the existing framework. The status of the water resources in the study area and pilot municipalities is presented and recommendations for protection, management and monitoring (indicators) of the resources are proposed.

1.4. STRUCTURE OF THE REPORT

This progress report is structured in four major parts. Part I includes the introduction, work methodology, and a background on IWRM principles and tools. Part II presents the assessment of the water resources in the CAMP area as well as in the three pilot municipalities, including a review of the legal and institutional frameworks of the water sector in Lebanon. Part III presents the IWRM principles that could be applied in the CAMP area, and more practically, in the three municipalities, in order to improve water management. Finally, Part IV provides conclusions and recommendations to set-up the necessary framework for sustainable water resource management in the country, based on the findings of this work.

2. The Work Methodology

Prior to embarking into this IWRM saga, it is judicious to first describe the overall methodology adopted to meet the objectives of the work. This section will briefly describe the different steps undertaken to gradually, and through a participatory approach, reach practical recommendations for the improvement of the water resources management in the study area, and in particular in the target municipalities.

2.1. Overall Methodology

The overall methodology adopted in this project is illustrated in Figure 2.1. The main activities include desktop data collection, field work activities, data analysis, participatory workshops and reporting.

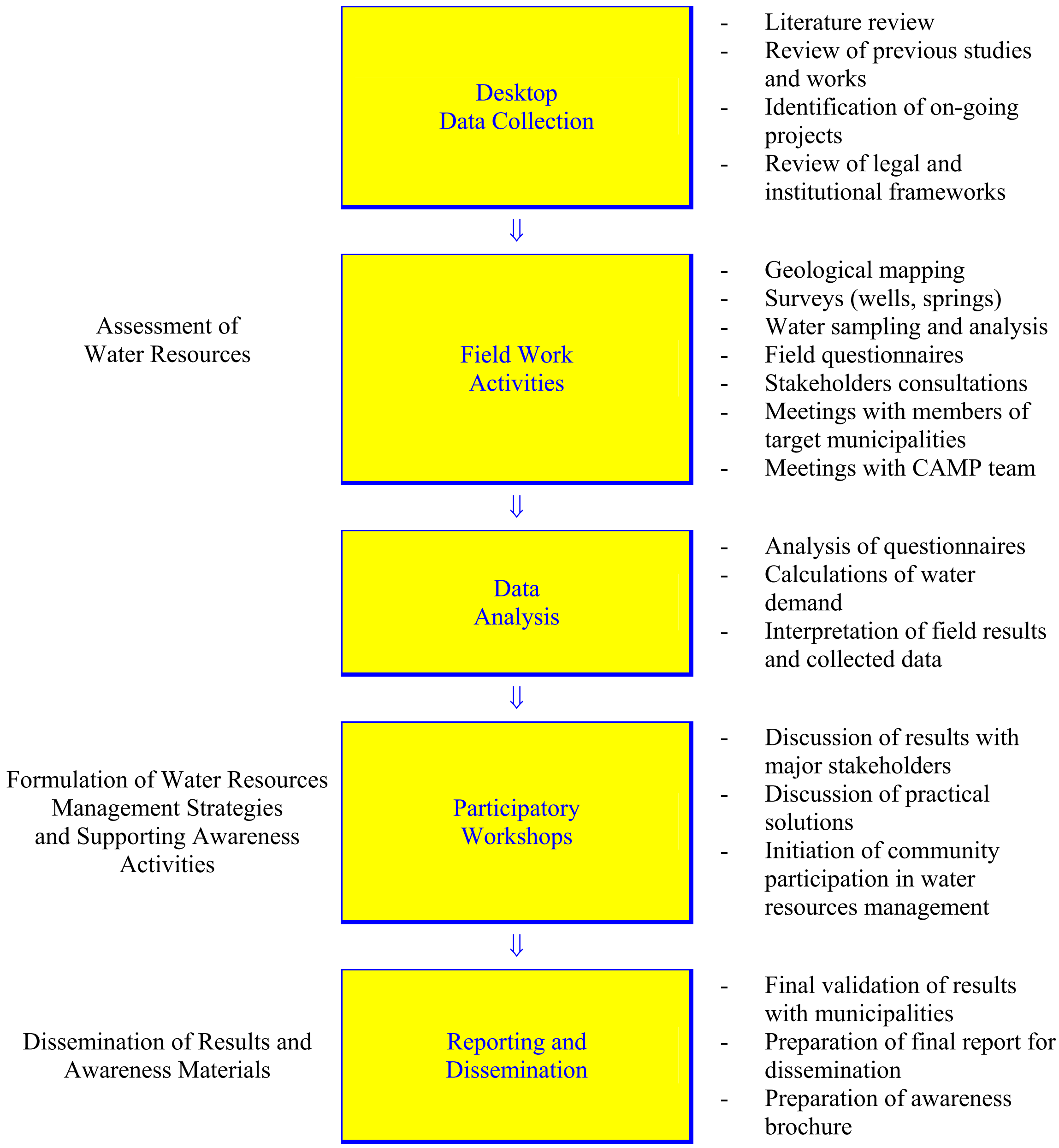


Figure 2.1. Overall Work Methodology

2.2. DESKTOP DATA COLLECTION

This initial activity sets the foundations of the entire work. It consists of reviewing existing studies and works performed in the field of IWRM as well as the work already conducted or on-going in the study area.

Major sources of information included libraries, review of academic work in universities (masters thesis, research), reports/data in relevant ministries and institutions such as the Ministry of Energy and Water (MoEW), Ministry of Environment (MoE), Ministry of Agriculture (MoA), relevant water authorities, the Council for Development and Reconstruction (CDR), the Central Administration for Statistics (CAS), the Directorate General for Civil Aviation (DGCA), as well as the internet. This activity includes also the review of the Lebanese legislation relevant to the water resources management sector in Lebanon. A comprehensive compilation of legal documents was undertaken.

2.3. FIELD WORK ACTIVITIES

Field work activities include field mapping (geology, hydrogeology), surveys, water sampling and analysis, consultation meetings, and meetings with the members of the target municipalities.

2.3.1 Mapping Activities

Field mapping activities at the scale of 1/20,000 were conducted to delineate the geological and hydrogeological features of the study area. The geological map of the CAMP area (shown at a scale of 1/100,000) and the target municipalities areas (shown at a scale of 1/20,000) are shown in Appendix A (plates A1, A2, A3, A4). These maps also show the results of wells and springs surveys that were conducted as part of the field work. The well survey is also shown in tabular form in Appendix B.

2.3.2 Water Sampling and Analysis

Water samples were taken in the target municipalities primarily to complement the existing information and obtain indication of potential pollution sources (primarily sewage, agriculture, and saltwater intrusion). Therefore, the sampling program is not meant to be a comprehensive one, but supports existing data and information, and underlines specific problems to the target municipalities. The sampling program is described in Table 2.1 and Table 2.2. At each location, two samples were retrieved, one using sterilized containers for bacteriological analysis and one using a PET bottle for the analysis of the remaining parameters. Location of the samples is shown in Appendix A (plates A2, A3, and A4). Samples were conserved at a low temperature (4^0C) until delivered to the Environmental Engineering Research Center (EERC) laboratory at the American University of Beirut (AUB). The main parameters selected for analysis were nutrients (as indicators of pollution from agriculture activities), chlorides and Total Dissolved Solids (TDS) (as indicators of salt water intrusion), fecal coliforms (as indicators of pollution from sewage), and Chemical Oxygen Demand (COD) for river samples (as indicator of industrial pollution).

Table 2.1. Description of Samples

Municipality	*Sample ID*	*Description*	*Schedule*	*Comments*
Damour	**D1**	Well used for domestic purposes	A	Located in Mar Mkhael; well used by BWA
	D2	River sample	B	Located at lower level dam
	D3	River sample	B	Located at upper level dam
	D4	Well used for domestic purposes	A	Located in the Saadyiat
	D5	Tap water sample	A	Located in Debbyié, Dahr el Maghara
	D6	Tap water sample	A	Located in Damour
	D7	Municipality well	A	Located in Damour
Sarafand	**S1**	Irrigation well	A	Agriculture field
	S2	Spring El Qantara used to fill swimming pools	A	Elissa Pools, Ras El Qantara
	S3	Well Al Zaatari used for Irrigation	A	Located in Dhour El Sarafand
	S4	Spring Ain El Hemma used for domestic purpose	A	Located in Ras El Chiq
	S5	Ain Abou Daynayn used for domestic purpose	A	Located inside the village
	S6	Tap water sample	A	Citern Teffahta
	S7	Tap water sample	A	Sohet El Ain
	S8	Municipality well	A	Tallet Blat
Naqoura	**N1**	Domestic Tap Water (municipality well)	A	Hay el Baydar
	N2	El Ain spring	A	Located in Wadi El Ain
	N3	Hamoul irrigation Well	A	Located in Wadi Hamoul
	N4	Hamoul Irrigation Spring	A	Located in Wadi Hamoul
	N5	Tap water sample	A	Located in Aalayban
	N6	Iskandarouna spring	A	Located in Iskandarouna
	N7	Private well for domestic use	A	Located in El Khallé
	N8	Municipality well	A	Located in Aalayban

Table 2.2. Parameters Analyzed in Water Samples

Schedule	*Parameters*	*Sampling Recipient*
A (Well, spring, and tap water samples)	Nitrates Phosphates Chlorides Total Dissolved Solids	PET Bottle 500 mL
	Fecal Coliforms	Sterilized Bottle
B (River samples)	Nitrates Phosphates Total Dissolved Solids Chemical Oxygen Demand	PET Bottle 500 mL
	Fecal Coliforms	Sterilized Bottle

2.3.3 Field Questionnaires

Field questionnaires were designed and developed to target water resources consumption and practices in the pilot areas. Specific questionnaires were prepared to address domestic and agricultural water consumption, which are the two main users of water in the target municipalities (Appendix C). The questionnaires target not only water consumption, but also awareness issues with respect to water conservation and management. The local communities in the target municipalities were involved as much as possible in the survey activity as part of the overall effort to increase local capacity and awareness. In that sense, meetings with interested local residents were conducted in each municipality to brief participants on the contents of the questionnaires and their objectives. Local residents have actively participated in collecting information using the questionnaire.

2.3.4 Consultation Meetings

As part of the overall participatory approach of the project, several consultation meetings were held with different stakeholders, and in particular with the target municipalities. The objectives of these meetings were to collect data, discuss important issues related to water management in the target areas, and involve the stakeholders at all stages of the project. Meetings were primarily held with:

- Representatives of relevant institutions (MoE, MoA, MoEW, LRA, CDR, water authorities);
- Target municipalities members and local communities members;
- CAMP national coordinator and consultants.

2.4. DATA ANALYSIS

In addition to obtaining important information on the water resources management frameworks in the study area, the desktop and field data were used to estimate actual water consumption in the target municipalities, and to derive theoretical water demand for irrigation water.

2.4.1 Estimation of Water Consumption

One of the most challenging activities during this project was to estimate the actual water consumption in both the domestic and agriculture sectors (Figure 2.2). This is primarily attributed to:

- The lack of monitoring/metering devices;
- Difficulty to obtain accurate data from the users;
- Use of private water supply sources (private wells).

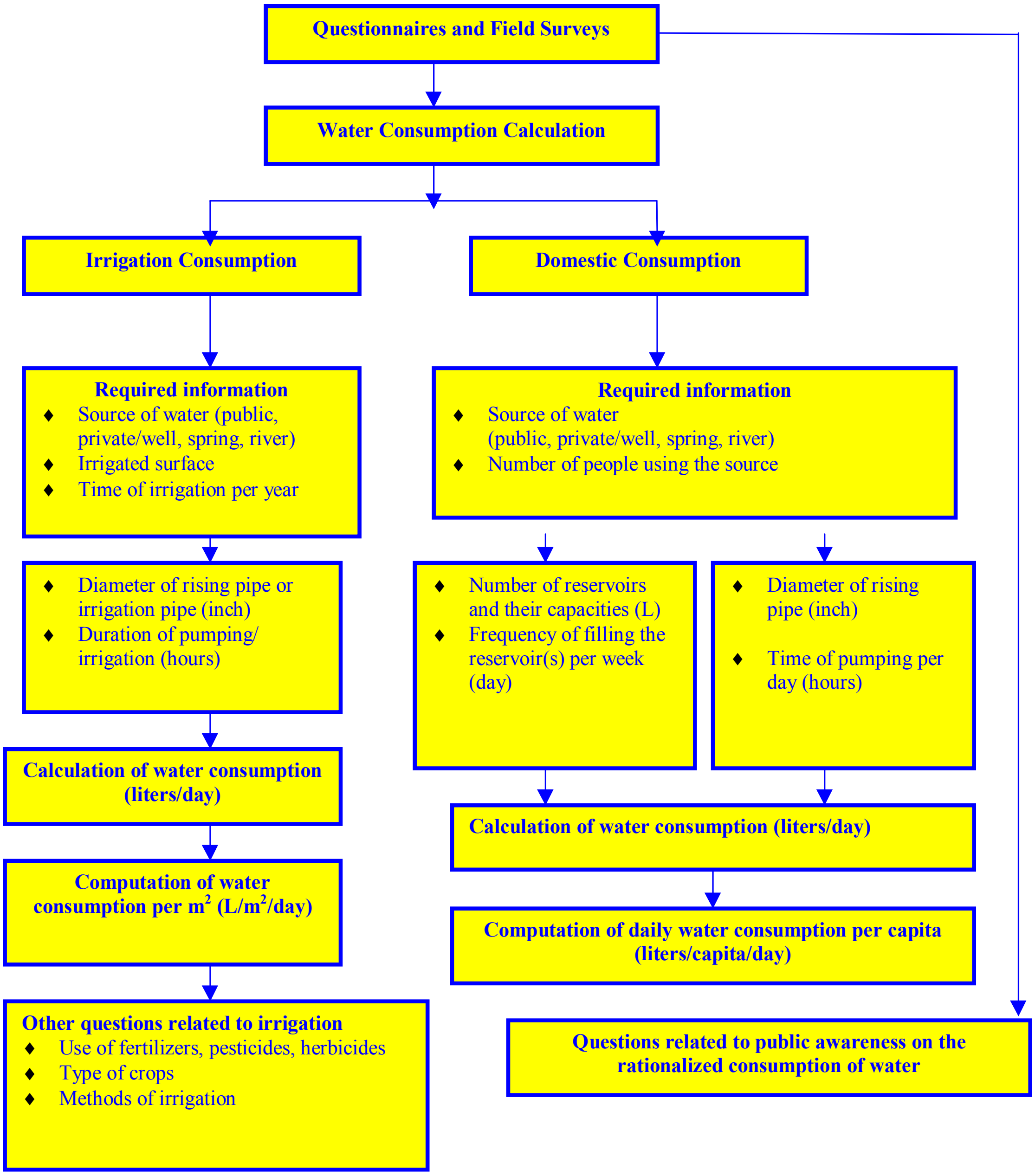


Figure 2.2. Methodology for the Estimation of Domestic and Irrigation Water Consumption

2.4.2 Calculation of Gross Irrigation Requirements

While domestic consumption was compared to typical consumption values ranging from 150 to 300 L/c/day, irrigation consumption was compared to theoretical values or Gross Irrigation Requirements (GIR). These were calculated based on the cropping patterns in the target municipalities, as reported by the CAS, and local climatic conditions. The detailed methodology used is presented in Appendix D.

2.5. Participatory Workshops

Participatory workshops were conducted in each municipality in order to involve all relevant stakeholders in the discussion of the major water resources management issues related to the specific municipality and to reach common solutions. In addition, these workshops represented a major step towards increasing the participation of local communities in water and environmental related issues. Detailed information on these workshops is provided in Appendix E.

2.6. Reporting and Dissemination

The results of the work are summarized in a report form. The final project report should be disseminated to major stakeholders to increase their appreciation of IWRM principles and tools towards sustainable water resources management. An awareness brochure was also prepared to facilitate dissemination of the technical information and emphasize the importance of water conservation and protection.

3. Integrated Water Resources Management Principles and Tools

3.1. The Theoretical Background

This section presents the theoretical background on IWRM principles and tools based on the most recent experiences and demonstrations from water management organizations worldwide. It sets the foundations for the development of sound water management strategies, and these principles are used to formulate sound recommendations towards integrated water resources management in the CAMP area and the three pilot municipalities. A case study on the management of water resources in France is also provided as an illustration of a relatively successful system that tries to promote an efficient use and protection of water resources.

3.2. IWRM: Definition and Objectives

3.2.1 Defining the Problem

What is IWRM? Why did this concept emerge, and why is it being increasingly adopted in many countries? Water demand has been increasing continuously and at higher rates in most parts of the world, and Lebanon is no exception. At the same time, water supply has not increased at the same pace as water demand, leading to water shortages in some countries, and in predicted shortage in others, like in Lebanon. Only to worsen the situation, non-sustainable development in major cities is leading to severe environmental problems, and in particular to the deterioration of water quality, resulting in even less available water of adequate quality for use, and/or in elevated costs of water due to the need for treatment.

As a result of this situation, conflicts among competing uses and users have become more and more frequent. Also with less water available, management of water resources is becoming more complex to satisfy all stakeholders, and existing public institutions lack the capacity and structure to properly deal with the situation. Local communities have increased needs that have to be accounted for. More costly investments are needed to increase supply and mitigate water pollution. The initial problem (decreasing amounts of per capita available water to satisfy different needs) is therefore producing effects that are worsening the situation in a snowball-like manner. These concepts are illustrated in Figure 3.1.

3.2.2 Definition and Objectives of IWRM

Given the importance of water resources, and the rapidly decreasing availability of this resource, the IWRM concept was developed. A quite comprehensive definition of the concept is proposed inhere: "Integrated water resources management involves projects and actions aimed at increasing the conservation of water and the efficiency in its use and by increasing complementarity and/or decreasing conflicts between competing uses, both in quantity and in quality, by managing both supply and demand and enabling adequate organizations, regulatory frameworks (laws, policies, strategies, plans, programs and rules) and human resources."

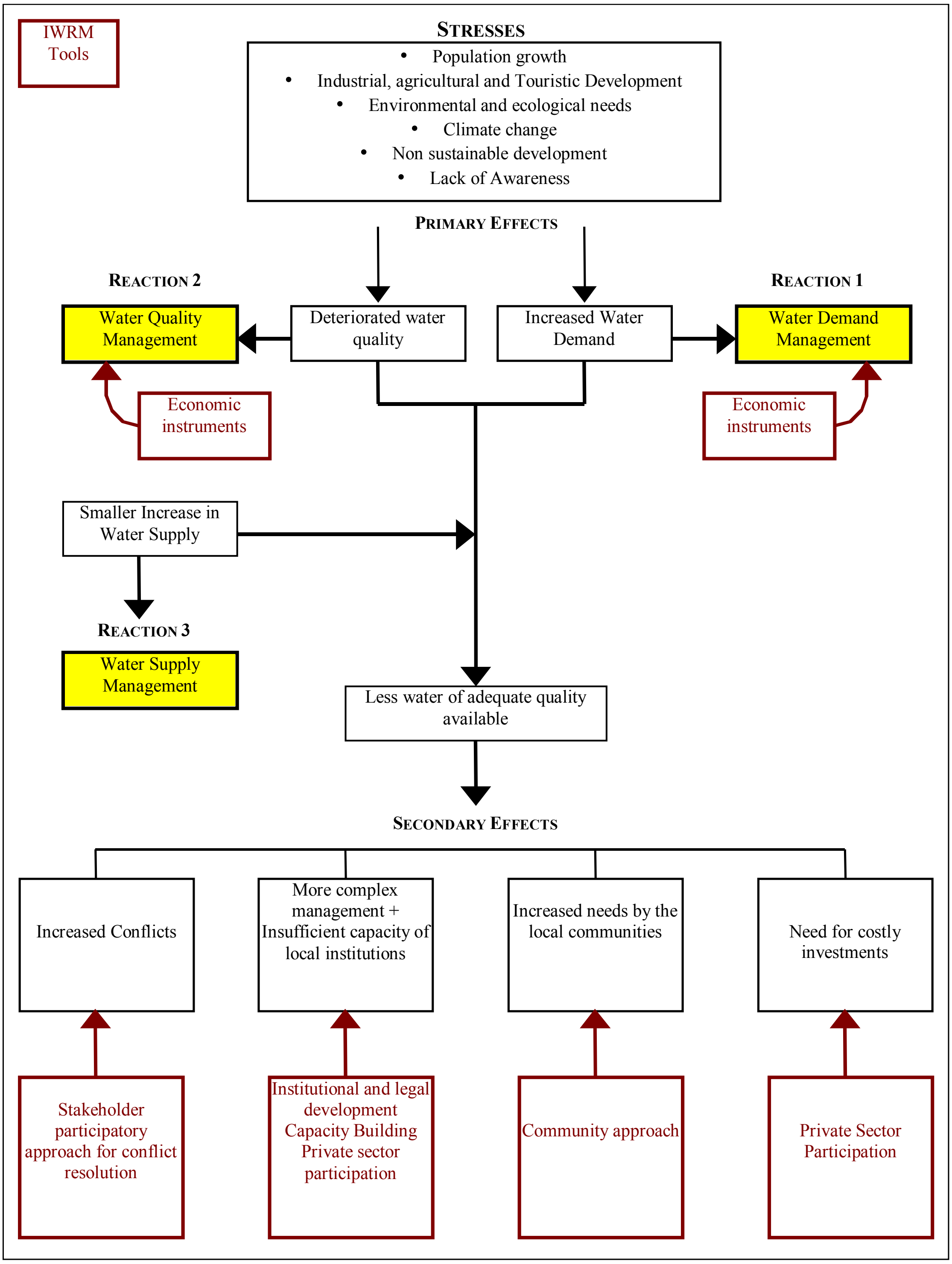


Figure 3.1. IWRM Tools for Sustainable Water Resources Management

The above definition encompasses most components of a sustainable IWRM strategy and advocates the need for water resources management activities to focus on supply augmentation *and* demand management, to incorporate economic, political, social, legal, and environmental considerations (water quality), and to be integrated across water using sectors (competing uses), such as potable water supply, industry, agriculture, while satisfying ecosystems needs.

The main objectives of IWRM include the following:

- To conserve water through a more efficient allocation of the resource;
- To solve conflicts among competing uses and users;
- To account for the social, economic and environmental value of water;
- To increase the participation of communities and the private sector in decision-making and financing.

Several economic and non-economic instruments can contribute to the success of an IWRM strategy. These include environmental management tools, community management, private sector participation, use of economic instruments, decentralized mechanisms and participatory management structures. These will be discussed after briefly reviewing the three pillars of a sustainable water management system: water supply, water demand and water quality.

3.3. THE IWRM TRINITY

The equilibrium of a water resources management strategy is achieved whenever *water supply* and *water demand* are balanced while maintaining *water quality*. These are the three initial factors that need to be considered when designing an IWRM plan and are briefly discussed below.

3.3.1 Water Supply Management

Water supply represents one end of the balance, and is related to the availability of water resources and how to optimize their use. Water supply management involves the identification of appropriate and cost-effective sources of water. These include groundwater, surface water, as well as alternative water sources such as submarine springs, desalinated water and treated wastewater. In a water management plan, one should first assess the resources available, then analyze the different options for water supply, and select the option or combination of options that would provide the needed amount of water in the most cost-effective manner while taking into account technical, social, and environmental criteria. On another hand, water supply management also deals with the optimization of the supply by minimizing losses and finding efficient ways of conveying and supplying water.

In an economic point of view, the problem facing water supply today is that most of the easily available resources have been exploited, and the cost of mobilizing additional resources is continuously increasing. It becomes then essential to efficiently use the water available and to minimize losses. However, as long as the true cost of water will not be taken into consideration, the cost of additional water resources to compensate the leakages in the network will not be considered.

Leakages are directly linked to the value given to water resources by the national community. Their detection is related to measurement techniques that, in turn, imply a management system that takes into consideration the real amount of water consumed by the users and a tariff system where every unit has a price. This price might not cover the true cost of water or might not incite users to more efficiency and savings, but metering the consumption would undoubtedly prove to be the first step towards an efficient management of the resource.

Last but not least, a proper water supply management system implies the existence of an effective institutional and legal framework that clearly sets the responsibility and role of the water management institutions with respect to water supply and control.

3.3.2 Water Demand Management

A sustainable water management system can not be attained without considering the water demand side. Water resources are finite, and if water demand is not managed, it becomes very difficult to meet the requirements of future generations in a cost-effective manner. Water demand management can take several forms, through either direct measures of regulating water consumption or indirect measures targeting intentional behaviors.

For instance, the policy that consists in applying a *uniform* price for water on a *lumpsum basis* on all the national territory is responsible for many distortions and leads to hidden subsidies that, in turn, are responsible for increased wasting. One way of looking at it, is that a uniform price that does not take into consideration the transportation costs of water means that the closest customers are paying for the remote ones and that these latter are benefiting from a hidden subsidy. The price they pay is lower than its cost and does not contribute to the conservation of the resource. In addition, pricing water on a *lumpsum* basis does not allow for an effective monitoring of individual consumption and does not increase awareness about the scarcity and the value of the resource.

On the other hand, successful water demand management will require sensitization of the public especially that it is the less costly measure that should be prioritized systematically when aiming at reinforcing water extraction, distribution and resource conservation. Experience proved that awareness campaigns might achieve some results. Long and intensive awareness campaigns in Morocco during the late 80's, using various techniques such as advertising campaigns, school awareness sessions, and others, managed to decrease the *growth* in water demand.

Controlling agricultural water demand is also extremely important, especially in countries like Lebanon where about 70 percent of the water demand is from the agriculture sector. Promotion of water efficient irrigation techniques such as drip irrigation is nowadays a common practice in an attempt to minimize water losses. Implementation of efficient irrigation projects is however closely related to the level of awareness of the farmers, and more importantly to the economical feasibility of the project. This is depends on the value or price given to water. In the industry sector, and in order to meet the evolving consumer demands, a growing number of companies in developing countries are being ISO 14000 certified and the major work done covers the following (UNEP, 2002):

- Savings in freshwater intake through water recycling and closed loop systems;
- Reduced pollution load discharges, through clean housekeeping and improved effluent treatment technology;
- New technologies for treatment and recycling of industrial waters;
- Dry cooling in power generation.

3.3.3 Water Quality Management

Balance of water supply and water demand is not sufficient to evaluate a region water situation. The quality parameters can in fact harmfully or harmlessly affect the overall water budget. Interaction between land-use and water resources is of a particular importance, since water is the principal carrier of all pollution and sediment, whereas groundwater and/or the sea are the end recipients. On the other hand, land use is the major source of pollution and, partially, recipient of the pollution carried by water and deposited to the ground. Figure 3.2 provides an illustration of the interaction of land-use and water resources.

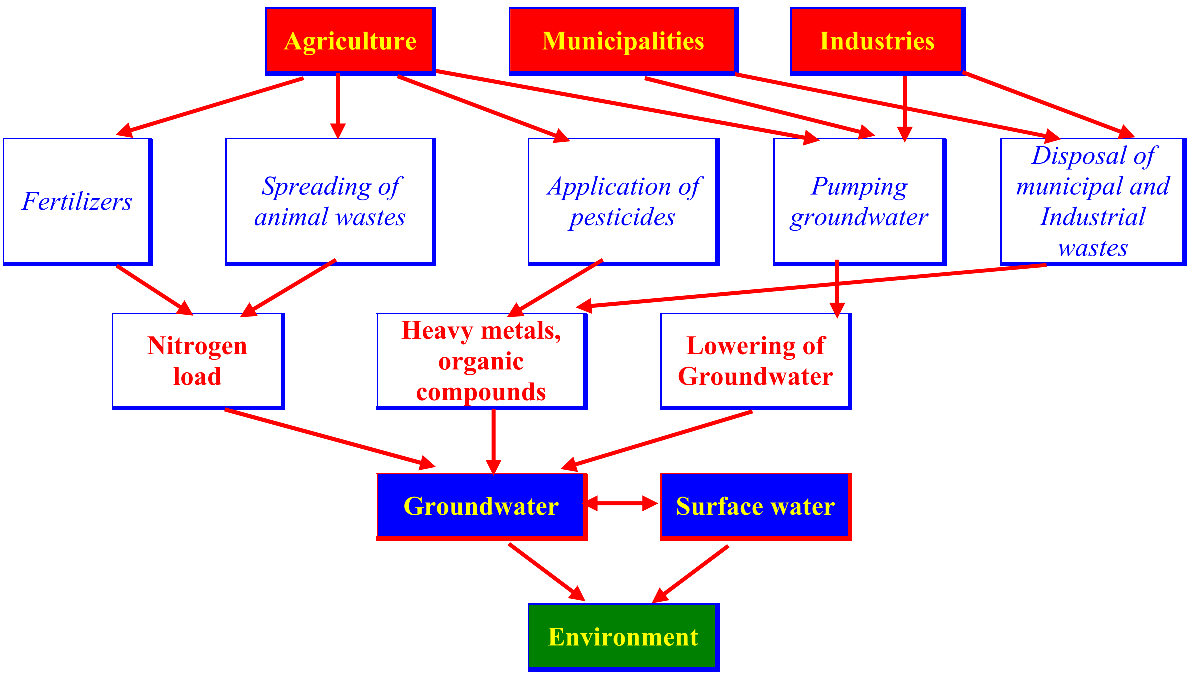


Figure 3.2. Interaction of Land-use and Water Resources (UNESCO/IHP-III Project 10.6)

Managing water quality related problems could be foreseen from two different angles; the preventive and the corrective (end of pipe) one. The first approach comprises legislative and institutional control preventing any unacceptable situation such as aquifer, surface water, and/or nutritional food contamination. This depends on an *adequate enforcement and monitoring* of laws and decisions.

Consequently, these measures are not always very effective or profitable to the stakeholders; therefore corrective actions are required to prevent quality problems from reaching the consumer. These measures could be summarized by corrective and rehabilitative actions to the storage tanks and the connections, in addition to water/wastewater treatment. On the other hand, a special concern should be drawn towards accidents management (or emergency response plans) to provide an effective and rapid response to inevitable situations (PAP/MAP, UNEP, 1998).

3.4. TOOLS AND INSTRUMENTS FOR IWRM

Several tools have been and are increasingly being tested and applied in various countries and locations. The most commonly applied and popular tools are described in the following paragraphs.

3.4.1 Environmental Management Tools

The use of environmental management tools is very important to achieve the objectives of an IWRM strategy. Water development projects can pose significant threats to the environment. Potential impacts need to be assessed and an environmental management plan (EMP) prepared to propose mitigation measures and monitoring schemes. These are part of an environmental impact assessment (EIA), which is a very useful tool to anticipate and minimize impacts from development projects. Such a tool reduces the likelihood that projects that have been intended to stimulate economic growth or provide more food have adverse effects on the natural resources and on local communities. The matter of environment and development became an issue of increasing international concern since the mid-1960s, and the key to reconciling the apparent conflict between development and environment lies on the incorporation of three critical elements in planning and policy making:

- Recognition of the concepts of sustainable development and resilience;
- The adoption of a comprehensive viewpoint;
- The pursuit of higher levels of efficiency.

Environmentally-sound water management implies that development is controlled in a way to ensure that the resource itself is maintained and that adverse effect on other resources are considered and where possible ameliorated (Thanh and Biswas, 1990). A more recent and increasingly used tool is strategic environmental assessment (SEA), which is implemented at the higher levels of policy, plans and programs (PPP) and offers improved opportunities for ensuring sustainable development.

3.4.2 Community Integrated Water Resource Management

" conflicting and competing demands between different user groups for water must be resolved and this resolution may be painful (involving losses for some, gains for others), and difficult".

Poor or marginal communities risk losing out to larger, more focused, and better organized competitors (commercial agriculture, industry, etc.) in the water user fora. Therefore, priorities should be to ensure that communities - and the individuals and households who make them up - become winners rather than losers in IWRM. This will entail focusing on the community and intermediate level of IWRM; strengthening communities' skills in decision making and negotiation – while at the same time helping local level support agencies to provide the necessary backup.

Working within a participatory approach on a community base requires several stages. It begins with the diagnosis where a combination of methods and tools are available such as semi-structured interviews, observations, participatory mapping, transects, seasonal and other diagrams of flows, causality, trends and local organizational relationships, ranking, brainstorming and portraits or case studies of experiments. For feedback, various visual and communication tools could be used, such as village meetings, celebrations, games, posters, and other visual means. Implementation follows a logical sequence, starting with the joint preparation by fieldworkers and project staff of a common framework for a support project and the selection of communities. This could be followed-up in the selected communities by a participatory situation analysis, a needs assessment, and problem identification, and recording past experiences and identifying possible solutions. All of these activities together form the diagnosing phase.

An interactive process can then be established with the communities to explore the problems facing the community and to discuss, jointly design and adapt possible solutions. These solutions, which may include technical readjustments to the water system, or methods and tools for improved management, can then be field-tested and evaluated by the communities themselves. These joint activities form the experimenting phase. The third and final part of the approach, the sustaining phase, focuses on disseminating methods and tools for improved management, sharing the findings, and planning and coordinating further work in order to sustain both the process and the outcome.

Facilitating processes in communities to strengthen the capacities of people to manage their water supply systems can only be done in close contact with them, with patience, wisdom and a good sense for community life. Such processes are not predictable because of the specific characteristics of each community, and one has to deal with setbacks and conflicts. However, the community members give a lot in return – their creativity, trust, and often real commitment. The relationships that develop between facilitators and community members are often intense, satisfying, and challenging for all (Lammerink *et al.*, 2001).

3.4.3 Private Sector Participation

It is generally accepted that privatization can have considerable economic benefits, although in most countries the greater part of the infrastructure is still managed by the public sector. There are many reasons to believe that private enterprises will be more efficient than public enterprises. However, the provision of water services, especially water supply and sanitation tends to be a natural monopoly and countries are faced with difficult decisions, such as:

- ♦ Continue provision through a public enterprise, although capital shortages are prompting the consideration of other alternatives;
- ♦ Encourage autonomous, self-governing voluntary cooperatives, although this has worked better for small systems in rural areas and small towns;
- ♦ Accept that paying monopoly prices for a high quality service may be better than continuing with an inferior service; or
- ♦ Transfer services to private management and use regulatory policy and instruments as a means to influence private sector behavior.

Although some still favor the first alternative, the last alternative mentioned above is being increasingly considered by many countries. This requires the establishment of an appropriate system of incentives to guide economic decisions in the private provision of water-related services. Under such conditions, *the importance of strong public institutions* capable of maintaining an adequate regulatory framework in place cannot be overemphasized. There is clear evidence that, under regulation, some kind of private sector involvement is beneficial to users. But where regulation is limited or unenforceable, it may genuinely be that transfer to the private sector is either not viable or undesirable where an uncontrolled private sector can be predatory, exploiting the vulnerability of the poor (European Commission, 1997). Lately, many new opportunities for private sector involvement are appearing, besides the traditional water supply / sanitation and irrigation water-related services. Data gathering and processing, wastewater treatment, recycling of waste- water and agricultural return flows, and new environmental technologies in general, are fields now benefiting from the innovative entrepreneurship of the private sector. This should be encouraged whenever conditions are favorable (García *et al.,* 1998).

3.4.4 Economic Instruments

3.4.4.1 Price Instruments

The price instruments, which are the most widely used economic instruments for a proper monitoring of water demand, are sophisticated ones. Different pricing strategies could be adopted by water management institutions, however it is very difficult to anticipate the best strategy given the challenge of properly establishing the demand curve of water, which dictates how much water one would consume at a given water price.

Pricing at the long term average cost of the resource

This pricing technique is a compromise between two contradictory facts. Water supply companies are asked nowadays, in most major advanced countries, to cover all their expenses including their maintenance costs, the depreciation costs and *the costs of future and long term expansion projects*. The additional cost on the long term for one additional unit of water is known as the "long term marginal cost". As the water supply companies are in the situation of what is called a "natural monopoly", their maximum profit would be obtained when that price equals their marginal benefit, i.e. their benefit for one additional unit sold. They could therefore make considerable profits but this is not what they are made for, especially that these profits would be made with the condition that they produce less than their maximum capacity.

Note 1:

It must be noted here that most municipalities in these countries are asked not only to have their global budget well balanced, but more specifically to have the accounts of their water supply units also perfectly balanced. This is a clear sign that the pricing must consider the scarcity of the resource and its true value.

Note 2:

It must also be noted that, given the previous, water prices might vary considerably from one region to another and in a single region from one period of the year to another, according to the availability of the resource and its exploitation costs that might vary considerably.

The alternative solution consists usually in selling at the long term *marginal* cost of the resource, a solution that increases the volume produced and decreases the selling price. Its inconvenience is that a deficit appears that has to be covered by governmental subsidies, as the marginal cost is usually below the average cost. *The compromise* consists therefore in selling at the long term average price that covers all present and future expenses but the price is higher and the quantities less than in the previous case. As in previous solutions, the price to all customers is unique.

Differential pricing

Differential pricing is a technique that consists in selling the same quantity that would be produced and sold when pricing at the long term marginal cost, thus generating losses; however, a first block of customers would pay higher prices to compensate for another block of customers that would pay the long term marginal cost. A condition of applicability is that the block of consumers that pays less cannot resell its share of the resource to the other block.

No need to say here that differential pricing techniques allow many different prices for different types of consumers provided overall income covers overall expenses, i.e. average selling price is higher than long term average cost. This, in turn, allows for *political decisions* to decide what social and economic sectors would benefit from lower prices, according to development priorities and social concerns. It must be clear, however, that differential pricing equals to subsidies paid by one part of the population to another part.

This technique also allows to set *penalties on large consumers* that should lead to a more moderate level of consumption. In the case of private consumers, the decrease in water consumption will stop when the “dissatisfaction” in consuming small amounts of water will equal the “dissatisfaction” of paying high amounts for water. This point of equilibrium will naturally vary from one individual to another.

As far as industrialists are concerned, high water tariffs will enhance the search for more water-efficient techniques leading to new investments in machinery and equipment. These investments will stop when their running costs and their depreciation will equal the price water increase. On the other hand, incentives could be given to less consuming industrialists.

3.4.4.2 Economic Incentives

Many economic incentives can be used to better control water consumption and protect water quality. These economic instruments are mainly fiscal incentives. These include usually:

- ♦ Accelerated depreciation for all the equipment and other fixed assets related to the new investment: for example, 1 year instead of 5-10 for the machinery and 5 years instead of 20 for the buildings and other civil works.

- ♦ Deduction from the taxable income of the part of the investment that comes from the reinvestment of the companies benefits provided this taxable income does not become negative. The Lebanese law on income tax gives such incentives for all industrial investments aiming at increasing either the total output or the quality of the production. Specific paragraphs should be added therefore to include investments aiming at reducing water consumption.

- ♦ Tax credits (i.e. tax cuts) proportional to the total amount of the investment (for example 20% of the investment) and spread over time (for example, over 4 years, meaning 5% of the investment every year), provided the due tax does not become negative.

- ♦ Special subsidies on interest rates for investments aiming at reducing water consumption. The Lebanese government already subsidizes interest rates on investment loans in the fields of industry, agriculture and tourism. However, these loans are submitted to the prior approval by private banks and as investments in improving water management might not appear to that latter as “productive” and profitable, special guaranties and incentives would have to be provided by the government to the banks.

3.4.5 Decentralized Mechanisms: Water-use Rights

This is a powerful mechanism that leads to more efficiency in water management, especially by individual farmers and industrial companies, and in which a central management authority is no longer needed after the system is launched. In this system, the central water authority or the community determines a maximum level of water consumption that depends on sustainability studies and other environmental considerations. Water-use rights are then either distributed freely to water consumers on the basis of the previous historical consumption records (a rule called the "grand-fathering" rule), or these rights are sold in an auction, which means implicitly that the community has the property of the water and sells it to the consumers.

The price of such water-consumption permits varies according to the demand by the various users and to the offer by a number of them who are willing to sell theirs. Indeed, individuals and firms who invest in technologies or change their habits in order to consume less water will sell their unnecessary rights to individuals and firms who have high water-consuming technologies or habits and who will be looking for water-use rights. Given the price of these, these intensive consumers will invest until the cost of one additional saved unit of water equals the cost of one additional water-use right. Finally, the price of water-use rights will make equal the costs of one additional saved unit of water of every single user. Water-users unable to invest in less water-demanding technologies will keep buying water-use rights from other users and will be continuously penalized until they are drawn out of the market. Meanwhile, the high price that is maintained by this demand allows additional investment in water-saving technologies by consumers who are able to invest until the cost of an additional unit of water saved equals the price of the water-use permit.

It is interesting to note that the local community or the state representative organism or any other water authority can in turn *buy* some permits in order to "freeze" them and decrease the total water available for consumption by ordinary users. This will raise the price of the permits and lead to new investments in less water-consuming technologies or to new water-consumption habits by individuals.

Water-use rights could also be exchanged between various areas of a country as areas with higher needs (more population, less resources) might buy them from areas with more available resources. The high price for water consumption paid in areas with less resources will discourage people from moving to such areas and encourage people to live in areas were resources are available. The plans by the government to encourage the development of areas with a poor level of water resources through subsidies for the purchase of these water-use rights will be clearly measurable and will have to be budgeted, thus debated publicly. High levels of spending will have to be justified by high expectations on the returns of the subsidized economic activities. The total costs for bringing water from one area to the other not only include the price paid to the local communities that will be recognized as the legitimate owner, but also total transportation costs including investment and yearly spending (interests on investment, maintenance, operational costs).

3.4.6 Participatory Management Structures

In order to implement an effective IWRM plan, broad consultations are necessary to reach the highest level of efficiency. Given the relative scarcity of natural resources in general and of water in particular, especially in the Mediterranean and Arabic countries, water authorities need to face strong reactions by local populations when it comes to the use of the resources. These reactions can be dealt with either through local forums of discussion that would regroup the representatives of the various local types of consumers (farmers, industrialists, private individuals, local institutions) and representatives of the governmental agencies.

Interestingly, it is to be noted that given the fact that water resources are very important to local populations, such resources were traditionally managed by local organisms whose main tasks were to reach consensus between the various interests and to control and enforce, when necessary, the implementation of agreements. Therefore, water management has a very ancient tradition of decentralized management and the heavy and frequently inefficient central agencies for water management are most often the recent creation of newly established states in search of strong demonstration of authority. A good example of a long tradition of local management that has survived to the formation of a strong central government is undoubtedly **France** were six local **basin authorities** manage the national water resources. Their management boards include not more than 30% of state representatives, together with 30% of local MP representing the private consumers and 40% of representatives of the various economic actors. The total number of board members reaches 70 to 120 persons, which means that the legislator has sought to see all the various interests represented within the authority.

The basic principle that governs the creation of these authorities is that, as long as water will follow the easiest way and flow based on gravity's action from “up” to “down”, water basins will be defined and its inhabitants will have to share the management of the same water resources. Every abuse in water management by one group of actors in the basin will immediately reflect on the availability and on the quality of water for the other groups. The excessive number of local water authorities seen in Lebanon in the past (249 in 1994) is a direct indicator of the large number of small local basins and of the limited needs for interaction among local communities on water transfers, each of them being self-sufficient. However, as local communities increased, notably with the development of large urban areas, water transfers became more important and this is what would have justified the creation of local authorities at a higher level but was indeed replaced by central, bureaucratic and state managed water authorities reflecting the strong desire and possibly the strong need to build a powerful central state as a response to the still fragile existence of Lebanon at the end of the fifties.

3.5. EXAMPLE OF AN ECONOMIC REGULATION OF WATER DEMAND : THE CASE OF FRANCE

3.5.1 The Framework

The legislative framework was set up in France in 1964 when the "Water Bill" was passed on December 16th. However, it is the new water law of January 3rd 1992 that really defined the national water policy. It is based on the following broad principles:

- Water is a part of the national wealth.
- Its protection, its use and the development of the new resources are of general interest.
- The aim of the law is to encourage a well-balanced use of the resource.

3.5.2 Planning the Use of Water

For every hydrological basin, a **"Basin Committee"** is created. As mentioned earlier, it regroups all the stakeholders of water management issues, and the central government has not more than 30% of the votes. This authority is in charge of the general water policy and planning and sets up a **"Master Plan for the Management of Water Resources"** for long-term action (15 years). At a lower level, at the level of small local basins, master plans are also set up that must match the general orientations and provide detailed implementation measures. These documents can be opposed to any further unilateral decision by the central government.

3.5.3 Collecting the Information

Several information networks are in charge of providing the basin committees with accurate figures about water availability, consumption, and quality. These networks can be private, public or mixed. They were regrouped under a national structure in charge of setting up the standards for the presentation of the data collected and the definition of the needed parameters.

3.5.4 Control of Frauds

Central state authorities still have an important role in the control of frauds. As the use of water is subject to prior agreement by these authorities within the framework set-up by the basin committees, the state authorities are in charge of fighting all possible frauds. For instance, a special police exists to repress illegal fishing activities and fight environmental violations as well accidental pollution.

3.5.5 The Property of Infrastructure Works

In conformity with the principle of decentralization in the management of water resources, all major infrastructure works related to water belong to the local authorities (cities, villages). These are in charge of maintaining them, and notably to maintain the banks of the rivers that cross their territory.

3.5.6 Exploitation of Water Resources

Local authorities typically choose between managing directly the water resources and sub-contracting to private companies. Many types of agreement formulas exist, but the ownership of the infrastructure works remains to the local authorities.

3.5.7 Financing the Water Policies

Two principles are adopted:

- The *polluter-pays principle* (PPP): every individual or firm that uses or pollutes water must bear the financial consequences.
- The *"Water Pays for Water"* principle: this means that 1) the used water has a price, water is a scarce and fragile resource and must be managed carefully; and 2) every company that distributes or treats water must be financially autonomous and well-balanced, the charges paid by the consumers covering all various expenses.

3.5.8 The Roles of the Various Players

3.5.8.1 The State

As water management is decentralized, the role of the state is limited to defining the rules and to control their application. The State participates in the collection of data, assists in flood prevention and maintains its own domain (some rivers). The State hardly intervenes financially.

3.5.8.2 The regional development companies

Regional Development Companies were created in France between 1955 and 1960 under the auspices of the Ministry of Agriculture to promote agricultural development. These companies sell the bulk water to the irrigators on one hand, and to the distribution companies for drinking water on the other hand. Although they benefit from advantages generally reserved to state-operated firms, they are private companies required to balance their budget.

3.5.8.3 The local authorities

They are the real authorities in charge of water management. They manage water resources either directly or by sub-contracting to specialized private companies, as mentioned earlier.

3.5.8.4 Basin committees and water agencies

These organisms reflect the strong commitment of the political authorities in France to share the management of water resources **in a democratic way** with all the local stakeholders. This was the main break-through of the 1964 Water Bill. **The Water Agencies** are a French specificity. Their role consists of providing advisory services to the basin committees, to make all the necessary and detailed studies, planning works and to provide consultancy services to the various local communities. They are responsible for applying the users-pay and polluter-pays principles by means of taxes. Their financial resources come from the fees paid by water users on pollution and catchment. They spend their resources in decontamination works, assessment of new water resources, and improvement works related to water quality and supply of drinking water.

3.5.8.5 Distribution companies

These are service providers that manage the distribution of water when the municipalities choose to sub-contract the service. Their huge dimensions and the wide range of services offered make them usually major players in the municipal life. The recently texts that were adopted by the House of Parliament on transparency in water markets aim at making the local MP's and people representatives the true deciders in water management issues.

3.5.9 Some Elements about the Water Price Structure

The average water price in France is around 2.5 euros/m^3 for domestic and industrial use. This price can be sub-divided as follows:

- Drinking water service: 50%. This amount represents the total cost of drinking water, including the depreciation of the investments and the reimbursement of loans. It must cover all the expenses of the distribution companies as these must be financially well balanced.
- Collection and treatment of sewage water: 30%. Same remarks as for drinking water. This part of the price is in steady increase since many years as pollution and rejects standards are increasingly high.
- Fees to the Water Agencies: 14%. These are **taxes** and they are of two types: 1) *the pollution tax* is set to reflect the concentration and nature of pollutants in industrial and household discharges. In theory, the tax should cover the cost of treating the contaminated water; in practice, it is set to assure budget balance of the local Water Agency; 2) *the catchment tax or resource tax* is set to manage water demand, to cover the costs of modifying waterways, to cover the costs of infrastructure and to compensate people who are harmed as the result of changes. It is comprised of a catchment component that is related to the abstracted volumes, a consumption (or net withdrawal) component, i.e. the difference between the abstracted volume and the return flow, a water diversion component calculated on the basis of the length of the watercourse made dry as the result of a diversion and a materials extraction component based on the tonnage of extracted alluvial material.

- Fees to the National Fund for the development of Water Supply: 1%.
- VAT: 5%.

3.5.10 Some Elements about the Income and the Expenses of the Water Agencies

3.5.10.1 Income

Water agencies incomes are generated from six (6) major sources: 1) fees on domestic pollution (59.5%); 2) fees on industrial pollution (9.2%); 3) fees on agricultural pollution (negligible); 4) catchment fees for domestic, industrial and agricultural users (13.2%); 5) reimbursement of loans by the water agencies (11.7%) and 6) financial income (6.4%).

3.5.11 Expenses

Expenses consist of ten (10) major types, reflecting the main activities of these agencies. These include:

- Assistance to clean-up activities from domestic wastewater pollution: 36%;
- Assistance to clean-up activities from industrial wastewater pollution: 8.8%;
- Bonus for pollution control: 15%;
- Assistance to the improvement and the increase of water resources: 16.6%;
- Rehabilitation of aquatic environment: 3.7%;
- Assistance to clean-up activities from pollution from the agriculture sector: 3.1%;
- Assistance to the exploitation of resources (good management, technical assistance, elimination of dangerous wastes): 8.4%;
- Studies: 1.8%;
- General management expenses: 6.3%;
- Participation to the general water policy set-up: 0.3%; this part is paid to the ministry of Environment in order to finance some actions of common interest (studies, measurement campaigns, water police, diffused pollution).

3.5.12 Some Elements about the Irrigation Policies in France

In France, a large part (1/3) of the irrigated lands is managed through 1800 professional “Authorized Unions” regrouping 134,000 members for a total irrigated surface of 450.000 hectares. Irrigation water is supplied to farmers by Regional Development Companies either through collective networks or through rivers. Water is then managed either collectively by “Authorized Unions” or directly by individual farmers. Irrigation water charges depend on the water management mode. Charges are higher for water conveyed to the field by a wholesaler like a Regional Development Company or an "Authorized Union" than for water conveyed by water companies. Charges are also higher when collective networks are used to convey water to the fields than when Regional Development Companies convey water from rivers. These companies differentiate their rates according to:

- categories of users (farmers or distribution companies for domestic and industrial use);
- distance from water source;
- pumping costs;
- nature of demand: year-round, seasonal, peak-period;
- season of use.

Charges for water by Regional Development Companies to distribution companies and to farmers have three components:

- an annual fee proportional to the rate of outflow diverted by the consumer;
- a volumetric charge that is based on the volume used and on the time of the year (charges are higher between May 15th and September 14th than during the rest of the year);
- a supplementary pumping tax covering the cost of the fuel when the company is required to pump water to supply its customers.

However, an important part of recent developments is due to individual installations with the creation of small hill lakes or direct pumping from the underwater resources or the rivers. Individual installations are responsible for 1.2 millions hectares today, i.e. the majority of irrigated lands, but, as the demand increases in summer, when surface water are at their lowest, the respect of high quality standards in surface water has lead to an increased need for a collective management of irrigation water.

It must be noted that the recent Orientation Bill for Agriculture of July 8th 1999 has reshuffled the framework of agricultural activities and broadened its content to include the management of the territory and of the environment. A "Territorial Exploitation Contract" is created and has to be signed by every farmer with the State for a total duration of not more than 4 to 5 years on the basis of a professional project that takes into account the patrimonial value of the land. It considers that the farmer can be remunerated for tasks that relate to the preservation and the improvement of the Environment. It also enforces a commitment by farmers who irrigate in favor of "best management practices".

PART II: ASSESSMENT OF WATER RESOURCES MANAGEMENT IN CAMP AREA AND THE THREE PILOT MUNICIPALITIES

4. LEGAL AND INSTITUTIONAL FRAMEWORKS FOR WATER RESOURCES MANAGEMENT IN LEBANON

4.1. INTRODUCTION

In the process of assessing the water resources management in a region such as the CAMP area and the three pilot municipalities, it is of primary importance to understand the legal and institutional frameworks that regulate water management. Such frameworks are the backbones of any water resource management system and can either promote its improvement or lead to its failure.

4.2. LEGAL FRAMEWORK OF THE WATER SECTOR IN LEBANON

4.2.1 The Background

Islamic laws, customary and codified, are considered being the basis from which emerged the Lebanese water laws. The Ottomans relied on these laws to develop the Ottoman Law, which was applied in Lebanon up to the French mandate period.

The codification of Moslem law was initiated during the Ottoman Empire Period (1300-1922 AD). During a second period of reforms (1845 – 1876), the civil law was codified again in what became known as the Mejell Code. The Mejell Code was framed on the basis of the Napoleon Code by Ottoman legislators, translated into Arabic and then imposed throughout the Ottoman Empire including Lebanon. This code remained prevalent even after 1922; it defined water resources as a public non-sellable commodity and divided rivers into those being part of the public domain and those being privately owned. It also defined water ownership and usage issues, rehabilitation of water canals, and definition of wells, springs, and rivers protection zones. Part of the Mejell Code is still applicable nowadays.

The Ottoman law was then modified and the first two water related laws were promulgated: Law 144 in 1925 and Law 320 in 1926 during the French mandate era. Water related laws started emerging since then aiming at organizing the water sector, water exploitation and investment, preserving the quality and quantity of these resources. A summary of the most important water legislation is presented in the following paragraphs. A list of the compiled legislation is provided in Appendix F.

4.2.2 Legislation Related to Public Water Properties

This section presents the governing laws related to public water properties. Three main legal texts were found to be relevant to this section. Article 1265 from the Ottoman Mejell code allows every farmer to use water of an un-owned public river to irrigate his land, unless he causes damage to the public such as causing water flooding, affecting biodiversity or prohibiting water from reaching others. This law has not yet been canceled; however, many exceptions govern surface water distribution and there is no law that defines these issues clearly, therefore constituting a major gap in the national legislation.

Law 144 (1925), issued during the French mandate period, defines public properties by being non-sellable and non-owned properties with time, but municipalities or other governmental bodies can for a pre-defined period of time give permits to exploit parts of these public properties as long as others peoples' rights are not disturbed. Public properties include the sea coast extending to the farthest point the waves attain during the winter, sandy and stony beaches, water streams extending to the upper limit water can reach before flooding, lands all along water streams up to 10 meters width, underground water and springs, in addition to all infrastructures built for public benefit and for power generation.

Decision 320 (1926), issued during the French mandate period, sets conditions to protect public water properties. According to this law, no one is allowed, unless having a permit, to interrupt water from running freely, to violate, misuse lands and dig holes near water bodies, and to excavate and explore underground or artesian water resources. This law allows also, under special conditions, the formation of local committees to manage local water issues.

4.2.3 Legislation Related to Potable Water Collection and Distribution

Two main legal documents were found to be directly related to potable water collection and distribution. Legislative decree 16 (1932), issued during the French mandate period, sets the minimum amount of potable water to be secured in locations including at least 500 persons to five liters per person per day. Decree 227 (1942), specifies the need to conduct geological, bacteriological and chemical investigations to be approved by the public health minister to identify suitable potable water sources.

At the same time, the Ministry of Energy and Water (MoEW), represented by the different water and wastewater establishments each within its own boundaries (according to the Law 377/2001 amending Law 221/2000 rectified by the Law 241/2000), is responsible for preparing the studies, implementing, investing, maintaining, rehabilitating and renovating water projects to distribute potable and irrigation water and to collect, treat and discharge domestic waste water. In addition, the water and wastewater establishments are responsible for setting tariffs for potable, irrigation and wastewater services taking socio-economic conditions into account.

4.2.4 Legislation Related to Water Exploration and Usage

Two major legal texts were found to address the issue of water exploration and usage. Decree 14438 (1970), prohibits any exploration works for underground water or well drilling unless a 4-year renovated permit from MoEW is available and tariffs are duly paid. These tariffs vary depending on the amount of water drawn from these wells and their usage purpose (domestic, irrigation or industrial). Note that the seventh and thirteen's articles of this decree specifies that no permit is needed in the following three cases: 1) the well is located in a private land and is non artesian, 2) the well has a maximum depth of 150 m, and 3) the well has a maximum flow of 100 m^3 of water per day; however the well has to be far from any other natural water source such as springs or rivers. In such cases, the well owner needs only to inform the ministry of his intention to drill a well.

In 2002, the MoEW issued an administrative memorandum (No.4/m.o) restricting the presence of private wells that can affect public ones; special geological and hydrogeological studies need to be conducted to assess the influence of private wells on nearby public ones. On the other hand, no legislation defines the distance that should separate two private wells from each other. It is also worth mentioning the existence of the construction law 148/1983 specifying a distance of at least two meters separating any kind of building from canals and water streams borders and public water properties.

4.2.5 Legislation Related to Water Quality Preservation

Several legal texts are directly or indirectly related to water quality preservation. Decision 320 (1926) forbids releasing animal fertilizers or making waste warehouses inside the protection zone of a spring used for public purposes. The fifth section of Decree 12 (1932) prohibits the construction of buildings, wells or boreholes that could negatively affect potable water. Decree 2761 (1933) prohibits the discharge and/or storage of wastewater within the protection area of a potable water source, on soils, in caves, and/or in bottomless wells unless taking appropriate measures to prevent underground water pollution, promote health protection, and preserve public cleanliness as stated also by the law executed by the decree 8735 (1974), related to preserving public cleanliness.

Decision 67 (dated 1972), issued by the MoPH, specified bacteriological water tests standards required to be adopted by all governmental laboratories of the Ministry of Public Health (MoPH). While these standards are the minimum required to test water quality, it is encouraged to adopt more advanced techniques.

In 1994, decision 20/b issued by the Ministry of Environment (MoE) listed the standards that should be followed to safeguard water quality. This ministerial decision was canceled by decision 52/1 dated 1996,issued by MoE, which defined the new criteria to protect surface and sea water from pollution, in addition to other standards related to soil and air quality. Last but not least, decision 8/1 was recently issued by MoE in the year 2001 amending the first article of decision 52/1 related to the determination of the specifications and the levels specific to limiting pollution of air, water and soil by canceling nine annexes, renaming five and adding five. The new five annexes set the specifications related to air pollutants and liquid waste generated by classified establishments, wastewater treatment plants and hospitals.

In addition to these standards, the Lebanese Government issued in year 2002 the Environmental Code Law 444 that aims at protecting the environment specifying several issues among others, how to protect the water, marine and ground environment from pollution. This law also calls for the need of an environmental impact assessment (EIA) including an environmental management plan (EMP) before the initiation of any kind of project that could negatively affect the environment.

4.3. INSTITUTIONAL FRAMEWORK OF THE WATER SECTOR IN LEBANON

Water Resources Management in Lebanon falls under the jurisdiction of several institutions and bodies. The responsibilities and roles of these institutions with respect to the management of water resources and wastewater are described in the subsequent paragraphs.

4.3.1 Ministry of Energy and Water (MoEW)

The ministry was first founded in 1966 via the law 20 and it was initially named Ministry of Hydraulic and Electrical Resources (MHER). Table 4.1 summarizes the main legislative documents related to the reorganization and roles of the ministry.

Table 4.1. Legislative Documents Establishing and Organizing MoEW

Legislative Document	Year	Summary
Law20/66	1966	Establishes the Ministry of Hydraulic and Electrical resources
Decree 5469	1966	Organizes and defines the role of the Ministry of Hydraulic and Electrical resources
Decree 9365	1968	Sets principles for water projects budget preparation and certification
Decree 14607	1970	Forms a committee to solve disputes within the ministry
Law 221	2000	Amends and modifies the role of the Ministry of Hydraulic and Electrical resources
Law 241	2000	Adjusts an error in the law 221
Law 247	2000	Cancels the Ministry of Hydraulic and Electrical resources, merges all its components to the Ministry of Energy and Water and amends its organization
Law 103	2000	Accredits the Director General some authorities
Law 377	2001	Amends the law 221 by adding the municipal wastewater sector to the ministry's responsibilities

In the year 2000, the Law 247 canceled the Ministry of Hydraulic and Electrical resources, merged all its components to the Ministry of Energy and Water and amended its organization; in addition to the laws 221/2000, 241/2000 and 377/2001, which considered that the protection and development of natural water resources are elements of the environment and natural balances protection framework and in the heart of public benefit. Finally, the main issues handled by the ministry as mentioned in the laws 20/66 up to the law 377/2001 are water, energy, mines related issues, domestic waste water; in addition to monitoring, tutoring and improving performance of different water establishments and bodies operational in the field of water and energy. The ministry's more specific and recent roles are the following:

- Assessment, monitoring, and studies of water resources, quantification of water needs and assessment of usage opportunities and domains.
- Development and continuous revision of master plans for distributing potable and irrigation water, in addition to handling domestic wastewater management issues.

- Monitoring surface and groundwater quality and specification of appropriate standards.
- Design and implementation of large water systems such as dams, artificial lakes, tunnels and rehabilitation of river borders and water networks.
- Feeding of aquifers when needed and monitoring of water quantities pumped and exploited from these aquifers.
- Protection of water pollution and overexploitation by providing adequate enforcing measures and taking appropriate actions.
- Provision of permits for groundwater explorations, public surface and groundwater exploitations.
- Approval on wastewater treatment plants and/or outlets locations.
- Provision of standards that have to be followed throughout water institutions studies, implementation activities, investments regulations, and water quality measurement and monitoring tools for surface, groundwater and domestic wastewater.
- Participation in the permitting of mines and quarries in terms of their effect on water resources.
- Ensuring public relationships with the citizens and provision of needed information about rational water usage.

4.3.2 Water and Wastewater Establishments

The first water related committees were established in Lebanon during and after the French mandate. Accordingly, the Lebanese government issued around 22 decrees and established 22 water authorities between the years 1951 and 1995. In addition to these authorities there are around 210 local committees mainly concerned with irrigation water issues.

In the year 2000, a new organization of the water sector emerged. Laws 221/2000, 241/2000 and 377/2001 reorganized the water sector in Lebanon by establishing four water and wastewater establishments having their financial and managerial independence under the supervision of the MoEW. These establishments are Beirut and Mount Lebanon Water and Wastewater Establishment, North Lebanon Water and Wastewater Establishment, South Lebanon Water and Wastewater Establishment and Bekaa Water and Wastewater Establishment. The 22 water authorities will maintain their activities until being completely merged into the corresponding establishment.

The major responsibilities of the above mentioned water and wastewater establishments, according to the above mentioned laws and noting that these institutions do not have yet specific organizational decrees, consist of:

- Studying, implementing, investing, monitoring and rehabilitating water projects, distributing potable and irrigation water, and collecting, treating and discharging domestic wastewater.

- Suggesting tariffs for potable, irrigation and wastewater management services, taking socio-economic situations into consideration.

- Monitoring and controlling potable and irrigation water quality and domestic waste water quality from the outlets of treatment plants.

Note that the previous water authorities were only accounted for managing and rehabilitating water projects rather then studying, implementing, monitoring and rehabilitating such projects. Also under the newly established water sector organization, the South Lebanon Water and Wastewater Establishment is only responsible for potable and wastewater management issues, since the Litani River Authority (LRA) is responsible for irrigation projects in the south.

4.3.3 Litani River National Authority (LRA)

The LRA was first established by the Law issued in 14 August 1954 and amended by the Law of 30 December 1955, and defined as a public authority enjoying administrative and financial autonomy. These laws state that the LRA is in charge of irrigation, potable water, and electricity production in the Litani valley and region. This includes all phases from project identification to implementation and management. In particular, the authority shall:

- Implement the Litani River Project for irrigation, drainage, potable water supply, and electric power generation within a comprehensive water management plan for Lebanon;

- Set up a connecting network between power generating plants in Lebanon;

- Operate and exploit all parts of the Litani Project from the technical and financial aspects.

Recently the Lebanese Government has been working on a project law aiming at attributing to LRA the responsibility of all irrigation projects in Lebanon; this law is yet to be approved.

4.3.4 Ministry of Environment (MoE)

The MoE was first established and organized in 1993 by Law 216, amended by Law 667 in 1997. The ministry is currently working on issuing a new law reorganizing its departments and directorates and thus their roles and functions. These laws consider the MoE responsible for planning and developing a national environmental policy, with long term and medium term projects dealing with the environment and natural resources management. The ministry is also to suggest and set guidelines to implement and monitor these projects. The ministry shall also:

- ♦ Prepare plans to protect the environment from pollution especially from wastewater and more specifically to prevent groundwater, potable and irrigation water pollution.
- ♦ Prepare legislative documents, set standards and necessary guidelines to promote and sustain environmental quality.
- ♦ Define environmental conditions to establish certain types of industries.
- ♦ Define sandy and stony beaches usage conditions to sustain and protect the environment.
- ♦ Perform periodical laboratory tests to define levels of air, soil, potable and irrigation water, seawater, and river water pollution, suggest corrective measures and monitor the implementation of these measures by the concerned parties.
- ♦ Organize and promote environmental awareness campaigns.

It is clear that some of the ministry's responsibilities overlap with MoEW and MoPH, especially in what concerns testing water quality and setting water quality standards.

4.3.5 Ministry of Public Health (MoPH)

The first decree organizing the MoPH was issued in 1961 (decree 8377); it was modified and amended several times; the last amendment was in the year 1994 by Law 369. According to these legislations, the ministry is held responsible for managing water quality related issues according to the following:

- ♦ The directorate of Health Protection – Health Engineering Department sets technical standards and specifications to be followed in designing and implementing, among others, the sewage and water networks.
- ♦ The directorate of Health Protection – Health Engineering Department- Statistics Unit assesses and evaluates the significance of health problems including those related to water among others.
- ♦ The Directorate of the Central Laboratory for Public Health – Bacteriology Laboratory carries out bacteriological laboratory tests for water and nutritional products, and sets the maximum allowable levels of bacteria for those to be suitable for consumption.
- ♦ The Directorate of the Central Laboratory for Public Health – Chemistry Laboratory carries out Chemical laboratory tests for potable water and salt water, and sets the maximum allowable levels of chemicals for those to be suitable for consumption.

4.3.6 Ministry of Public Works (MoPW)

Before the establishment of the MoEW in 1966, the MoPW used to be held responsible for water and electrical projects in Lebanon. Afterwards, its role became confined to minor issues related to study rainwater, and infrastructure projects related to water, electricity, phone and sewage networks. The department of Technical Infrastructure is responsible for gathering data on rivers, water and soil, perform needed local studies and investigations to develop maps and considerations to build the needed infrastructure in collaboration with concerned parties and bodies.

4.3.7 Municipalities

The Municipalities law first issued and implemented by the decree 118 (1977), amended by the laws 665 (1997) and 316 (2001), considers all municipalities responsible for every public related activity within its municipal boundaries. The municipality is to advise and propose suggestions in different sectors having municipal public benefits to the different concerned and responsible bodies. In addition, the municipality is held responsible for public works, health issues, cleaning, water, sewage networks, municipal waste and lighting projects. The executive authority at the municipality represented by the head of municipality undertakes the following activities:

- Prevents and forbids activities disturbing public health, peace and comfort.
- Takes preventive measures to avoid fires, blasting, flooding and inundation.
- Gives permits to install water, electricity, sewage and phone networks, insuring in return the initial shape of the roads as it was before the works not excluding public institutions and governmental bodies.

4.3.8 Other Concerned Stakeholders

There are several other institutions concerned with water related issues such as the Council for Development and Reconstruction (CDR), Council for the South, and local NGOs that might have a role in implementing water projects, funding and sometimes monitoring (Majzoub, 2003). On the other hand, the Ministry of Displaced (MoD) is taking the responsibility of water and infrastructure projects in all displaced areas (Majzoub, 2003). As for the Ministry of Agriculture (MoA), the only role directly related to the management of water resources falls under the umbrella of the “Green Plan Project”, which aims at reforesting and irrigating lands across the country. Last but not least, the Mouhafez, representing all centralized authorities except the Ministry of National Defense (MoND) and the Ministry of Justice (MoJ) in the six Mouhafazat, has a role in insuring implementation of rules and disciplines within the Mouhafaza’s boundaries and connecting the municipalities with the different ministries. One of the Mohafez main duties is to supervise local water committees and all public related projects.

4.4. OUTLOOK

While a legal framework exists for the Lebanese water sector, it is not well organized and structured as to avoid mismanagement and overlap of responsibilities. The legal setup presents several weaknesses such as:

- There are still no definite and specific laws organizing surface water management; rivers are chaotically exploited quantitatively and qualitatively.
- There is no clear water right definition; this is leading to conflicts between different communities, and most of the times, agricultural fields are being adversely affected.
- Water consumption tariffs are still based on a lump-sum value and do not take into consideration the quantity of water consumed.
- The Lebanese legislative framework does not specify the parties responsible for surface water quality and quantity management; however MoEW is held responsible for dams and artificial lakes construction when needed.
- As to the underground water exploitation, there is no legislative document that organizes underground water exploitation in terms of the distance or requirements that should be respected when drilling two near-sited wells for example.
- There is no legal document that deals with illegal wells spread all over the Lebanese territories, specifying penalties and responsible authorities.

Overlapping of responsibilities and gaps in water resources management are also quite evident. For instance, concerning water quality, there is a clear overlap in responsibilities concerning testing, monitoring water quality and setting appropriate standards especially among MoEW, MoPH and MoE. This overlap may result sometimes in unaccomplished duties, and therefore unprotected resources adversely affecting the public health welfare. Table 4.1 presents a summary of the responsibilities of the different stakeholders, and highlights duplication of efforts that need to be corrected.

Another major deficiency in the institutional setup for water resources management in Lebanon is that the four water and wastewater establishments are based on jurisdiction boundaries rather than watersheds or river basins, which would lead to a more efficient management of water resources, if properly planned. This is a major drawback in the water management structure in Lebanon that hinders the implementation of IWRM principles and sustainable water management.

As a summary, the Lebanese government needs to have a water code law, tackling water related issues from cradle to grave. It has to specify responsible institutions for surface and groundwater management issues and eliminate all kinds of overlaps in responsibilities and duties among different governmental and institutional bodies. It has also to solve surface and ground water quantity and quality related matters, ownership issues, exploitation tariffs, and penalties issues.

Table 4.2. Responsibilities Matrix in Water Resources Management in Lebanon

INSTITUTION	Water quantity management	Potable Water Collection and Distribution	Water properties protection from misuse	Water quality management	Waste water management
MoEW	• Designs and implements large water systems such as dams, artificial lakes, tunnels and rehabilitates river borders, water networks to put them for investment. • Feeds aquifers when needed and monitors water quantities pumped and exploited from these aquifers	• Assesses, monitors, and studies water resources, quantifies water needs and assesses usage opportunities and domains. • Develops and continuously revises master plans for distributing potable water	• Provides permits for groundwater explorations, public surface and groundwater exploitations • Interferes when giving permits to mines and quarries in terms of their effect on water resources • Protects water overexploitation by providing adequate enforcing documents and taking appropriate actions.	• Monitors surface and groundwater quality • Specifies appropriate quality standards • Protects water pollution by providing adequate enforcing documents and taking appropriate actions • Interferes when giving permits to mines and quarries in terms of their effect on water resources.	• Develops and continuously revises master plans for handling domestic wastewater management issues • Gives the approval on wastewater treatment plants and/or outlets locations
MoPH				• Carries out bacteriological laboratory tests for water and nutritional products, and sets the maximum allowable levels of bacteria for those to be suitable for consumption. • Carries out Chemical laboratory tests for potable water and salt water, and sets the maximum allowable levels of chemicals for those to be suitable for consumption.	• Sets technical standards and specifications to be followed in designing and implementing, among others, the sewage and water networks.
MoE				• Puts plans to protect the environment from pollution especially from wastewater and more specifically to prevent groundwater, potable and irrigation water pollution among others. • Prepares legislative documents, set standards and	• Sets standards for discharge of treated wastewater

INSTITUTION	Water quantity management	Potable Water Collection and Distribution	Water properties protection from misuse	Water quality management	Waste water management
				necessary guidelines to promote and sustain environmental quality. • Perform periodical laboratory tests to define levels of potable and irrigation water, seawater, and river water pollution, suggest correction measures and monitor the implementation of these measures by the concerned parties.	
LRA		• Implements the Litani River Project for potable water supply within a comprehensive water management plan for Lebanon			
Water establishments	• Suggests tariffs for potable, irrigation and discharges of wastewater services, taking socio-economic situations into consideration	• Studies, implements, invests, monitors and rehabilitates water projects, to distribute potable water		• Monitors and controls potable and irrigation water quality and domestic waste water quality onto the outlets of treatment plants.	• Studies, implements, invests, monitors and rehabilitates waste water projects in order to collect, treat and discharge domestic wastewater. • Suggests tariffs for wastewater discharges services, taking socio-economic situations into consideration.
Municipalities		• Supervises and advise on the projects within the municipal boundaries	• Takes preventive measures to avoid, flooding and inundation. • Gives permits to install water, networks, insuring in return the initial shape of the roads as it was before the works not excluding public institutions and governmental bodies.		

INSTITUTION	Water quantity management	Potable Water Collection and Distribution	Water properties protection from misuse	Water quality management	Waste water management
MoD		• Studies, and implement potable water projects in displaced areas			
CDR		• Plans and implements projects			• Plans and implements projects
Council for the South		• Plans and implements projects			
Mouhafez	• Ensures implementation of rules and disciplines within the Mouhafaza's boundaries		• Supervises all public related projects		

5. Water Resources Management in the CAMP Area

This section presents an overall assessment of the water resources in the CAMP area based on literature information, official reports, field visits, and interviews. After presenting the CAMP area, the institutional setting and water infrastructure are briefly described, and the existing situation regarding exploitation of the water resources in the area is depicted. While one reads this section, the importance and urgency of protecting and preserving the water resources of the CAMP area, which are already threatened, should become clearer.

5.1. Delineation of the CAMP Area

The CAMP area extends southwards from Khaldé to Naqoura and about 8 Km eastwards from the coast line (Figure 5.1). It should to be noted however that an IWRM could not be separated from the entire hydrological and hydrogeological basin of the study area. Not only do upgradient zones of the coastal CAMP area contribute to the water budget, but also human activities in these zones might have a significant impact on water resources. Such zones were therefore included in this assessment whenever deemed necessary.

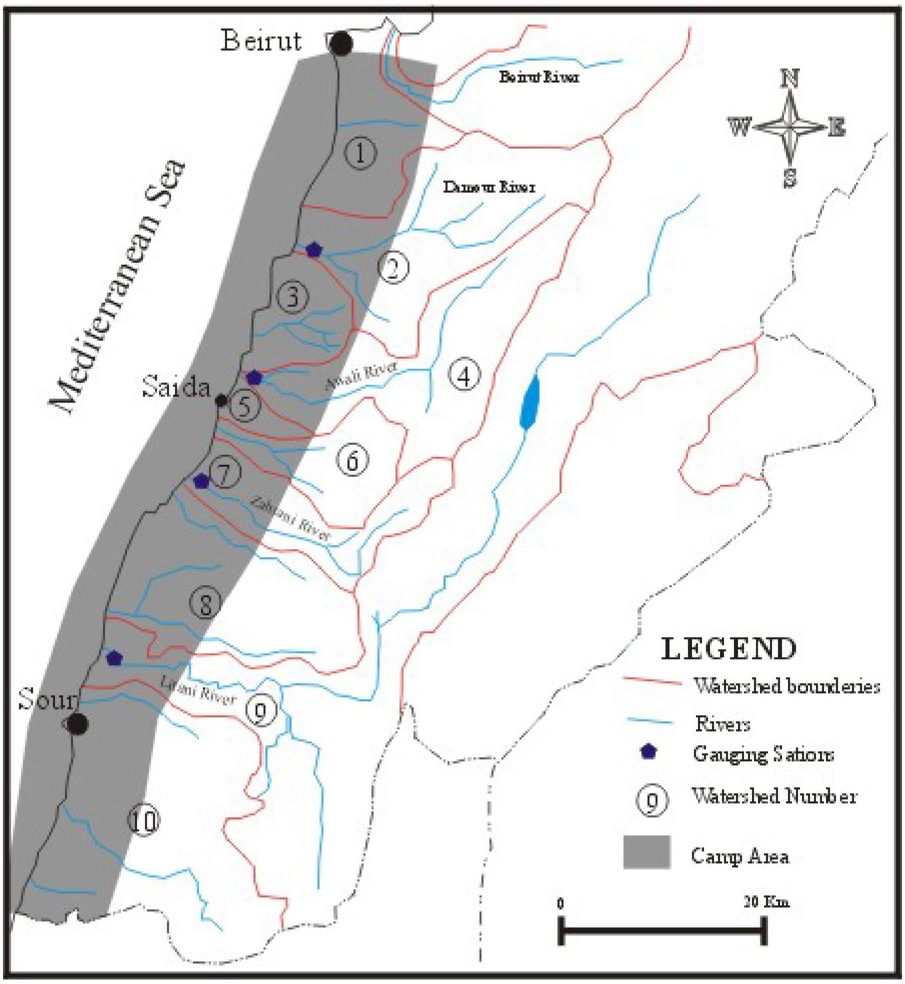


Figure 5.1. Delineation of CAMP Area and Watershed Boundaries

5.2. INSTITUTIONAL SETTING AND WATER INFRASTRUCTURE

The purpose of this section, which complements section 4.3, is to provide a brief description of the different institutions responsible for water management in the CAMP area, as well as a short description of the available water infrastructure, which is described in more details in previous studies (Dar Al Handasah, 1996).

Water Resources within CAMP area used to fall under the jurisdiction of four water authorities: Beirut Water Authority (BWA), Barouk Water and Irrigation Authority (BWIA), Nabaa El Tasseh Water Authority (NWA), Saida Water Authority (SWA) and Tyre Water Authority (TWA). Recently and according to the New Water Law 241/2000 that reorganizes the existing 22 local water offices into four regional water establishments, CAMP area water resources would fall under the management of only two water authorities. The Northern portion of the CAMP area extending from Khalde to the Awali River would fall under the jurisdiction of the Beirut and Mount Lebanon Water Establishment, whereas the remaining area extending southward till Naqoura would fall under the South Lebanon Water Establishment.

The BWA exploits eleven wells present within the Damour area. The BWIA partly exploits the Damour River and operates wells in the Chouf and in Saadyiat area. The NWA covers 163 towns in Nabatieh, Zahrani and Jezzine Region supplying a surface area of about 875 Km^2. The total length of the main distribution water network is about 310 km of main line with reservoirs of total capacity of 10,100 m^3. The main water supply sources for this office are El Tasseh Spring, Fakhreddine Wells and other sources such as Azibeh El Faouqa, El Zarka Spring, Zrarieh Well, Al Charkieh Well, Jabchit Well and others.

The SWA is responsible for an area of 18 km^2 covering Saida City and three major suburban towns. The length of the distribution network is about 95 km and a water treatment station was installed in the high elevation area of Ain El Heloueh for the treatment of water supplied from Al Kfaroueh Spring. A reservoir of 5000 m^3 capacity was constructed near the treatment station. The main water supply source is the Kfaroueh Spring yielding 15,000 m^3/day in winter and half of it in summer. In order to meet the increased water demand, the SWA constructed several wells with pumping stations.

The TWA office is supplying water to about 85 villages and towns covering a surface of about 450 km^2. The total reservoir capacity is about 12,450 m^3. The water supply sources are mainly two, the Rachidieh Spring and the Ras El Ain spring. In addition to these sources, many wells are exploited, especially in Wadi Jilo and near the Saddikin station.

5.3. METEOROLOGICAL SETTING

Before the Lebanese civil war, which lasted from 1975 until 1990, the Lebanese Meteorological Service (LMS) used to operate over one hundred (100) meteorological stations geographically covering the entire country. The Climatological Atlas du Liban was prepared before the onset of the war and is currently the best reference available on the national climate, since it was based on relatively long data series, usually exceeding 30 years (DCA, 1966). During the war, most of the existing stations ceased their operation. A new meteorological network has been recently established with automatic stations including 8 synoptic stations and 35 climatological stations. These stations have however been in operation for less than 5 years, and the available data is not yet statistically significant. In order to satisfy the needs of this project, average values for the required climatological parameters were retrieved from the atlas du Liban (DCA, 1966). The main stations used are those of the Beirut International Airport, Khaldeh, and Adloun, which fall within or close to the study area. The data used is presented in the relevant sections of the report.

5.4. SURFACE WATER IN CAMP AREA

Four major and several minor rivers cross the CAMP area. The four major rivers, starting from the north, are the Damour River, the Awali River, the Zahrani River, and the Litani River (Qasmieh River). The minor rivers include from the north to the south Saitaniq, Abou Assouad rivers and Aazziye River. The major and minor river basins form ten (10) watersheds that extend beyond the boundaries of the CAMP area to the north, south and east (Figure 5.1). The different watersheds crossing the CAMP area are summarized in Table 5.1.

Table 5.2 summarizes the characteristics of the major watershed basins and shows the average annual flow and yield of the major rivers that cross the CAMP area. Fortunately, data from gauging stations are available at the Litani River Authority (LRA). Discharge values presented in this report were retrieved from unpublished LRA records. Note however that most river gauging stations were damaged during the war and became operational again only after 1990.

The average yearly yield of surface water discharging into the sea from the five major rivers in the south is approximately 874.3 Mm^3 (Table 5.2). In the seasonal year 2000-2001, the total volume of water discharging into the sea from the five major rivers was approximately 280 Mm^3 (Table 5.3), which represents a 70 percent reduction compared to the yearly average. Note also that approximately 75 percent of this amount is discharged during the rainy season between December and April (Figure 5.2); this period represents the months of the year when the water is least needed. Two rivers, the Zahrani and the Saitaniq, dry out completely during 8 months of the year. Three rivers are permanent, the Litani being the most important in terms of discharge. Table 5.4 presents the surface coverage and the percentages of the geological formations of the major watersheds. Out of the karstic formations, the Middle Cretaceous Formations have the largest surface coverage in the watersheds of all the major rivers in the study area.

Table 5.1. The Different Watersheds Crossing the CAMP Area (Dar Al-Handasah, 1996)

Watershed Number	*Watershed Name*	*Comments*
1	Khaldé	The watershed is characterized by the presence of several small seasonal rivers including Yabés and Ghadir rivers form the coastal Khaldé watershed
2	Damour	Two main rivers, the Es Safa River and Zeble River, converge to form the Damour River; a third affluent, El Hamman River, converges into the Damour River just uphill the coastal plain; the Damour River forms a watershed that has an area of about 304 Km^2 and originates at an altitude of approximately 1948 m
3	Barja	Barja watershed is composed of several seasonal rivers including Ouadi el Zeini River; this is a coastal basin with an area of about 100 Km^2
4	Awali	The Barouk River and Aaray River converge to form what is known as the Bisri River; in its lower section, the river is named as Nahr Awali; the Awali River forms a watershed that has an area of about 294 Km^2 and originates at an altitude of approximately 1942 m
5	Saida	Saida watershed is a coastal basin with several seasonal rivers, it covers an area of about 32 Km^2
6	Saitaniq	Chemis River and Jannet River converge to form the Saitaniq River; the watershed of the Saitaniq River has an area of about 140 Km^2 and originates at an altitude of approximately 1418m
7	Zahrani	The Zahrani River is also known as Ouadi El Akhdar in its upper reach; the Zahrani watershed covers an area of about 106 Km^2 and originates at an altitude of approximately 1418m
8	Aadloun	The Aadloun watershed covers an area of approximately 290 Km^2 with Ouadi Abou Assouad as its main seasonal river
9	Litani	The Litani River originates from various karstic springs from the Bekaa valley; its lower section receives affluent of Ouadi Ghandouriyeh. The Litani River in its coastal section forms the Qasmeih watershed
10	Tyre	Various small valleys desiccate the Tyre watershed (Nahr Abou Zeble, Nahr Aazziye, Ouadi Ain Chamaa and Ouadi Ain Zaraa). Aazziye River, with watershed covering about 154 Km^2, originates at low altitude hills and has a minor contribution to the water resources of Lebanon

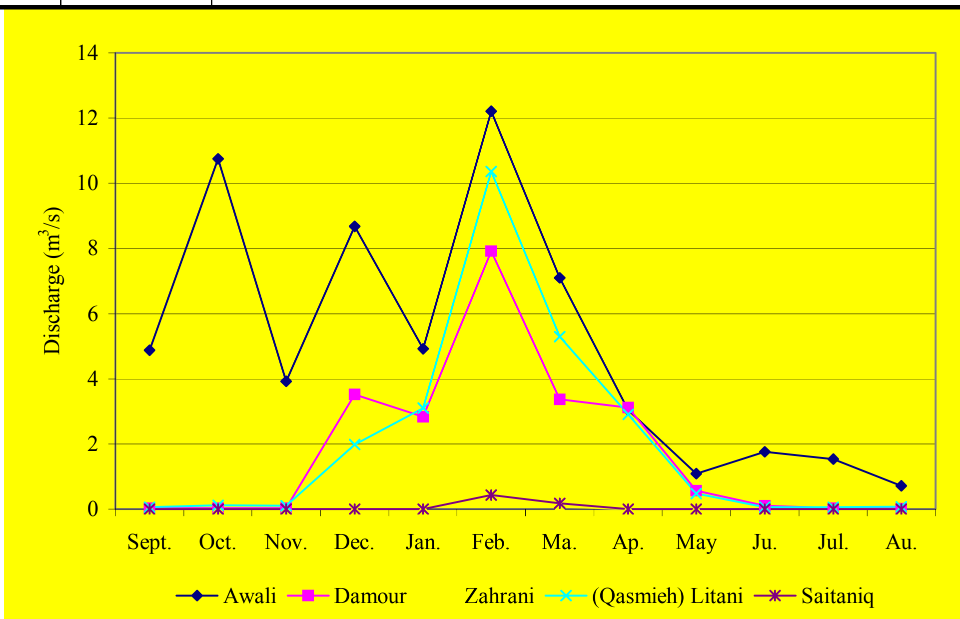


Figure 5.2. Hydrographs of the Major Rivers within the CAMP Area (years 2000-2001)

Table 5.2. Characteristics of Watersheds and Average Flow of Major Rivers Crossing the CAMP Area (Dar Al-Handasah, 1996)

River	Watershed Basin				Gauging Station					Average Annual Flow and Yield [a]	
	Area (Km^2)	Maximum Elevation (m)	Gauged Area (Km^2)	Non Gauged Area (Km^2)	Name	Altitude (m)	Current Condition	Type	Period of Record	Flow (m^3/s)	Yield (Mm^3)
Damour	306	1948	303	1	Mouth of River	5	IS [b]	–	1992-1993 1994-2001	3.212	100.717
Awali	294	1942	293	1	Saida	5	IS	LG [c]	1991-2001	10.1625	321
Saitaniq	140	1418	139	1	Mouth of River	20	IS	–	1965-1975 1979-1980 1991-2001	0.407	12.306
El Zahrani	103	1418	102	1	Mouth of River	30	IS	–	1965-1975 1979-1981 1991-2001	0.66	20.68
Litani (Qasmieh watershed)	–	–	–	–	Mouth of River	10	IS	–	1944-1950 1965-1975 1991-2001	13.317	419.586
										Total	***874.289***

[a] Average values obtained from the years when the gauging stations were in service
[b] IS: In Service
[c] LG: Limnigraphic station

Table 5.3. Comparison between Total Yield and 5-Month Yield Measured at the Mouth of Major Rivers (years 2000-2001)

River	Total Yield (Mm^3/year)	5-month Yield (December-April)	
		Mm^3	%
Awali	157.915	92.83	58.78
Damour	55.468	53.306	96.1
Zahrani	1.841	1.841	100
(Qasmieh) Litani	62.973	60.396	96
Saitaniq	1.53	1.53	100
Total	***279.727***	***209.903***	***75***

Table 5.4. Lithological Characteristic of the Different Watersheds (LRA, FAO, UNDP, 1972)

Major Watershed Basins	Lithology							
	Karstic Formations						Non-Karstic Formations	
	Jurassic		Middle Cretaceous		Eocene			
	Km^2	%	Km^2	%	Km^2	%	Km^2	%
Damour	10	3	77	24	_	_	236	73
Awali	29	9	137	48	_	_	124	43
Saitaniq	4	3	64	46	_	_	72	51
Zahrani	_	_	59	55	8	8	39	37
Litani Downstream of Qaraoun	49	8	135	21	263	42	183	29

Figure 5.3 shows the annual discharge volume of the Damour, Awali, Saitaniq, Zahrani, and Litani rivers as measured in the last 10 years. The discharge volume was obtained from gauging stations positioned at the mouth of these rivers, unless otherwise specified. One can notice that during the last ten years the volume of discharge from the mouth of those major rivers has decreased dramatically. Such a decrease in volume can be attributed to two major possible reasons:

- Climate change, primarily through decrease in precipitation levels (Figure 5.4);
- Human exploitation of source springs, surface water, and/or aquifers (leading to an increase in the infiltration (recharge) from the river to the aquifer).

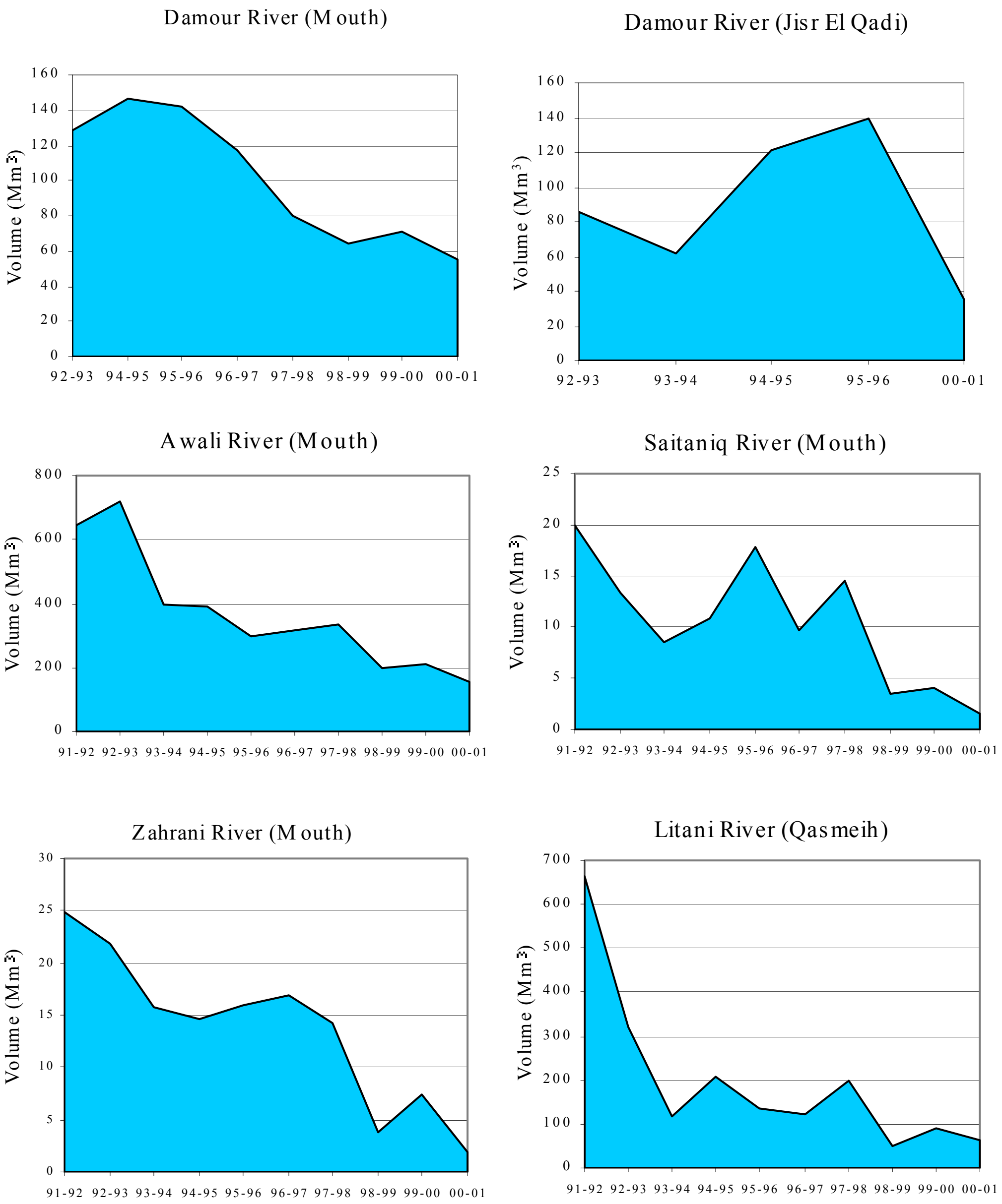


Figure 5.3. Variation in Discharge Volume of the Major Rivers in the CAMP Area

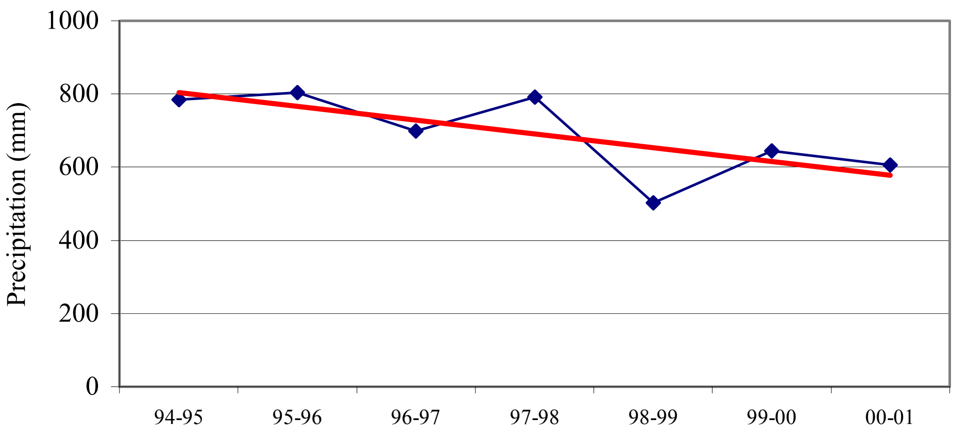


Figure 5.4. Precipitation Records in the Last 7 Years (BIA Records)

> The amount of surface water available in the CAMP area has decreased in the last 10 years; the cause of such decrease could be climate change or human overexploitation, or most probably, a combination of both; in any event, the reality is that less water from surface streams is available, which could contribute to severe problems in water supply if the situation is aggravated by further uncontrolled exploitation.

5.5. GROUND WATER IN CAMP AREA

Most of the water supply in the CAMP area is derived from groundwater through wells or springs. The Sannine Aquifer is the main aquifer being exploited in the region (Appendix A). The Eocene and Kesrouane Aquifers are also being used to a lesser extent. These aquifers extend beyond the boundaries of the CAMP area to the north, south and east. This section is structured in four major parts: description of the major aquifers and their estimated budget, description of the main hydrogeological provinces, description of groundwater wells and description of springs.

5.5.1 Aquifers

5.5.1.1 Sannine Aquifer

The Sannine Aquifer, of Middle Cretaceous age, is the major groundwater source for the CAMP area. The hydrogeological boundaries of the Sannine Aquifer extend beyond the boundaries of the CAMP area.

The Sannine Aquifer is a thick sequence of limestone, marly limestone and dolomites that is slightly inclined to the sea. The Sannine Aquifer is desiccated by parallel NE-SW faults. The Eocene and Chekka Formations overly the Sannine Formation in several parts of the study area. However the rivers descending from the mountains cut through the protective layer and expose the underlying Sannine Aquifer. The Sannine aquifer is bordered from the north by the plateau of Beirut, and extends from the south out of the Lebanese territories. It is bordered from the west by the sea and from the Northeast by the western Mount Lebanon flexure extending to the Roum Fault and ending south east by Houla depression.

The Sannine aquifer has a thickness of approximately 700 m and is characterized by its secondary porosity causing groundwater to flow mainly through fractures, joints and channels, which is characteristic of karstic aquifers. Along the coast the aquifer can be found either under water table conditions or under confined conditions, while inland the aquifer is mainly under water table conditions (section 5.5.2).

The exposure of the Sannine Aquifer reaches approximately 843 Km^2. In order to estimate the recharge of the aquifer within the CAMP area, three major sources are considered: 1) direct infiltration from rainfall, 2) surface water infiltration from rivers, and 3) groundwater leakage from overlying aquifers. Direct infiltration from rainfall is the major source of recharge to the Sannine Aquifer. Assuming a precipitation rate of 850 mm/year (Service Météorologique du Liban, 1970) over the entire outcrop and an infiltration rate of approximately 40 percent (UNDP, 1970), the total recharge from infiltration is estimated at about 286.6 Mm^3/year. The used figure for infiltration is extracted from the most detailed hydrogeological study that has been conducted in Lebanon (UNDP, 1970).

Surface water, mainly from river, also contributes to the recharge of this aquifer. Surface water from Zahrani River is being recharged to the Sannine Aquifer at a rate of about 2 Mm^3/year (LRA, FAO and UNDP, 1973). Moreover, approximately 18 Mm^3/year of surface water from the Saitaniq River is being recharged into the Sannine Aquifer based on the same study. The total discharge from the Sannine Aquifer to the Awali River is approximately 26 Mm^3/year. Unfortunately, an estimation of the loss or the intake from the Damour and Litani Rivers to the Sannine Aquifer is not available and can not enter into the balance. Although the Litani and the Damour are perennial rivers, their effect on the aquifer is not well understood due to the lack of adequate studies.

In addition to the above-mentioned sources, groundwater leakage from the overlying Eocene Aquifer and the Quaternary Aquifer also contributes to the recharge of the Sannine Aquifer. A volume of approximately 12.5 Mm^3/year is infiltrating from the Eocene Aquifer in the Nabatiye area (LRA, FAO and UNDP, 1974). Last but not least it is likely that the recharge of the Sannine Aquifer might also occur from adjacent provinces via major faults such as the Roum Fault. In sum, the estimated total annual recharge of the Sannine Aquifer amounts to about 293 Mm^3, and is distributed as shown in Figure 5.5.

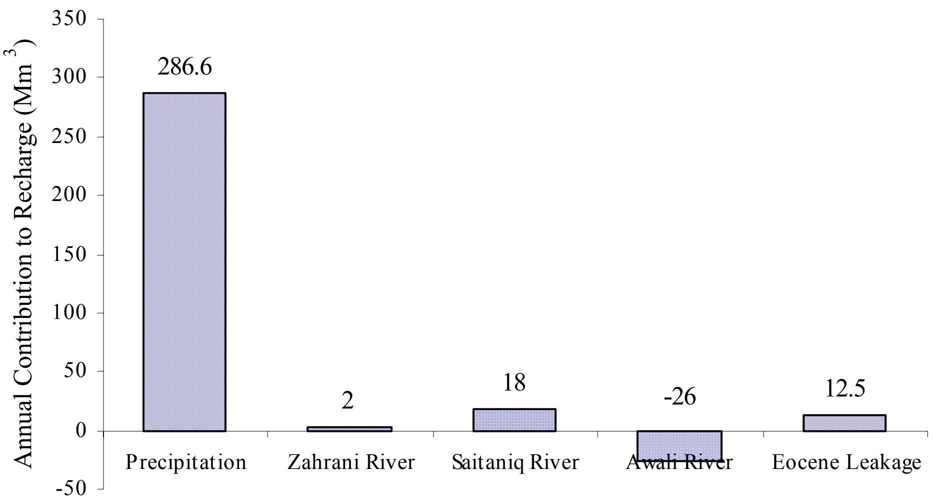


Figure 5.5. Major Sources and Sinks of the Sannine Aquifer in the Study Area

5.5.1.2 Eocene Aquifer

The second most important aquifer in the Camp area is the Eocene aquifer. This aquifer is essentially composed of calcareous marl that grades laterally into limestone further away from the sea. The Eocene Aquifer extends along the coast and its limestone and marl beds are inclined towards the sea. It is separated from the Sannine Aquifer by the Chekka Formation, which acts as a relatively impermeable unit restricting the hydraulic interconnectivity between both aquifers. Similarly to the Sannine Aquifer, the Eocene Aquifer is of karstic nature. Groundwater flows mainly through fractures, joints and faults. The thickness of this aquifer reaches approximately 300 m. The major focus in this study is the Eocene aquifer in the coastal section mainly concentrated south of Saida, although large outcrops exist between Nabatiye and Bent Jbail. The Eocene Aquifer along the coast is mainly under water table conditions (section 5.5.2). The coastal Eocene outcrops cover an area of about 227 Km^2.

Similarly to the Sannine Aquifer, direct infiltration from rainfall is the major source of recharge to the Eocene Aquifer. Assuming an average rainfall of approximately 800 mm/year (Service Météorologique du Liban, 1970) and an infiltration rate for the Eocene Aquifer that ranges between 28 and 35 percent (UNDP, 1970), the estimated recharge would vary between 50 and 63.6 Mm^3/year. Note that the average precipitation value used is lower than that used in the case of the Sannine Aquifer because the Eocene Aquifer outcrops closer to the coast, where precipitation levels are lower. The effect of the major rivers to this aquifer is not well understood. However, major rivers (e.g. Litani) pass a short distance over this aquifer before discharging into the sea.

5.5.1.3 Quaternary Aquifer

The Quaternary Aquifer is not considered as a major aquifer in the CAMP area due to its proximity to the sea and its limited thickness (not exceeding 20 m). This aquifer is present as a coastal stretch in the Damour coast and between Saida and Tyre. It is composed mainly of reddish brown sands and clays as well as conglomerates. Generally it is recharged from direct precipitation, return flow from irrigation and seepage from rivers. In several locations along the coast the Quaternary Aquifer is recharged from underlying aquifers that are under confined conditions such as in Brak and Ras El Ain. This aquifer is under water table conditions with shallow water table.

5.5.1.4 Kesrouane Aquifer

The Kesrouane Aquifer, of Jurassic age, is considered one of the major aquifers in Lebanon. It consists of a monotonous sequence of limestone and dolomite. It is characterized by secondary porosity and by the presence of preferential karstified channels. Although not having a large surface exposure, the Kesrouane Aquifer could become an important groundwater resource in the CAMP area. It outcrops as an elongate stretch in the valley of Damour River east of Damour village.

The aquifer is under confined conditions and the piezometric level is near the surface (ARD, 1999). The recharge zone of the Kesrouane Aquifer is well outside the study area. It recharges through sinkholes and fractures from the Jurassic massif of the Barouk-Niha range (ARD, 1999). The presence of the coastal flexure in front of the Kesrouane Aquifer acts as a hydrogeological barrier allowing the water to accumulate behind it, hence increasing the potential of this aquifer to be exploited.

5.5.2 Hydrogeological Provinces

It is usually useful to subdivide aquifers into hydrogeological provinces that are differentiated inhere based on their relative importance as a groundwater resource, relative connectivity with the sea, and water quality (primarily in terms of level of salt-water intrusion).

5.5.2.1 The Hydrogeological Provinces of the Sannine Aquifer

The Sannine Aquifer in the CAMP area can be subdivided into two interconnected water provinces: (a) the coastal province that extends between Khalde and Naqoura and (b) the inland province, which extends between Baaqline and Jabal Aamel.

(a) The coastal province

In the areas extending from Khalde to Naame and from Saadiyat to Saida, the Sannine Aquifer is in direct contact with the sea. The underground fresh water mixes with the seawater. The thin freshwater lens is being heavily exploited in this area, where a large number of wells exist. These wells are being used for domestic, industrial, and irrigation purposes. Examples include wells in Khalde, Naame, and Saadiyat. For instance, Total Dissolved Solids (TDS) and chlorides concentrations in a water sample from a well in Saadiyat were 1850 mg/l and 1240 mg/l respectively, which are relatively high (section 7.2.4).

In the Damour area, the Sannine Aquifer is protected from direct contact with the sea by the Chekka Formation. This resulted in the establishment of an important quantity of water that is larger than those on the northern and the southern parts of this hydrogeological province. Nevertheless, the aquifer appears to be overexploited as noted by the increase in salt content with time (section 6.2.4).

In the area extending from Saida to the Refinery, despite the fact that the Chekka Formation and the Eocene Aquifer protect the Sannine Aquifer, seawater intrusion has already been noted. More than 116 wells are tapping the Sannine Aquifer between Saida and Refinery. TDS concentrations, as measured in August 2000 in two municipal wells in Saida, were 500 mg/l and 455 mg/l (ARD, 2000).

In the Brak area, the Sannine Aquifer is flowing under artesian conditions. The Sannine Formation is hydraulically connected to the Eocene and Quaternary Aquifers despite the presence of the Chekka Formation. The hydraulic connection is likely attributed to the presence of faults and fractures that act as preferential pathways. More than 34 wells are located in the Brak area. These wells are mainly used for irrigation. The yearly water consumption of this area alone amounts to approximately 22.75 Mm^3.

The piezometric level of the Sannine Aquifer can reach several meters above mean sea level. Analysis of TDS of a well in June 2001 showed values averaging 690 mg/l (ARD, 2001).

The area extending from Sarafand to Kharayeb is characterized by the presence of the Sarafand syncline that trends in a northern direction (ARD, 2001). This resulted in the outcropping of the Sannine Aquifer along the coast such as in areas of Insariye, Aadloun and in the valley of Abou Assouad. This aquifer is under water table condition and is characterized by the presence of seawater intrusion due to the direct contact with the sea. The piezometric level is controlled by the seawater level. Brackish water was reported in numerous wells tapping this aquifer such as in Sarafand (section 7.2.4). The municipality well in Sarafand exhibited a TDS value of 630 mg/l. The water is at high concentration of salts in Aadoussiyé area (UNDP, 1970). In the well of Babliyé, the saltwater intrusion is noticed 3 km inland (UNDP, 1970). The feature persists till Qasmiyé where the saltwater/fresh water interface starts to approach to the sea.

In the area extending from Tyre to Ras El Ain, groundwater is available in large quantities and the presence of faults results in corridors of salt-water intrusion in certain areas. Important fresh groundwater sources exist, namely Ras El Ain, Rachidiyé and Qasmiyé. The first two are under artesian conditions and pass through the 300 m-thick Chekka and Eocene Formations and the second is at the contact between the Sannine, Chekka and Eocene Formations. The discharge regime of Qasmiyé and Ras el Ain is poorly understood. The Ras El Ain source discharged approximately an average of 9.5 Mm^3/year in the last three years based on measurements from LRA. Discharge for Ras El Ain and Rachidiyé reaches approximately 1.02 m^3/s (UNDP, 1970). The Qasmiyé is situated in the Litani valley. The only reliable discharge measurements of this spring were made during the years 1966-1967 and 1967-1968, and were estimated at 1.6 and 1.8 m^3/s, respectively.

In the area extending from Azziye to Naqoura, the Sannine Aquifer is in direct contact with the sea. The Sannine Aquifer in this section has two water bearing zones separated by a relatively impermeable layer that acts as a protection zone for the lower water bearing unit from salt water intrusion. This resulted in acceptable quantities of water in this coastal zone. However, water samples have indicated that saltwater intrusion could be initiating, even in that area (section 8.2.4).

(b) The Inland province

This area extends from the outcrops of the Sannine south of Baaqline passing though outcrops in Roumine and Deir El Zahrani and ending in Jabal Aamel. The groundwater in this section of the Sannine Aquifer is under water table conditions and is found at depths exceeding sometimes 500 m as in Harouf and Deir el Zahrani and 600 m as in Qaaqaiet el Jisr. Aquifer budget calculations indicate that this aquifer is being overexploited (section 5.6). The major characteristics of the Sannine hydrogeological provinces are summarized in Table 5.5.

Table 5.5. Major Characteristics of the Sannine Hydrogeological Provinces

Sannine Aquifer	*Section*	*Contact with Sea*	*Conditions*	*Status*
Coastal Province	Khalde-Saida	Direct contact	Water table	Over Exploited
	Saida -Refinery	Indirect contact	Confined	Over Exploited
	Brak	Indirect contact	Artesian	Over Exploited
	Sarafand-Kharayeb	Direct contact	Water table	Over Exploited
	Tyre-Ras-El Ain	Indirect contact	Artesian	Over Exploited
	Azziye-Naqoura	Direct & indirect contact	Water table & confined	OK
Inland Province	Baaqline-Jabal Aamel	Not Applicable	Water table	Over Exploited

5.5.2.2 The Hydrogeological Provinces of the Eocene Aquifer

The Eocene Aquifer within the CAMP area can be subdivided into four major hydrogeological provinces: (a) between Saida and the Refinery, (b) the Brak area, (c) between Sarafand and Kharayeb and (d) between Tyre and Azziye. The provinces extending from Saida to the Refinery and from Sarafand to Kharayeb are generally under water table conditions. The Eocene Aquifer in these provinces is already contaminated with saltwater intrusion. The Brak province and the province extending between Tyre and Azziye are generally under water table condition. The Eocene aquifer in these areas is hydraulically connected to the underlying Sannine Aquifer despite the presence of the Chekka Formation. This hydraulic connection is likely attributed to the presence of faults and fractures that act as preferential pathways for groundwater to flow from the Sannine Aquifer to the overlying Eocene Aquifer. This is evidenced by the presence of several springs and wells in Brak and Tyre that are discharging groundwater in large quantities from the Eocene Aquifer.

5.5.3 Groundwater Wells in the CAMP Area

Information on groundwater wells (Appendix B) present in the CAMP area as well as those covering the Sannine Aquifer beyond the CAMP area was gathered from previous technical documents (ARD, 1999; ARD, 2000; Cannan 1992; Dar Al-Handasah, 1996; and Hamzeh, 2000). Moreover, information on public wells was gathered from different water authorities, namely Beirut, Saida and Sour Water Authorities as well as the Litani River Authority. Information regarding wells in the three pilot areas were gathered from interviews with the municipality staff, local citizens, and well owners. The result of the well investigation revealed the presence of about 826 wells in the whole CAMP area and Sannine Aquifer of which 208 (25 %) are public water supply wells, and the remaining 618 (75 %) are private wells. This number represents of course only a portion of the total number of wells available in the CAMP area, but provide sufficient basis to generate initial statistics and estimations on water consumption within the study area. The distribution of these wells in terms of usage and type of aquifer tapped is indicated in Figure 5.6 and Figure 5.7, respectively.

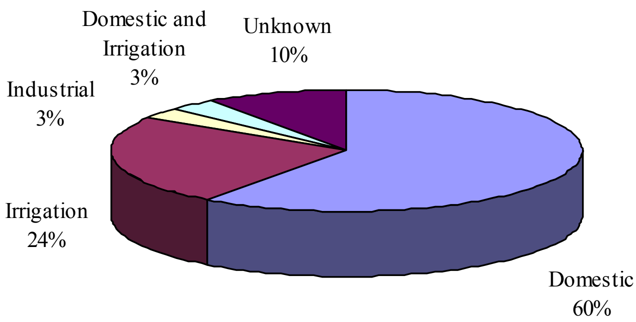


Figure 5.6. Distribution of Wells in the CAMP Area by Water Usage

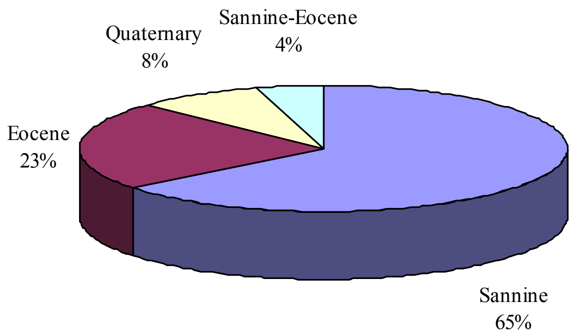


Figure 5.7. Distribution of Wells in the CAMP Area by Type of Aquifer Tapped

Note that the water usage of about 10 percent of the wells could not be identified. People are very skeptical in releasing information on their well and its usage. Note also that a large proportion of the wells is private, and many were illegally installed. Figure 5.7 confirms the importance of the Sannine Aquifer as a major groundwater resource in the CAMP area.

An attempt is made herein to estimate the amount of water consumed from such a well field. Note that this is only an estimate in an attempt to capture the overall situation of groundwater water exploitation within the CAMP area that could be overestimating or underestimating the real conditions depending on many parameters. Table 5.6 summarizes the different assumptions that were adopted. These assumptions are based on typical practices and conditions usually experienced in Lebanon. Table 5.7 presents the values obtained for total yearly consumption from wells in the CAMP area, based on these assumptions.

Table 5.6. Main Assumptions Used for Estimation of Water Consumption from Wells

Item	*Assumption*
Operation of public wells for domestic use	12 - 18 hours /day
Operation of private wells for domestic use	2 - 4 hours / day
Operation of private wells for irrigation use	5- 7- months / year
Operation of wells for industrial use	Lumped with wells used for irrigation
Capacity of public wells with unknown information	20 L/s
Capacity of private wells with unknown information	2 L/s

Table 5.7. Estimated Consumption from Groundwater Wells in the CAMP Area

Type	Use	Aquifer Tapped	No. of Wells with Reported Pump Discharge Rate	No. of Wells with Unknown Pump Discharge Rate	Total No. of Wells	Average Pump Discharge (m^3/day)	Volume Exploited (Mm^3/year)	
							Low	High
PUBLIC	Domestic	Sannine	183	21	204	2508	93.37	140.08
		Eocene	3	_	3	1958	1.07	1.61
		Total			**207**		**94.44**	**141.69**
PRIVATE	Domestic	Sannine	97	71	168	397	2.03	4.06
		Eocene	90	14	104	286	0.90	1.81
		Quaternary	6	_	6	352	0.06	0.13
		Total			**278**		**3.00**	**5.99**
	Irrigation	Sannine	100	39	139	979	20.41	28.58
		Eocene	69	12	81	1398	16.99	23.78
		Sannine-Eocene	36	_	36	3065	16.55	23.17
		Quaternary	63	_	63	1019	9.63	13.48
		Total			**319**	**6461**	**63.58**	**89.01**
Total No. of wells and the total yearly discharge					**804**		***161.02***	***236.69***

Note: 22 wells are out of use

The total yearly estimated volume of water exploited from wells varies from about 160 to 235 Mm^3/year. The total estimated volume of water exploited from wells tapping the Sannine Aquifer and the Eocene Aquifer ranges between 132 and 195 Mm^3/year and 35 to 50 Mm^3/year, respectively.

5.5.4 Springs in the CAMP Area

Information regarding the major springs present in the CAMP area was gathered from previous technical documents (ARD, 1999; Dar Al-Handasah, 1996; Hamzeh, 2000; Howard Humphreys & Partners, 1995) and from Beirut, Saida, Sour Water Authorities and Litani River Authority. The result of the spring survey revealed the presence of 15 major springs in the study area (Table 5.8), with 13 springs emerging from the Sannine Aquifer and 2 discharging from the Eocene Aquifer. Most of the springs are used for irrigation and domestic purposes. The most important of these springs are the Rachidiyye, Ras El Ain and Qasmieh springs. The total estimated discharge rate of these major springs discharging from the Sannine Aquifer reaches approximately 224.8 Mm^3/year. The total discharge of major springs from the Eocene Aquifer is approximately 14.2 Mm^3/year.

Table 5.8. Characteristics of Major Springs in the CAMP Area

Spring No.	Name	Coordinates			Feeding Aquifer	Average Discharge (m^3/day)	Usage [a]
		X	Y	Z			
1	Rachidiyye	101.190	145.540	20	Sannine	194400	Irr-Do
2	Ras El Ain Sour	101.060	144.450	15-20	Sannine	86400	Irr-Do
3	Qasmieh Springs	105.330	155.510	20	Sannine	293760	Irr
4	Kfaraoue 1	122.000	168.100	190	Sannine	15000	?
5	Kfaraoue 2	122.100	168.100	190	Sannine	?	?
6	Kfaraoue 3	122.200	168.100	190	Sannine	5000	?
7	Kfaraoue 4	122.200	168.100	190	Sannine	?	?
8	Kfaraoue 5	122.200	168.000	190	Sannine	?	?
9	Qsaibe Springs	118.040	156.340	283	Sannine	8000	?
10	Izziye	101.460	139.180	200	Sannine	8640	Irr
11	Ain Zarqa South	99.180	132.630	150	Sannine	1720	Irr
12	Hamoul	96.120	132.870	61	Sannine	1728	Irr
13	Iskandarona	95.710	135.710	30	Sannine	1296	Irr-Do
Total discharge of the Sannine Aquifer from springs						**615944**	**224.8 Mm^3/year**
14	Adloun	_	_	2	Eocene	25920	Irr
15	Hjair	_	_	230	Eocene	12960	Irr
Total discharge of the Eocene Aquifer from springs						**38880**	**14.2 Mm^3/year**

[a] Irr: Irrigation; Do: Domestic; ?: unknown

5.6. Water in CAMP Area: Need for Action

Whether we consider the conditions of surface water or groundwater, the CAMP area is in serious need for action. Surface water availability has been decreasing in the last decade. Groundwater aquifers are being exploited heavily, which has led to saltwater intrusion in almost the entire coastal stretch of the CAMP area. Table 5.9 presents the estimated water balance for the two major aquifers (Sannine and Eocene), and further highlights to level of overexploitation of these aquifers. Note that discharge from the Sannine Aquifer exceeds in all cases recharge into the same aquifer. Besides, these estimates are made based on a sample of the total number of wells actually available within the CAMP area. The number and figures are quite alarming, and the need to develop and implement an integrated water resources management plan is urgent.

Table 5.9. Water Balance for Major Groundwater Aquifers in CAMP Area

Quantities (Mm^3/year)			***Sannine Aquifer***	***Eocene Aquifer***
Recharge			293.1	63.6
Discharge	Springs		224.8	14.2
	Wells	Low	132	35
		High	195	50
Balance	Low		- 63.7	14.4
	High		- 126.7	-0.6

While in one hand the discharge of the major rivers that cross the CAMP area has been decreasing in the last decade, on the other hand exploitation of the major aquifers has been increasing in an uncontrollable manner through the installation of thousands of private wells; these aquifers are being overexploited with the amount of water extracted exceeding recharge values; while the quantity of available water is decreasing, the quality of the water is being deteriorated at a fast pace as well; urgent measures need to be put in place to avoid reaching an irreversible stage.

6. WATER RESOURCES MANAGEMENT IN DAMOUR

6.1. FACTS AND FIGURES

Damour extends over an area of about 25,000,000 m^2. The municipality's mayor has indicated that 30,000 persons are registered in Damour (year 2000), 5,000 of whom are permanent residents during winter and summer, in addition to 10,000 permanent emigrants. On the other hand, records from the Central Administration for Statistics (CAS) indicate a population of 995 for the year 1996 in Damour. It is important to note that the majority of the Damour population had to leave the village during the war. While the population is slowly returning to the village, it is very difficult to forecast population growth.

The municipality elected in May 1998 performed some achievements in terms of cleaning, rehabilitating the village, its infrastructure and buildings. In addition they have constructed a potable water station, built new dams on the Damour River and rehabilitated irrigation canals.

The major problem faced by the municipality is related to the high level of emigrants (displaced) that have left Damour, depriving it from its important human resources. In addition, major environmental concerns of the municipality can be summarized by the following:

- Pollution of Damour River;
- Improper solid waste management;
- Lack of environmental awareness and concern.

Based on CAS statistics, only 50 percent of the housing units were connected to a potable water network in 1996, and less than 45 percent were connected to a wastewater network. The Saadiyat area is not connected to the water supply network.

Damour is also known by its agricultural plains in which farmers cultivate mainly bananas and vegetables. Irrigation water is provided mostly from Damour River and few artesian wells.

6.2. WATER RESOURCES MANAGEMENT IN DAMOUR

6.2.1 Legal and Institutional Frameworks in Damour

Damour used to fall under the jurisdiction of Barouk Water and Irrigation Authority; after the emergence of the New Water Law it will be part of the newly established Beirut and Mount Lebanon Water and Wastewater Establishment. The municipality is currently successfully managing by itself two wells for domestic water consumption located within its municipal boundaries. In addition, the municipality is also managing the distribution of the Damour river water to agricultural fields located mainly in the Damour plain.

Improved coordination between the Damour municipality and the water establishment would help avoid conflicts in the future related to water resources management in the area.

One main legal and institutional problem specific to the Damour area is related to the management of the Damour River water. Current legislations do not handle the issue of the distribution of the river water among neighboring lands and villages and do not specify responsible bodies to manage such distribution. Damour farmers have stated on their land ownership certificates the right to irrigate their lands located in the plain using the Damour river water. However they have been facing water shortages especially during summer because of overexploitation of upstream river water. Legislation is also not clear about who is responsible to monitor river water quality.

6.2.2 Water Supply in Damour

6.2.2.1 Surface Water in Damour

The major river that passes through the Damour area is the Damour River. This river is one of the 17 perennial rivers in Lebanon. It originates at an altitude of 948 m well beyond the study area to the east. Safa and Barouk springs, along with other smaller springs, supply the river with water throughout the year. The total length of this river is 40 Km with the last 8-10 Km crossing the CAMP area.

Along its stretch in the CAMP area, the Damour River flows gently till it reaches the base level. At a short distance from the mouth, the river develops meanders, which indicate a mature stage of evolution of the valley. The tributaries in the upper parts of the Damour River provided alluvial deposits from a wide alluvial plain near the mouth of the river. This is in conjunction with the fluvio-marine deposits along the coast. The fine alluvial and fluvio-marine deposits provided the material for the soil of the cultivated coastal plains of Damour (Arkadan, 1999).

Approximately 75 percent of the discharge of the major rivers of Lebanon flows during a five-month period between December and April. In the years 2000 and 2001, more than 96 percent of the flow of the Damour River occurred between December and April (during the wet season) (Table 5.3). Figure 6.1 shows the hydrographs of the Damour River in the last 8 years (measurements at the mouth of the river). Figure 6.2 shows a general decrease in discharge at the mouth of the river and in flow at the level of Jisr El Qadi during the last 8 years. This is a result of either a decrease in rainfall (climate change) and/or a result of increase in surface usage and overexploitation of the Sannine Aquifer in the area.

Two dams are constructed on the Damour River to divert part of the water for irrigation purposes. The lower dam diverts approximately 1,100 m^3/hour (Photograph 6.1) and the upper dam diverts about 650 m^3/hour (Photograph 6.2).

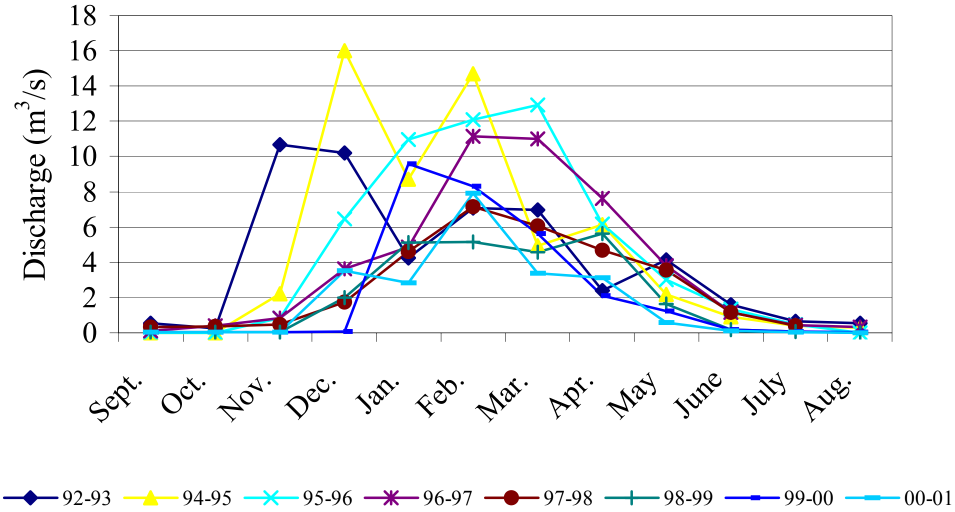


Figure 6.1. Hydrographs of the Damour River in the Last 8 Years

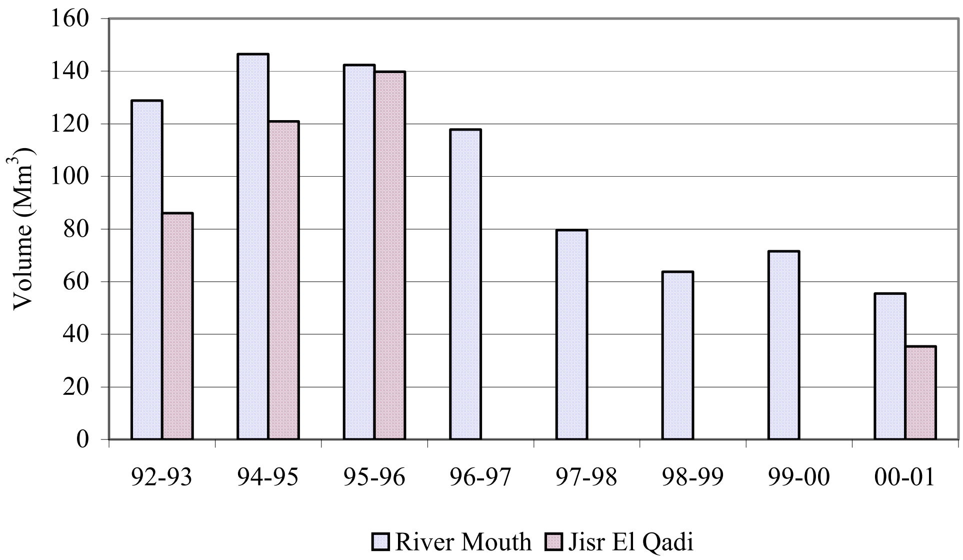


Figure 6.2. Yearly Variation in Discharge at the Mouth and Jisr El Qadi Stations - Damour

Photograph 6.1. Lower Dam on the Damour River

Photograph 6.2. Upper Dam on the Damour River

6.2.2.2 Ground Water in Damour

The groundwater resources in the Damour area are mainly stored in the Sannine Aquifer (Appendix A). In the Damour area, the Sannine Aquifer is being protected from direct contact with the sea by the Chekka Formation. This has resulted in the development of an important source of groundwater. In the Saadiyat area, the Sannine Aquifer is in direct contact with the sea and the fresh water is mixed with the salt water. Recharge of the Sannine Aquifer in the Damour area is primarily from direct infiltration and infiltration from Damour River. As indicated previously, the area of recharge extends westward well beyond the CAMP area.

The Sannine Aquifer is being exploited through artificial wells and natural springs. Table 6.1 summarizes the detailed well survey undertaken in the Damour area. In estimating the total amount of water exploited from wells, the same assumptions listed in Table 5.6 were adopted when enough information was not available.

The total volume of water that is being pumped from Damour and exported to Beirut from July till January is 7.2 Mm^3 according to the Beirut Water Authority. The total estimated consumption from wells in Damour ranges between 1.14 and 1.7 Mm^3/year. These values reach 8.9 Mm^3/year when wells of Beirut water authority are operating. It is interesting to note that based on the present estimations and information from Beirut Water Authority, approximately 80 percent of the total quantity exploited from Damour is used outside Damour.

Table 6.1. Results of Well Survey in Damour

Type	Use	Aquifer Tapped	No. of Wells with Known Pump Discharge	No. of Wells with Unknown Pump Discharge	Total Wells	Average Pump Discharge (m^3/day)	Volume Exploited (Mm^3/year)	
							Low	High
PUBLIC DAMOUR	Domestic	Sannine	2	0	2	2376	0.29	0.58
PUBLIC BWA	Domestic	Sannine	14	0	14	3115	_	7.2*
PRIVATE	Domestic	Sannine	44	0	44	310	0.31	0.41
	Irrigation	Sannine	6	0	6	1958	0.54	0.71
Total No. of wells and the total yearly discharge					**64**		***1.14***	***8.9***

*Beirut Water authority wells pump only from July till January, i.e. during a period of 6 months annually

The Sannine Aquifer is being overexploited in the Damour area, as indicated by high levels of salt water intrusion in most of the wells (section 6.2.4). In the Saadiyat area alone, approximately 42 private wells were surveyed. These wells are used mainly for domestic purposes given the high concentration of salts found in the water. Although it is located outside the Damour area, the Dakoun spring is the only major spring that falls within the authority of the Damour Municipality. However, this spring could not be accessed. Smaller scale springs and submarine springs exist along the coast, but their discharge has never been measured.

6.2.2.3 Water Supply Infrastructure in Damour

Figure 6.3 illustrates the major features of the water supply infrastructure at Damour (Appendix G). The municipality operates two wells (5000 m^3/day) that pump for approximately 5 to 10 hours per day according to the season, and generate between 880 m^3/day and 1360 m^3/day. One major reservoir (2000m^3) is used to store the water, which is distributed within Damour.

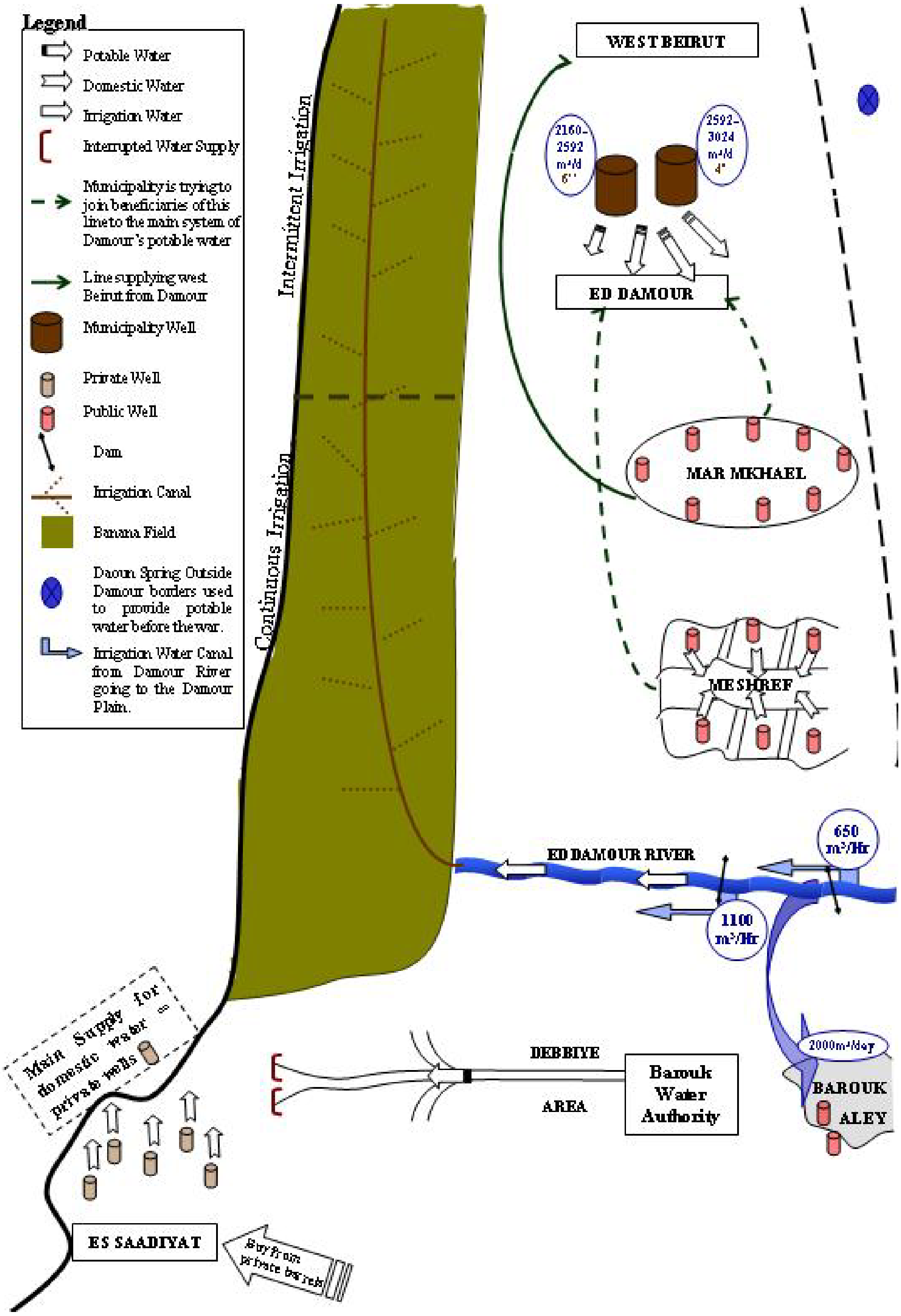
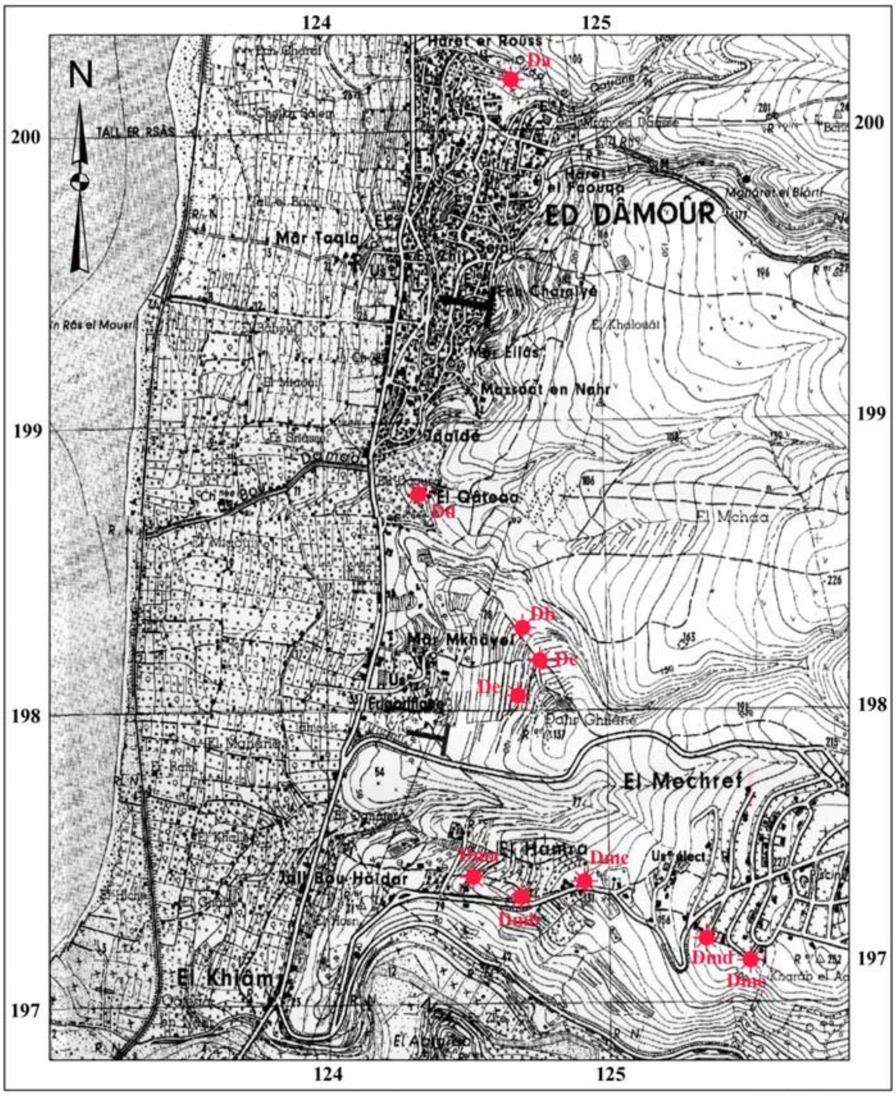


Figure 6.3. Illustration of Water Supply Infrastructure in Damour

The municipality charges housing units connected to the main water network 100,000 Lbps per year for unlimited supply of water. A limited zone of Damour is being supplied by the Meshref wells field and Beirut water authority in El Hamra and Mar Mkhael regions respectively.

Irrigation water is primarily obtained from the Damour River, where two dams store water that is directed though irrigation channels to the agriculture fields. The municipality charges agricultural landowners 30,000 Lbps per 1000 m^2 per year. Note that in the Saadiyat area, the main source of domestic and irrigation water is through private wells. Last but not least, Damour faces the problem of water withdrawal from within its boundaries to serve other regions. On one hand, the Beirut Water Authority is currently operating 14 wells in Mar Mkhayel region that pump water to outside Damour. The initial number of wells was 11, but 5 years ago Beirut Water authority (BWA) drilled 3 new wells (Dmd, Dme, and Dmf) because of the increasing demand in water of the Beirut area. Figure 6.4 shows the location of Beirut Water Authority wells in the Damour area.



1:20 000

Figure 6.4. Beirut Water Authority Public Wells in Damour

It is worth mentioning that according to Beirut water authority data, the Damour area provides 10 percent of the total water consumption of the Beirut area which is about 500,000 m^3/day. On the other hand, the Damour River is being highly exploited by up stream neighboring villages, especially through wells upstream that induce recharge from the Damour River, thus diminishing its discharge at the Damour plain. As a matter of fact, the plain faced water shortage during summer 2001, and farmers had to exploit existing and new wells to satisfy irrigation water needs.

6.2.3 Water Demand in Damour

Water demand in Damour is primarily from domestic and agriculture origins. While domestic consumption is derived from groundwater wells, irrigation water is mostly obtained from the Damour River.

6.2.3.1 Domestic Water Demand in Damour

Fields surveys have been conducted in the Damour region. Water consumption values have been estimated for both the Damour region and Saadiyat region, which constitutes a part of the Damour area. The only difference between the two regions is that municipality wells supply water to the Damour region, whereas water in Saadiyat is supplied by private wells.

Domestic water consumption in the Saadiyat area was estimated to range between 340 and 400 L/c/day. Estimated values for daily water consumption in the Damour area range however between 130 and 170 L/c/day. While the domestic consumption in Saadyiat is higher than typical average domestic consumption values (150 L/c/day), consumption in Damour is within the regular range.

Due to the absence of a metering system in Damour, it is very difficult to calculate losses in the networks. However, since the quantities of water supplied by the municipality to the Damour region were known, an estimation of the water losses could be calculated following the approach summarized in Figure 6.5. Table 6.2 summarizes the results. Discrepancies between water supplied by the municipality and water consumed can be attributed to unaccounted for water consumption (in construction activities, etc.) and to losses in the networks. The values fall however typical values for water losses in water supply networks reported in Lebanon.

Table 6.2. Estimations of Water Losses or Unaccounted for Water in the Damour Area

	Quantities of water supplied by the municipality (L/c/day)	Actual water consumption (l/c/day)	Losses (%)
Winter	180-270	134	25-50
Summer	311-418	170	45-61

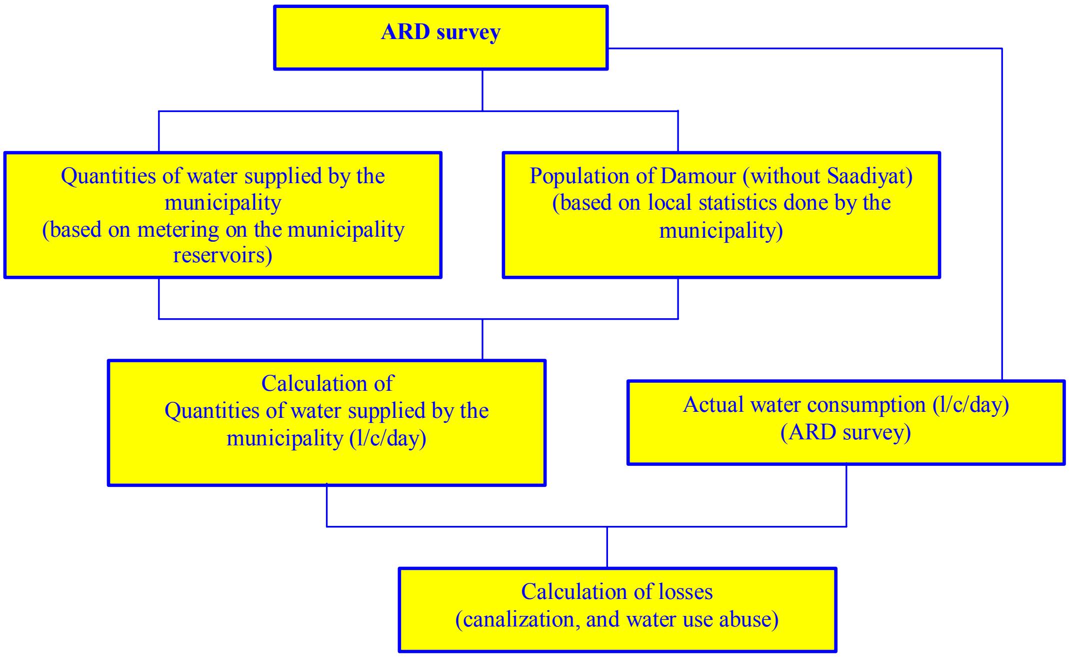


Figure 6.5. General Approach to Estimating Water Losses in Damour

6.2.3.2 Agriculture Water Demand in Damour

The theoretical irrigation water demand in Damour was calculated according to the methodology and calculations presented in Appendix D. The theoretical water demand is the one that meets the needs of the crops based on site specific conditions (climate, soil). At the same time, 364,400 m^2 of agricultural land were surveyed in order to obtain information about the local irrigation practices and estimate the actual values used for irrigation. Values for actual irrigation water consumption of banana plantation using the surface and trickle irrigation techniques are shown in Table 6.3. It can be noted that farmers irrigating using the trickle technique have a much better control of water consumption than those using surface irrigation. In the latter case, actual water consumption exceeds theoretical values by more than 50% during winter and more than 150% during summer (more than twice the theoretical value).

Table 6.3. Irrigation Water Consumption in Damour

Irrigation Technique	Season	Actual Water Consumption ($L/m^2/day$)	Theoretical Water Consumption ($L/m^2/day$)	Over Use (percent)
Surface	Summer	16.7	6.6	+150%
	Winter	8.7	5.9	+47%
Trickle	Summer	4.7	4.4	+6.8%
	Winter	2.7	3.1	-13%

6.2.4 Water Quality in Damour

Both groundwater and surface water quality are at risk in Damour due to overexploitation and lack of adequate sanitation and proper environmental practices. Recent studies analyzed 13 water samples from Beirut Water Authority wells that exploit water from Damour. These studies have shown that 65% of the analyzed samples exhibited TDS values between 435-1163 mg/L, whereas 86% of the analyzed samples showed chlorides values exceeding 200 mg/L (Khadra, 2003). These results indicate that the Damour Sannine aquifer is subject to salt water intrusion. The same studies have also shown that chloride levels have tripled and that TDS levels have doubled in most of the wells located close to the saltwater freshwater interface from 1983 till now (Khadra, 2003). Chlorides concentration in the Damour wells from 1990 till 2003 obtained from the Beirut Water Authority records show a drastic increasing trend as shown in Figure 6.6. This figure also shows that chlorides concentration in the Naameh reservoir, where the water coming from the Damour wells is stocked, have increased by approximately 300 percent.

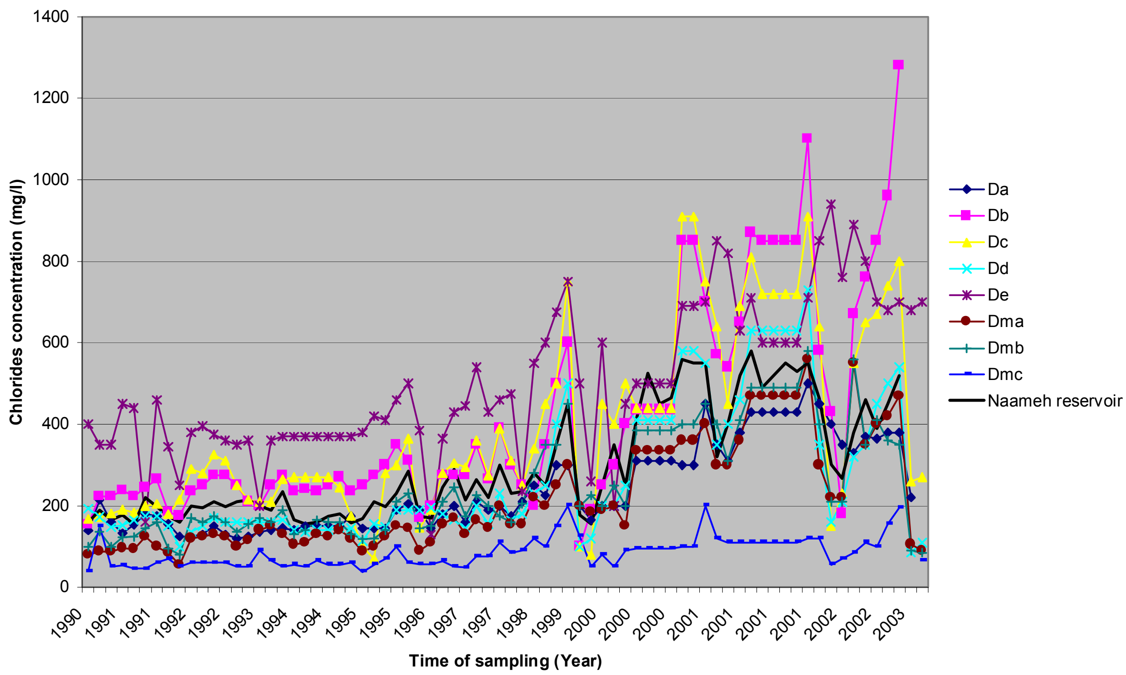


Figure 6.6. Chlorides Concentration in BWA Wells in Damour (1990 until 2003)

Additional samples were taken and analyzed during this study to complement the available data (section 2.3.2). Table 6.4 presents the results obtained. The results are consistent with the above findings since more than half of the samples have exceeded the maximum admissible values for domestic use for chlorides. Note that the Saadyiat sample (D4) exhibits very high chlorides concentration (Figure 6.7) due to the direct contact of the Sannine Aquifer with the sea, coupled with excessive water pumping in the area.

Table 6.4. Water Quality Results for Damour Samples

Sample ID	TDS (mg/L)	Chlorides (mg/L)	Nitrates (mg/L)	O-Phosphates (mg/L)	Fecal Coliforms (CFU/ 100 mL)	COD (mg/L)
D1	547	174	30	0.18	0	NA
D2	239	NA	19	0.27	126	<2
D3	222	NA	12	0.17	13	16
D4	1850	1240	14	0.11	0	NA
D5	313	20	5	0.1	0	NA
D6	667	239	16	0.13	0	NA
D7	612	212	12	0.27	0	NA
Guidance Value [a]	-	25	25	0.4	-	-
Maximum Admissible Value[a]	500	200	50	5	0 (domestic) 200 (irrigation)	-

[a] All values according to Ministerial Decision 52/1 issued by the MoE, except for TDS where EPA standards are included and fecal coliforms where EPA standards for irrigation are used.

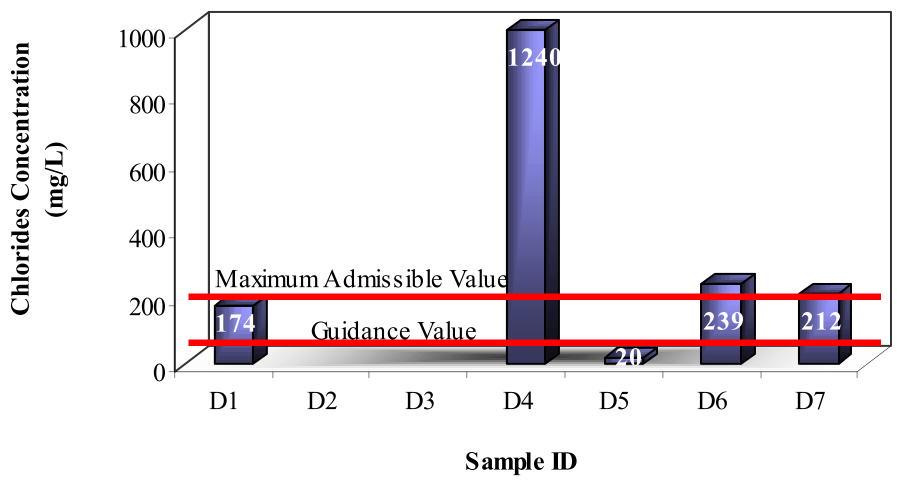


Figure 6.7. Chlorides Concentrations in Damour Water Samples

Two river samples (D2 and D3) were also retrieved and the results obtained highlight the effect of pollution from sewage (as indicated by the presence of fecal coliforms) and industrial/chemical sources (as indicated by the COD concentrations). Water quality data is very limited at the Damour River, and there is no systematic monitoring performed by any of the institutions responsible for water management in the area. A recent report (MoE/ARD, 2003) has highlighted the different environmental violations on the Damour River Basin, which include disposal of untreated sewage from most villages, disposal of restaurants wastewater, industrial wastewater (olive oil, stone cutting, concrete and asphalt), waste oil from gas stations, farm wastes, and use of pesticides and fertilizers.

7. WATER RESOURCES MANAGEMENT IN SARAFAND

7.1. FACTS AND FIGURES

Sarafand extends over an area of 9,500,000 m^2 with a registered population of 12,000 permanent residents in 2002, according to the Mayor. Based on the CAS records, the Sarafand population in 1996 was about 9,850. Assuming a 2.5 percent annual increase in population, projections for the year 2002 would reach 11,500.

The municipality has been working hard to connect housing units to the potable water network and sewage. Based on the CAS survey, about 50 percent of the housing units were connected to a potable water network in 1996, but only about 10 percent of the units were connected to a sewer network. The municipality had also a role in providing social and financial support to some of the residents, Non Governmental Organizations (NGOs), and clubs. Major environmental concerns of the municipality could be summarized as follows:

- Lack of adequate potable water management;
- Lack of adequate wastewater management;
- Improper solid waste management;
- Sea water pollution
- Lack of public gardens.

Farmers cultivate mainly corn, bananas, citrus trees, coastal fruits, "accidenia", avocado, watermelon, and vegetables. Irrigation water is provided mostly from the Litani Irrigation Canal in addition to private wells.

7.2. WATER RESOURCES MANAGEMENT IN SARAFAND

7.2.1 Legal and Institutional Frameworks in Sarafand

Sarafand used to fall under the jurisdiction of Nabaa El Tasseh Water Authority in terms of potable water but after the emergence of the New Water Law it will become part of the newly established South Lebanon Water and Wastewater Establishment (SLWWE). While the new water law states that such establishments are responsible for domestic, irrigation and waste water issues, the SLWWE will be responsible to manage domestic and waste water issues only, since the LRA is already taking care of irrigation projects in the South region (Nizam A., 2003).

7.2.2 Water Supply in Sarafand

7.2.2.1 Groundwater in Sarafand

The two aquifers outcropping in Sarafand are the Eocene and Quaternary Aquifers (Appendix A). The Quaternary Aquifer outcrops along the coast and in the valleys. Its thickness does not exceed 20 m. The Eocene Aquifer outcrops higher upland in Dhour El Sarafand. The thickness of the Eocene Aquifer in this area is approximately 150m. The Sannine Aquifer outcrops along the coast further south of Sarafand. It is located at a depth exceeding 400 m within the Sarafand area. The Eocene and Sannine Aquifers are under unconfined conditions. Previous studies (UNDP, 1970) show that the Sarafand area is characterized by the presence of seawater intrusion due to the direct contact of the Sannine Aquifer with the sea. Furthermore there are few abandoned wells exceeding 500 meters in depth, present in the Zaatare farmland in Dhour El Sarafand and tapping the Sannine aquifer. All the pumping wells in the Sarafand area are tapping the Eocene aquifer. This aquifer is slightly affected by saltwater intrusion since brackish water was reported in some wells. Moreover the Eocene aquifer is characterized by a relatively low discharge.

A total of 153 wells were surveyed in the Sarafand area. The total estimated amount of ground water extracted from those wells ranges from 4 to 6 Mm^3/year (Table 7.1). The assumptions listed in Table 5.6 were adopted in the calculations. Out of the surveyed wells, 21 are tapping the Quaternary Aquifer, 135 are tapping the Eocene Aquifer and 1 is tapping the Sannine Aquifer. One of the wells is public and owned by the Nabaa Tasseh Water Authority. The public well is mainly being used for domestic purposes. The private wells are being used for both irrigation and domestic purposes.

Six springs are present in the Sarafand area (Table 7.2). Ain el Qantara and Ain el Hemma are coastal Quaternary springs discharging 371.5 and 86.4 m^3/day, respectively. Ain el Qantara is being used to fill a swimming pool in a beach resort (Photograph 7.1). Ain el Hemma is not being currently used (Photograph 7.2). Few fishermen use it for drinking purposes. Spring Bou Daynayn and Ain el Jdideh are small springs having discharges of approximately 4.3 and 2.9 m^3/day, respectively. Both are discharging from the Eocene Aquifer and are being used locally for domestic purposes. The Ain el Dellieh is a very small seepage zone. Note that there exists a sixth spring called Ain Mahmoud located in the village. This spring flows in significant quantities especially after a heavy rainfall. This spring discharges on the main street and it is locally used, when available, by few houses.

Table 7.1. Results of Well Survey in Sarafand

Type	Use	Aquifer Tapped	No. of Wells with Known Pump Discharge	No. of Wells with Unknown Pump Discharge	Total Wells	Average Pump Discharge (m^3/day)	Volume Exploited (Mm^3/year)	
							Low	High
PUBLIC	Domestic	Sannine	1	-	1	1037	0.13	0.13
PRIVATE	Domestic	Eocene	78	27	105	315	0.75	1.49
		Quaternary	21	-	21	864	0.55	1.10
	Irrigation	Eocene	22	5	27	703	2.32	3.25
Total No. of wells and the total yearly discharge					**153**		***3.74***	***5.97***

Note: The number of surveyed wells is 153.

Table 7.2. Groundwater Springs in the Sarafand Area

No.	Name of Spring	X (m)	Y (m)	Z (m)	Discharge (m^3/day)	Aquifer	Usage	Remarks
1	Ain el Qantara	170.490	108.890	5	371.5	Quaternary	Filling up of a swimming pool	–
2	Ain el Hemma	171.110	109.990	1	86.4	Quaternary	Not used	The flux is stronger when the lands above are irrigated. The source passes through conglomerates and lithified coarse grained limestone
3	Spring Bou Daynayn	168.890	109.640	118	2.9	Eocene	Local domestic use	–
4	Ain el Dellieh	167.310	109.410	126	The spring is a seepage on the surface (like Ain ech Chouche few meters away)			
5	Ain el Jdideh	168.870	109.290	100	4.3	Eocene	Local domestic use	The original spring is beneath the road
6	Ain Mahmoud							

Photograph 7.1. Ain el Qantara Spring

Photograph 7.2. Ain El Hemma Spring

7.2.2.2 Water Supply Infrastructure in Sarafand

Figure 7.1 illustrates the water supply infrastructure in Sarafand (Appendix G). Domestic water is supplied to Sarafand primarily through Teffahta wells, which provide about 1,000 m^3 of water per day according to Nabaa el Tasseh water authority. Moreover the municipality well located in Dhour El Sarafand provides $300m^3$ of water per day that are mixed with the quantity that is supplied by Teffahta and distributed through the Water supply Network.

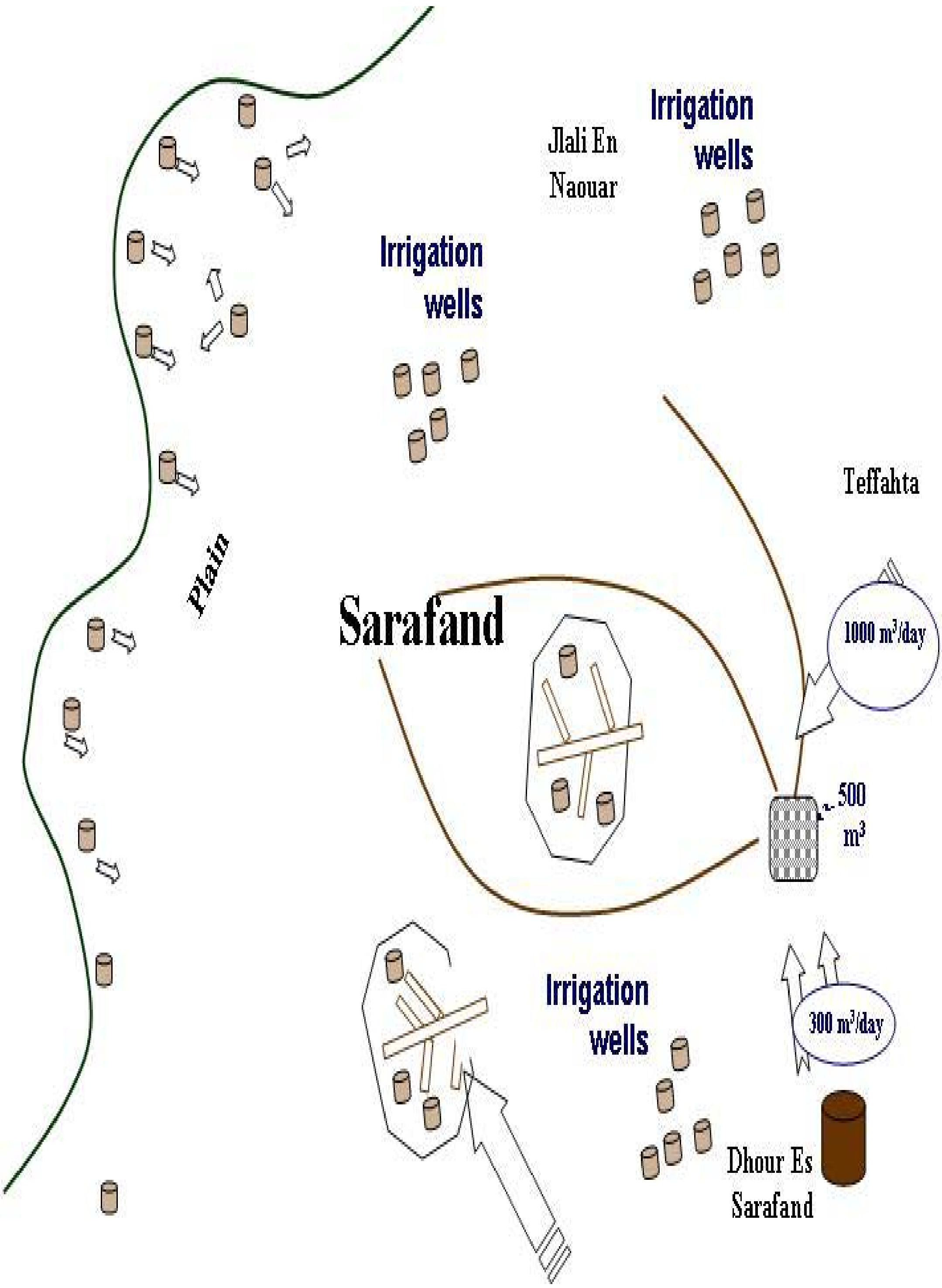


Figure 7.1. Illustration of Water Supply Infrastructure in Sarafand

However despite the fact that the totality of the village is connected to the water supply network, only 1200 housing units, i.e. less than 50% of the total number of housing units are subscribed to the Water Authority service. In order to subscribe to the main public network, each housing unit in Sarafand has to pay 250,000 Lbps for the connection and 220,000 Lbps as an annual fee. Hence those who can not afford to pay such fees prefer to use their private wells, especially that operating these wells costs annually between 150,000 Lbps and 180,000Lbps, which is less than the subscription fee to the public network. Note that more than 50% of the Sarafand is using private domestic wells located throughout the village, and few springs with low discharge.

The Litani Irrigation Canal provides water for the agricultural plains situated close to it, whereas private irrigation wells provide water to the irrigated areas of Dhour Es Sarafand, Jlali El Naouar, and a small section of the coastal plain. There are 300 subscribers to the Litani Canal supply system, and they pay 60,000 Lbps per 1000 m^2 of irrigated land. This fee is reduced to 40,000 Lbps in case they irrigate their land using more efficient irrigation techniques such as the trickle technique instead of surface irrigation.

7.2.3 Water Demand in Sarafand

7.2.3.1 Domestic Water Demand in Sarafand

The use of private wells is widespread in the Sarafand area. Domestic water consumption was estimated using data such as diameter of the rising pipe, pump power, hours of operation of the wells, and number of persons using the well. On the other hand, for the portion of the population using water coming for Teffahta, water consumption was deduced from the reservoirs capacity, the number of times the reservoirs are filled per week, and the number of persons in the housing unit using this water resource. Estimations showed that domestic water consumption in Sarafand ranges between 190 L/c/day and 210 L/c/day. Estimation of losses was difficult to perform because the number of people using the public water supply system is not well defined due to many illegal connections to the system.

7.2.3.2 Agriculture Water Demand in Sarafand

The ARD team surveyed an area of 1,044,500 m^2 of agricultural lands (about 20 percent of total agriculture land area in Sarafand). Actual water consumption for irrigation was compared to the theoretical values calculated as shown in Table 7.3 (Appendix D). Actual values exceed theoretical values by 40 to 300 percent, indicating a significant potential for water savings. This is probably due to inadequate use of the water because of its availability from the Litani Canal, even though water is not regularly supplied by the LRA, according to the farmers. Note also that the highest levels of over use are related to surface irrigation techniques, which are more difficult to control the water consumption.

Table 7.3. Irrigation Water Consumption in Sarafand

Mode of Irrigation	Irrigated Surface (m^2)	Actual Irrigation Water Consumption ($L/m^2/day$)	Theoretical Irrigation Water Consumption ($L/m^2/day$)	Type of Irrigated Crops	Over use (%)
Surface	877 000	12-13	3.5-4.5	Vegetables Citrus	150-300
Sprinkle	12 000	6-7	3.5-4.0	Citrus Banana	70-100
Trickle	155 000	5	3.5	Banana	40

7.2.4 Water Quality in Sarafand

Water quality data is not abundantly available for the water resources in Sarafand. A limited number of samples was collected and analyzed to fill as much as possible the lack of information, and at least provide an indication of the level of water pollution in the area (section 2.3.2). The sampling program is by no means a comprehensive one, and needs certainly to be backed by a more systematic and complete sampling schedule. Table 7.4 presents the results obtained for the Sarafand water samples. Results indicate the possible presence of biological, agricultural and seawater contamination.

Ain El Hemma, Ain El Qantara on the coast, and Ain Bou Daynayn springs show values of fecal coliform that exceed the admissible value for domestic use. It is worth noting that Ain Bou Daynayn is being used for drinking and domestic purposes by three nearby houses. It has been noticed that children from these houses have stomachaches and bad digestive behaviors probably due to the high values of fecal coliforms in the drinking water. This spring is probably contaminated by the wastewater that is being discharged upstream in Hay Es Sarassir where the sewage network is missing.

Other samples, particularly the Spring El Qantara sample and the irrigation well sample show relatively high values of nitrate that exceed the admissible values (Figure 7.2). These excessive levels of nitrates, especially in the irrigation well (S1) located in the agricultural field, are most probably due to the use of fertilizers and inadequate agricultural practices.

Moreover the sampling shows that the municipality well that is tapping the Sannine aquifer exhibits values of chlorides that exceed the maximum admissible value for domestic purposes (Figure 7.3). Furthermore a well that has been drilled down to 500 m in Dhour As Sarafand was abandoned because it had penetrated the salt water wedge. As for the Eocene aquifer, there is no clear evidence of saltwater intrusion from the sampling however some wells in the village pump brackish water from the Eocene aquifer.

Table 7.4. Water Quality Results for Sarafand Samples

Sample ID	TDS (mg/L)	Chlorides (mg/L)	Nitrates (mg/L)	O-Phosphates (mg/L)	Fecal Coliforms (CFU/ 100 mL)
S1	553	82	82	0.29	0
S2	453	77	67	0.2	2.7
S3	377	50	7	0.28	0
S4	435	80	35	0.38	4
S5	532	78	64	0.22	17
S6	304	31	17	0.15	0
S7	313	33	18	0.18	0
S8	630	207	5.4	0.32	0
Guidance Value [a]		25	25	0.4	0
Maximum Admissible Value [a]	500	200	50	5	0 (domestic) 200 (irrigation)

[a] All values according to Ministerial Decision 52/1 issued by the MoE, except for TDS where EPA standards are included and fecal coliforms where EPA standards for irrigation are used.

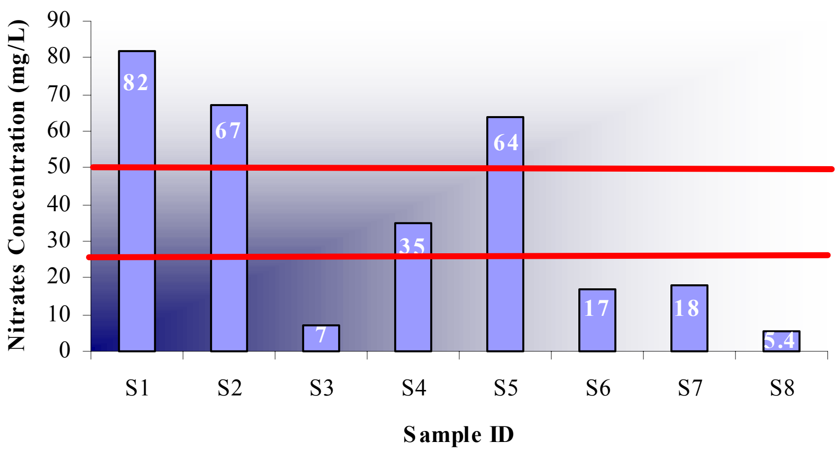


Figure 7.2. Nitrates Concentration in Sarafand Water Samples

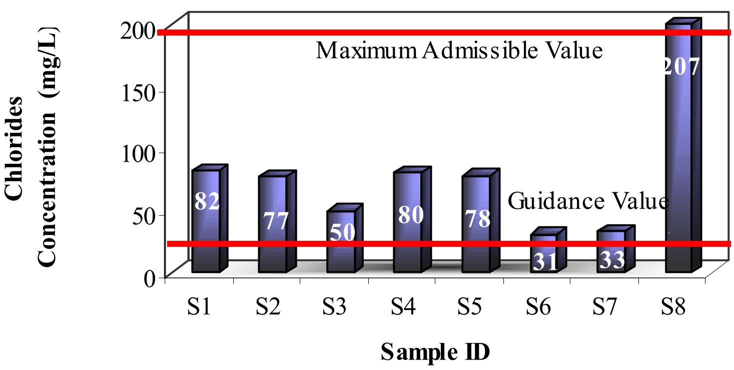


Figure 7.3. Chlorides Concentration in Sarafand Water Samples

8. WATER RESOURCES MANAGEMENT IN NAQOURA

8.1. FACTS AND FIGURES

Naqoura extends over an area of 28,000,000 m^2 with a registered population of 4,000 persons in the year 2000, according to the Mayor. Records from the Central Administration for Statistics (CAS) indicate that the population of Naqoura was about 1,460 in 1996. Assuming a 2.5 percent annual increase in population, this value would reach about 1600 in the year 2000. Although there is a discrepancy between the Mayor's value and the one derived from CAS records, this discrepancy could be due to the recent liberation of the area, which could have attracted old inhabitants back.

The first municipality elected in September 2001 made some achievements despite the lack in personnel and financial resources, primarily in the fields of solid waste collection and disposal, water distribution, and lightening of public roads. On the other hand, the municipality is having a problem with government delays in assessing public properties in Naqoura. In addition, major environmental concerns as raised by the municipality are related to the lack in wastewater and solid waste management infrastructure. According to CAS statistics, while over 80 percent of the village was connected to a potable water network in 1996, the village was completely deprived of a sewer network. This situation has improved, and today most of the village is connected to a sewage network.

Farmers mainly cultivate citrus trees, bananas, vegetables, "achta" fruits, and tobacco. Irrigation water is provided mostly from private wells.

8.2. WATER RESOURCES MANAGEMENT IN NAQOURA

8.2.1 Legal and Institutional Frameworks in Naqoura

Naqoura used to fall under the jurisdiction of Tyre Water Authority in terms of potable water but after the emergence of the New Water Law it has become part of the newly established South Lebanon Water and Waste Water Establishment (SLWWE). Even though the new water law states that these new establishments are responsible for domestic, irrigation and waste water issues, the new establishment will manage domestic and waste water issues only, since the LRA is already responsible for irrigation projects in the South region (Nizam A., 2003).

The SLWWE has not yet assumed its responsibilities in Naquoura. The Municipality is currently managing water related issues and operates a well located within its municipal boundaries and connected to the majority of house units in the municipality. During the discussions held during the participatory workshop in Naqoura, it was revealed that the MoEW is initiating a dam project on the Hamoul River; disagreement was brought up concerning the responsible body that should manage the project after completion, whether the LRA or the Municipality. The institutional setup for water resources management needs to be put in place.

8.2.2 Water Supply in Naqoura

8.2.2.1 Groundwater in Naqoura

The major water source in Naqoura is groundwater. The aquifer exploited is the Sannine Aquifer (Appendix A). This aquifer is in direct contact with the sea. However, the nature of the Sannine Aquifer, having a relatively impermeable layer separating two water-bearing zones, resulted in the protection of the lower water-bearing unit from saltwater intrusion. The upper unit is more affected by saltwater intrusion than the lower unit. The piezometric level of both units is quite similar and equivalent to the mean sea level.

The major recharge zone for the Sannine Aquifer is from outcrops present north and east of the Naqoura area. Minor recharge comes from direct precipitation on the aquifer in the area.

Groundwater in Naqoura is being exploited through wells and springs. Two clusters of wells exist in the Naqoura area. One cluster is present in the village and the other is in Hamoul valley. Approximately 62 wells were surveyed, 17 of which are not in use (Table 8.1).

Table 8.1. Results of Well Survey in Naqoura

Type	Use	Aquifer Tapped	No. of Wells with Known Pump Discharge	No. of Wells with Unknown Pump Discharge	Total Wells	Average Pump Discharge (m^3/day)	Volume Exploited (Mm^3/year)	
							Low	High
PUBLIC	Domestic	Sannine	1	-	1	3456	0.42	0.63
PRIVATE	Domestic	Sannine	1	0	1	604	0.04	0.05
		Sannine	5	1	10	293	0.02	0.04
	Irrigation	Sannine	29	8	37	1396	1.30	2.60
Total No. of wells and the total yearly discharge					**45**		***1.78***	***3.33***

Note: 17 wells are out of use

Wells not in use are either contaminated by saltwater or not equipped. Moreover many wells are abandoned since the municipality well is providing enough water for all the housing units. The remaining wells are private and are mainly used for irrigation purposes (Appendix B), yet few are used for domestic purposes. The estimated total volume of groundwater being exploited from wells in the Naqoura area, based on assumptions listed in Table 5.6 ranges from 1.8 to 3.3 Mm^3/year.

Photograph 8.1. Private Well used for Irrigation

Four main springs, namely Hamoul, Iskandarouna, Labbouneh and Al Ain are present in the Naqoura area (Table 8.2). Hamoul and Iskandarouna springs are being used for irrigation and their estimated yield is approximately 3000-3450 m^3/day and 2000-2595 m^3/day, respectively.

Table 8.2. Groundwater Springs in Naqoura

Spring #	Name of Spring	X (m)	Y (m)	Z (m)	Aquifer	Discharge (m^3/day)	Usage	Remarks
1	Hamoul Spring	96.120	132.870	61	Sannine	3000-3450	Irrigation	Located in a military zone
2	Iskandarona Spring	95.710	135.710	30	Sannine	2000-2595	Irrigation	Close to the coast
3	El Ain Spring	93.400	132.440	30	Sannine	100-172	Irrigation and domestic	Many branches that distribute water to neighboring houses.
4	Labbouneh Spring	Located in a military zone could not be visited						

The El Ain spring is being used by part of the village for domestic purposes and its discharge is approximately 100-172 m^3/day. Labbouneh spring was not visited because of its location in a military zone. All of those springs discharge from the Sannine Aquifer. Several submarine springs with unknown discharge are also present along the coast of Naqoura.

Photograph 8.2. El Ain Spring in Naqoura

8.2.2.2 Water Supply Infrastructure in Naqoura

Figure 8.1 illustrates the water supply infrastructure in Naqoura (Appendix G). There are five major sources of domestic water supply in Naqoura.

The municipality well, which has a maximum discharge of 3456 m^3/day, pumps for 8 to 12 hours in summer providing about 1010 m^3/day, and pumps for 2 to 4 hours during winter providing 865 m^3/day. The fee of subscription to the main water supply system is 10,000 Lbps per month. All houses in Naqoura are connected to the main water supply network, except for houses located uphill at the end of the village, and some parts of the coast starting from Hamoul section northward.

The second source of water is Sfeir Private Well, located at the coast, which provides mostly the houses and shops along the coast and the UN units with 150 m^3/day in summer time, and with 75 m^3/day of water in winter time. Approximately 200 housing units are subscribed to this service. There is a committee from Naqoura responsible for monitoring and operating the well.

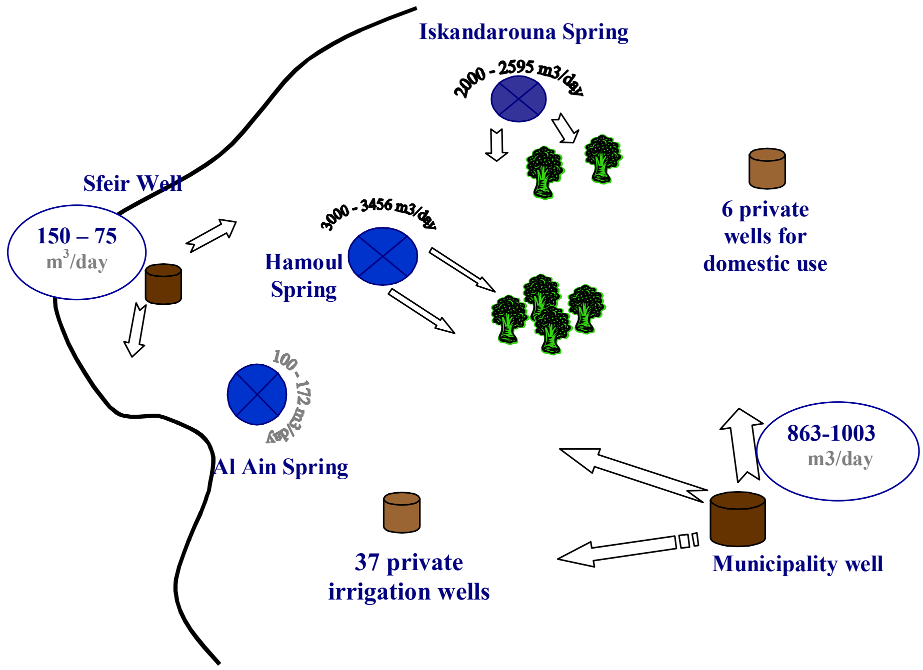


Figure 8.1. Illustration of Water Supply Infrastructure in Naqoura

Some of the habitants also exploits two major springs in the area, namely Nabaa El Ain and Iskandarouna. Nabaa El Ain is a spring located in Al Ain Valley; it supplies water to all the neighboring houses (5 houses). It has a daily discharge of 172 m^3/day. Nabaa el Iskandaruna is located in the northern part of Naqoura near the Coast. It provides 7 m^3/day for a house of 8 persons. There are also six private wells located throughout Naqoura that are used either because of dissatisfaction with the quality of the municipality well, or because operation of the private well is cheaper than the subscription to the main water supply service. It is worth mentioning that the wells pump water using fuel operating motors rather than electricity operating motors, since electricity is not always available.

As for irrigation water supply, land owners use private wells or springs that are located in or next to their lands, namely Iskandarouna and Hamoul springs. Iskandarouna spring provides 2595 m^3/day for a 6-month period. It is used to irrigate using the trickle technique 600,000 m^2 of banana fields. Hamoul Spring has a maximum yield of 3456 m^3/day. It is used to irrigate lands located in the valley. Also, 37 Private irrigation wells are scattered throughout Naqoura village, especially in Hamoul area, El Khalle, Aalaibat, Ech choumara, and Labbouneh. These private wells have discharge rates ranging between 1100 and 1300 m^3/day. They all pump an average of 5400-6600 m^3/day of water per season.

8.2.3 Water Demand in Naqoura

8.2.3.1 Domestic Water Demand in Naqoura

Field surveys have been performed for approximately 220 housing units. An estimate for water consumption per capita per day for summer and winter time was calculated. The methodology of calculating domestic water consumption for Naqoura is shown in Figure 8.2.

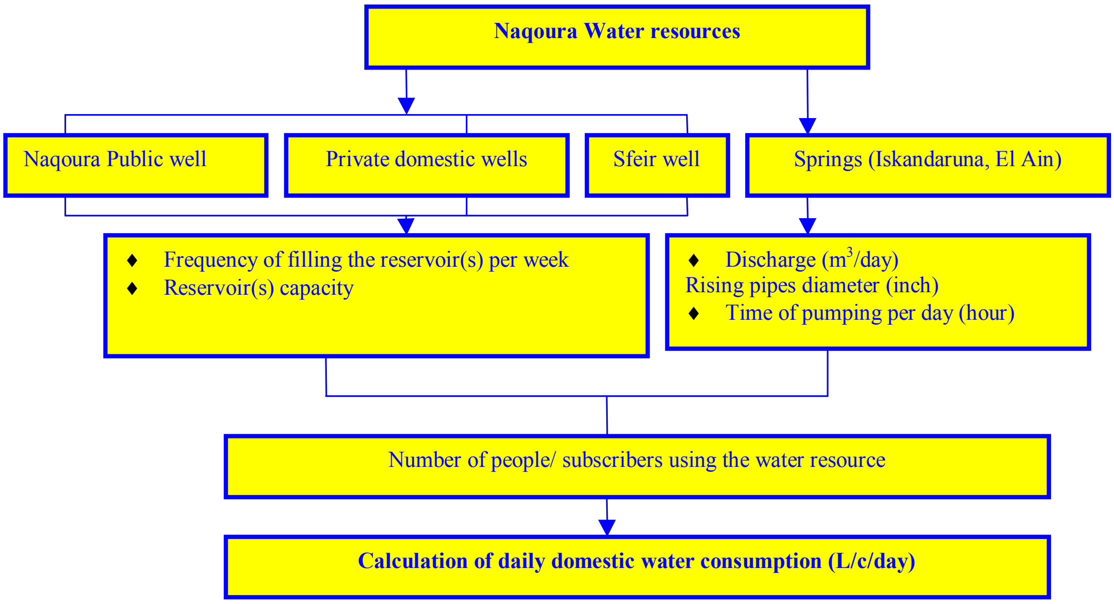


Figure 8.2. Methodology for Estimation of Domestic Water Consumption in Naqoura

Water consumption for winter time averaged 122 L/capita/day while it averaged at 204 L/capita/day during summer. These values are close to the consumption recommended by the UNDP (150L/cap/day).

Note that there are special cases of overexploitation of water in Naqoura: some housing units have water consumption values that exceed by 10 times the recommended values, this is mainly due to the lack of awareness of local residents coupled with the availability of water that is neither expensive nor scarce in the area.

8.2.3.2 Agriculture Water Demand in Naqoura

In order to estimate irrigation water consumption from private wells and springs in Naqoura, 770 000 m^2 of agricultural lands were surveyed. Actual irrigation water consumption was calculated based on the discharge of the spring or well for each mode of irrigation. Actual water consumption was compared with theoretical water consumption for each type of crops as calculated in Appendix D (Table 8.3). The actual consumption exceeds theoretical crop demand by no more than 20 percent, which is a rather good result. This value is actually within the margin of error in the estimations, but needs to be confirmed by future monitoring of irrigation water consumption.

Table 8.3. Irrigation Water Consumption in Naqoura

Mode of irrigation	Irrigated surface (m^2)	Actual values ($L/m^2/day$)	Theoretical values ($L/m^2/day$)	Type of crops	Over use (%)
Surface	45 000	7.28	6.8	Banana	7-10
Trickle	725 000	4.26- 6.2	3.7-5.3	Banana Citrus	17-22

8.2.4 Water Quality in Naqoura

Table 8.4 presents the results obtained for the Naqoura samples (section 2.3.2). While no major signs of pollution were yet identified, indication of potential pollution or water quality deterioration was found:

- Although fecal coliforms were not encountered in the wells, tap water, or even spring samples, minor contamination in Iskandarouna spring (N6) was detected; hence, while the level of sewage pollution is still not alarming, despite the lack of wastewater treatment, the situation call for the immediate protection of the rich water resources in the area.
- Possible saltwater intrusion was detected in one sample; one well located in El Khalle (200m deep), tapping the first layer of the Sannine aquifer showed high value of TDS and Chlorides exceeding maximum admissible values (Figure 8.3); the first layer of the Sannine Aquifer could be affected by salt water intrusion especially that it is in direct contact with seawater; as for the municipality well (375m deep), it is taping the third layer of the Sannine aquifer, which is protected from salt water intrusion from an overlying impermeable layer.

Table 8.4. Water Quality Results for Naqoura Samples

Sample ID	TDS (mg/L)	Chlorides (mg/L)	Nitrates (mg/L)	O-Phosphates (mg/L)	Fecal Coliforms (CFU/ 100ml)
N1	421	42	18	0.18	0
N2	443	50	5	0.12	0
N3	356	40	28	0.39	0
N4	377	36	30	0.43	0
N5	411	41	15	0.51	0
N6	440	48	23	0.32	1
N7	856	790	8	0.26	0
N8	412	41	14	0.24	0
Guidance Value [a]		25	25	0.4	0
Maximum Admissible Value [a]	500	200	50	5	0 (domestic) 200 (irrigation)

[a] All values according to Ministerial Decision 52/1 issued by the MoE, except for TDS where EPA standards are included and fecal coliforms where EPA standards for irrigation are used.

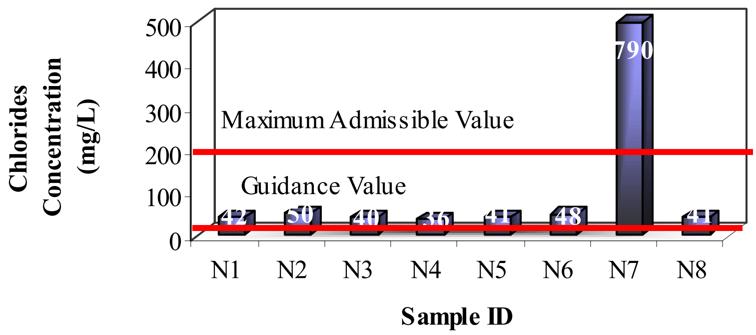


Figure 8.3. Chlorides Concentration in Naqoura Water Samples

PART III: APPLICATION OF INTEGRATED WATER RESOURCES MANAGEMENT PRINCIPLES IN CAMP AREA AND THE PILOT MUNICIPALITIES

9. IWRM IN CAMP AREA

IWRM involves projects and actions aimed at increasing the conservation of water and the efficiency in its use, while decreasing conflicts among competing uses, both in quantity and quality. This can be done by managing BOTH supply and demand and enabling adequate organizations, regulatory frameworks (such as laws, policies, and strategies) and human resources. While designing a detailed IWRM plan is outside the scope of this project, this section will provide the elements of an IWRM plan that are consistently missing in the government's approach towards sustainable water management in the country. A SWOT analysis is first provided to identify the main issues that promote or offer a challenge for water management, and then the IWRM principles that should or could be carried on are described and assessed. Note that the analysis could be easily expanded to cover the entire country, since the CAMP area holds most of the characteristics relevant to the national territory.

9.1. THE SWOT ANALYSIS

The SWOT analysis presents the strengths, weaknesses, opportunities and threats of the water resources management system in the CAMP area (Figure 9.1). Note that strengths and weaknesses are those issues internal to the CAMP area, related to its inherent characteristics. Opportunities and threats come from outside the boundaries of the CAMP area.

Strengths	**Weaknesses**
- Availability of groundwater - Presence of major surface water courses - Presence of Litani River Authority that manages major irrigation projects - Limited industrial activities - Acceptable level of urbanization - Feasibility study for water supply in the area already prepared	- Peak demand for irrigation occurs during summer when water is least available - Geologic formations with fissured karstic bedrock and narrow steep valleys do not always favor construction of dams for storage of surface water - Distribution of water establishments and offices by geopolitical boundaries rather than by water basin limits - Old water supply infrastructure leading to excessive losses - Lack of wastewater management infrastructure - Lack of adequate monitoring data for proper assessment of water resources - Seawater intrusion in coastal aquifers due to overexploitation - Insufficient level of awareness and knowledge of best management practices in agriculture - Inadequate water pricing and lack of economic incentives for efficient water use and less polluting practices
Opportunities	**Threats**
- Interest from international funding sources in the development of the new liberated south leading to potential financial assistance that can be used in water resource management activities/projects	- Difficult climatic conditions with most of the rainfall occurring within a short period of time - Attraction of new investments that could pose a stress to water resources if not properly planned - Sensitivity to geo-political context that hinders economic development

Figure 9.1. SWOT Analysis for Water Resources Management in CAMP Area

When looking at the SWOT analysis, one would think that there are too many weaknesses and threats to allow for a sustainable water resources management system to be secured in the CAMP area. The government should however capitalize on the strengths and opportunities to overcome as much as possible the difficulties posed by weaknesses and threats, while promoting principles of IWRM to move towards a system whereby all users would enjoy the quantity and quality of water needed. Some guidelines are proposed in the following section to improve the protection and management of water resources in the CAMP area. Note that it is outside the scope of this study to propose alternatives for water supply. This has been done in other studies (Dar Al Handasah, 1996). It is important here to propose those elements that would complement GoL's strategy, which is focused on water supply management, without addressing water demand and water quality issues.

9.2. IWRM PRINCIPLES IN THE CAMP AREA

Many of the IWRM principles discussed in section 3 can be used to improve the balance between water supply and water demand in the CAMP area while maintaining water quality.

9.2.1 Environmental Management Systems

The use of EMS in the CAMP area is crucial to avoid further deterioration of water quality in the CAMP area, which already suffers from seawater intrusion in coastal aquifers, bacteriological pollution, and agricultural pollution. For instance, one of the major threats to the water resources in the area is the potential future development, especially in the newly liberated south, which could increase water demand and the impacts on the water quality. Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE), depending on the type and magnitude of the project, should be performed to ensure from the beginning that the project meets the minimum standards of environmental quality. The CAMP area should capitalize on one of its major strengths, i.e. the relatively limited amount of industries and reasonable population density, and promote an overall preventive approach towards water and environmental management.

Similarly, new cleaner production (CP) processes should be promoted in new industrial projects that could be proposed within the CAMP area. The MoE has a clear track of projects that promote CP in industries, and therefore it has an important role to play in this area. Following the success of the SPASI project (Strengthening the Permitting and Auditing Systems for Industries) sponsored by the European Community (EC), the Lebanese Cleaner Production Center (LCPC) has been launched and is also financed by EC and hosted by the MoE. New industries should therefore seek advice from this new center and implement technologies that pollute less and consume less water, rather than having to invest later on expensive end-of-pipe treatment technologies.

The MoE has been for the last several years the host of numerous projects that promote cleaner technologies and processes in industries such as SPASI, LCPC as well as Compliance Action Plans for sectors such as the olive pressing and pulp and paper sectors, identification of best treatment alternatives for animal farms wastes, and other environmental studies from which local activities could benefit to improve their environmental management practices; enhanced coordination should be promoted between the MoE and the economic sectors to promote EMS and therefore ensure an environmentally sustainable economic development in the CAMP area.

9.2.2 Economic Instruments

Economic instruments should be used by the government to promote efficient use of water (demand-side management) and reduce water pollution. At least two major instruments should be assessed:

- Water pricing
- Economic/fiscal incentives

An excellent example within the CAMP area of a successful initiative in using economic instruments, and more specifically water pricing, is the one of the Saida Water Authority (SWA). A comprehensive metering system has been installed covering all the subscribers of the service, and a progressive water pricing structure was established, whereby a premium is paid for every additional cubic meter of water consumed. Not only the pricing structure reflects the true costs of water supply, but it also promotes water conservation. The SWA has observed significant reductions in water consumption and is one of the most efficient water authorities in the country, with a positive balance sheet.

This model should be followed by other water authorities in the CAMP area. Not only the installation of metering systems will allow a better monitoring of the resource and potential losses, but also and effective water pricing mechanism will promote water savings among the population. The same applies for irrigation water supply. It is interesting to note that the LRA already provides cost reductions to subscribers that invest in water saving irrigation technologies. Whether the incentive has been enough to encourage farmers to shift from surface irrigation to more efficient technologies remains to be confirmed. Nevertheless, it is important to see that the LRA, which plays an important role in water distribution within the CAMP area, has a vision towards a more efficient use of water and is conscious of the importance of conserving water to avoid water scarcity problems in the future.

Similarly, principles such as the polluter-pays principle, or economic incentives to industries that invest in water saving of cleaner technologies should be promoted by the GoL. Note that the Environmental Code (Law 444 issued in 2002) provides the legal framework for such principles; yet the law needs to be enforced and implemented.

Other projects such as the privatization of the water sector undertaken by GoL or the South Lebanon Water Policy Program (SLWPP) financed by the United States Agency for International Development (USAID) should incorporate economic instruments in their outputs and strategies. It becomes then rather a problem of how to implement and enforce the recommendations. Major challenges remain:

- Financial: important investments are needed in equipment and infrastructure (metering systems, water supply networks, rehabilitation of old networks and canals); note that some of the rehabilitation works were already executed under the National Emergency Rehabilitation Programme (NERP);

- Human resources: relevant agencies need to have sufficient human resources to monitor practices and identify violations;

- Institutional: responsibilities should be clearly defined to determine the role of the different institutions; this is particularly important in the context of a future privatized sector, and responsibilities of the public sector and the private sector will depend on the privatization mechanism adopted.

9.2.3 Capacity Building and Awareness

Capacity building and promotion of awareness are particularly important to complement the water supply options by helping regulate water demand and improve water quality. Capacity building should be prioritized in two areas:

- Improving the technical capabilities of the personnel of water authorities that are directly responsible for the execution and monitoring of water related projects;

- Improving the technical knowledge of farmers especially in irrigation water requirements and in the use of fertilizers and agro-chemicals.

The latter is particularly important since farmers do not have a reliable source of information with respect to the quantities of water actually needed to irrigate specific crops and certain climatic conditions and with respect to the quantities of fertilizers and agro-chemicals to be used. For instance, the latter information is primarily obtained from the suppliers of the products, which is a rather unreliable source of information. The supplier would definitely recommend higher ranges of use to increase his product selling. This generally leads to an over use of chemicals which in turn are discharged in the environment. The Management Support Consultants (MSC), as part of the Investment Planning and Programming (IPP) – Environment, financed by the EC and again hosted by the MoE, is currently preparing a study on the impacts of agricultural practices on water resources, and identifies the major obstacles towards the implementation of Best Management Practices (BMP) by local farmers. One of the major barriers is the lack of adequate information to allow farmers improve their practices and pose less stress on water quantity and quality.

One way of improving the capacity and technical knowledge of farmers would be to setup information centers where farmers can get technical data related to irrigation requirements and agro-chemical application practices; better informed farmers will irrigate more efficiently and apply agro-chemicals in appropriate quantities hence reducing the impacts on water resources.

Similarly, awareness regarding the importance and necessity of water conservation is needed to increase the participation of the population in reducing the overall demand of water, hence contributing to reaching a balance between water supply and demand.

9.2.4 Participatory Management

Among the most important elements of IWRM is a participatory management approach, whereby the different users and stakeholders are involved in the water management system. This involvement can vary depending on the stakeholder and the structure available for participation, and can go from simple information sharing to participation in policy formulation and planning. The main purpose of the participatory management is to provide a framework to minimize conflicts and reach consensus among different water users and uses.

Promoting participatory management in Lebanon and in CAMP is perhaps one of the most difficult objectives that water management strategy could have. Lebanon does not have a track record of participatory mechanisms, and it is difficult to initiate one. The government sets plans and policies without major involvement of the end-users and other stakeholders, which many times makes implementation of the plans very difficult. This is easily demonstrated from the numerous national solid waste management plans that were prepared in the past and have never been implemented because of lack of public acceptance among other politically-driven reasons.

Another element that makes promotion of participatory management processes difficult is that water authorities are divided based on geo-political boundaries rather than water basin boundaries like in France. The same authority is therefore responsible for water management for different users that do not share the same water resources. In a water basin, users share the same water resources, and typically water basin committees are created, among other things to:

- Identify the problems of immediate concern within the basin and the causes of these problems;
- Acknowledge conflicting interests and create mechanisms for their resolution;
- Prioritize the solutions given limited economic and human resources.

It is more likely in the case of Lebanon and CAMP in particular, that smaller communities form committees to achieve the above objectives. Some of these activities have already been initiated in the pilot municipalities (Damour, Sarafand and Naqoura). More effective forms of participatory management would only be possible if the institutional structure of the water management sector were changed.

9.2.5 Environmental Monitoring

Many gaps still exist in environmental monitoring data that hinders the proper evaluation of water resources and the preparation of a reliable water management plan. While some data exist, additional stations are needed to provide better coverage of the region. These gaps in information and monitoring are summarized in Table 9.1. The table also shows which aspect of water management the monitoring data would facilitate evaluation (water supply, water demand, water quality).

Table 9.1. Needs in Environmental Monitoring Data

Monitoring Need	*IWRM Trinity Component*	*Comments*
Meteorological data	Water supply	Data on precipitation, humidity, solar radiation, temperature, wind speed and direction are important to assess the water resources and perform accurate water balances; data on snow cover is also very important and is completely non-existent; meteorological data is limited in the CAMP area and poses a severe limitation to reliable water resources management plans
Surface water gauging data	Water supply Water demand	The LRA maintains a network of river limnigraphic stations that are used to measure rivers flow; it is important to upgrade this network to include more stations along the different rivers to be able to track upstream diversions and monitor river discharge, which is important in water balance estimations
Groundwater level	Water supply Water demand	Groundwater level is not systematically monitored; such data is very important to assess the level of water exploitation and monitor groundwater use
Water consumption	Water demand	Metering systems should be instituted for different water uses including domestic and agriculture; this would represent a first step towards controlling water losses, and moving towards a water pricing mechanism that would encourage water savings
Surface water and groundwater quality	Water quality	There is no systematic monitoring of surface or groundwater quality in the country or in CAMP area; in addition, the responsibilities in water quality monitoring are not clear, and no institution is actually undertaking this activity; it is extremely important that a network of water quality monitoring stations be implemented and operated by a dedicated institution; this is a priority step towards water protection
Effluent monitoring and compliance monitoring	Water quality	Compliance monitoring is very important to secure water quality; while standards were developed for effluents discharge in water bodies, little has been done to ensure compliance to these standards
Environmental violations	Water demand Water quality	Monitoring of illegal practices/enforcement of legislation should be implemented, perhaps with the aid of and environmental police; violations include illegal wells, discharge of untreated wastewater in water bodies, and other polluting activities

9.2.6 Preventive Management

Preventive management should be promoted primarily to minimize the risks of deteriorating water quality. Three major fronts should be tackled:

- Increasing the pace of construction of the *domestic wastewater treatment plants* as part of Lebanon's National Wastewater Programme; note that three wastewater treatment plants (WWTP) are planned within the CAMP area, in Chouf coastal area, in Saida and in Tyre; while construction of Saida's WWTP has began and is financed by the Japanese government; Chouf's plant has secured funds (French government) but Tyre's plant remains without source of financing; other areas remain without even planned infrastructure for wastewater treatment; a proactive approach from the local communities is very important in a step forward towards preventive management; coordination with the government is essential, but motivation from the rural and urban communities is crucial to exert a momentum in projects formulation and implementation.

- Promotion of best management practices (BMPs) in agriculture to reduce the impacts from non-point source pollution; farmers should become aware and trained in such practices, but most importantly, barriers for the implementation of BMPs should be identified and overcome.

- Promotion of cleaner technologies in industries to reduce industrial pollution along the coast and in water bodies.

9.3. INDICATORS FOR SUSTAINABLE WATER USE

Setting indicators for sustainable water use is an efficient way to measure the efficiency and effectiveness of the tools and principles applied. Indicators are specific continuous monitoring tools to evaluate and analyze, among others:

- The effectiveness of IWRM decisions;

- The efficiency of the investments undertaken;

- Whether benefits of the IWRM project have been equitably distributed among the various beneficiaries and stakeholders of the community;

- The impacts of these actions on the environment

Sets of indicators include daily, monthly, annual and long-term indicators. Measuring a combination of these parameters allows a complete picture of the state of a water resource to emerge, or of a water management system. Table 9.2 presents a list of indicators that could serve the above purposes. Note that indicators are of three types: state (S), pressure (P), or response (R).

Table 9.2. Possible Indicators for Sustainable Water Use

Title	Unit	Type	Time Frame	Concerned Institution	Reference	
					Blue Plan	MoE-LEDO
Access to safe drinking water	% of total population	R	Long	Central Administration of Statistics Ministry of Public Health, UNICEF, Water Authorities	13	12
Access to water networks	% of population	S	Medium	Ministry of Energy and Water, CDR, MoPH, WA		13
Total water demand per sector	Mm^3/ year or %	P	Short	MoEW, MoA, MoI		25
Destination of municipal waste	%	R	Short	MoE, MoIM, CDR	108	29
Share of irrigated agricultural area	%	P	Short	MoEW, MoA, Green Plan, FAO, LRA	52	34
Agricultural water demand per irrigated area	M^3/year/hectar	P	Medium	MoEW, MoA, Green Plan, FAO	53	35
Sea water quality	Quantity per volume and quality classes	S	Long	MoE, NCSR	35	55
Industrial releases into water	Tons/day	P	Medium	MoE, CDR, MoEW, NCSR, IRI	63	56
Water global quality index	Mg/l or % of samples complying with standards	S	Medium/Long	WA, MoE, MoEW, MoPH, NCSR	87	57
Ground water quality index	Mg/l or % of samples complying with standards	S	Medium/Long	WA, MoE, MoEW, MoPH, NCSR		58
Surface water quality index	Mg/l or % of samples complying with standards	S	Medium/Long	WA, MoE, MoEW, MoPH, NCSR		59
Share of collected & treated wastewater by the public sewerage system	%	R	Long	WA, Municipalities, MoE, MoEW, CDR	88	60
Amount of wastewater collected by type (industry / domestic)	%	R	Long	WA, Municipalities, MoE, MoEW, CDR		61
Amount of wastewater treated by type (industry / domestic)	%	R	Long	WA, Municipalities, MoE, MoEW, CDR		62
Area irrigated with treated sewage	% of total irrigated area	P	Medium	MoA, Municipalities, MoE, MoEW, MoPH		63
Area irrigated with untreated sewage	% of total irrigated area	P	Medium	MoA, Municipalities, MoE, MoEW, MoPH		

The above indicators deal primarily with issues related to the quality and quantity of water. Additional indicators could also deal with IWRM principles related to public participation, stakeholders involvement, and other less tangible aspects of water resources management. Examples drawn from international experience are presented below (IRC, 2002).

IWRM Principle: Water allocation should be between stakeholders within a national framework;

Example indicator: percentage of management committees with a clear task assignment.

IWRM Principle: Management needs to be taken care of at the lowest appropriate levels;

Example indicator: percentage of management committees with a clear task assignment.

IWRM Principle: Capacity building is the key to sustainability;

Example indicator: percentage of budget allocated for training or capacity building.

IWRM Principle: Involvement of all stakeholders is required;

Example indicator: percentage of stakeholders perceiving themselves as being involved.

IWRM Principle: Efficient water use is essential and often an important "source" in itself;

Example indicators: Percentage of persons in user groups who identify inefficient use as a problem or percentage of persons in user groups adopting water-saving measures.

IWRM Principle: Water should be treated as having an economic and social value;

Example indicators: percentage of water users that pay for water (water supply, irrigation, industry) or percentage of users considering they pay a fair price.

10. IWRM IN THE MUNICIPALITY OF DAMOUR

An IWRM plan stretches beyond the limits of a municipality, and comprises elements such as fiscal incentives or legal and institutional measures that can not be decided by the municipality alone, especially given the institutional/legal setup in the country. The recommendations presented in this section should facilitate the transition towards a better water management system in the municipality, which incorporates some practical elements of an IWRM strategy. The section first presents the SWOT analysis for water management at the municipality before providing recommendations for improved water protection and management.

10.1. SWOT ANALYSIS FOR WATER MANAGEMENT IN DAMOUR

The SWOT analysis presents the strengths and weaknesses of the Damour municipality in terms of water management, as well as the opportunities and threats that could promote or disfavor, respectively, a sound water management in the area (Figure 10.1).

Strengths	**Weaknesses**
• Availability of groundwater • Presence of major surface water course (Damour River) • Limited industrial activities • Acceptable level of urbanization • Newly built water supply network • Domestic water supply under control of the municipality • Geological protection from seawater intrusion, except for the section of Saadyiat	• Peak demand for irrigation occurs during summer when water is least available • Incomplete sewage infrastructure and lack of domestic wastewater treatment • Insufficient level of awareness and knowledge of best management practices in agriculture among farmers • Inadequate water pricing to promote efficient water use (on a lump sum basis for domestic and area of land basis for irrigation) • Lack of monitoring in water consumption • Insufficient coordination with water authorities and upstream users
Opportunities	**Threats**
• Potential return of highly qualified old Damour residents • Strong political influence that could be used to attract funds to the area for water related projects/investments	• Attraction of new investments that could pose a stress to water resources if not properly planned • Uncontrolled development of the area with the return of displaced population • Uncontrolled upstream use of river water • Environmental violations in Damour River Basin leading to the deterioration of the river water quality • Aquifer mining to feed water to areas outside Damour (Beirut and Ain El Delbe)

Figure 10.1. SWOT Analysis for Water Resources Management in Damour

10.2. IWRM IN DAMOUR

This section provides recommendations for the protection and better management of the water resources in Damour according to IWRM principles, and based on the SWOT analysis as well as the results from the participatory workshop conducted in Damour (Appendix E). The recommendations are classified in four major categories: 1) water monitoring; 2) conflict resolution; 3) water quality protection; and 4) community participation.

10.2.1 Strengthening Monitoring Capabilities

Strengthening the water monitoring capabilities of the Damour municipality would represent an important progress towards a more sustainable water management system. In particular, it is to the advantage of the municipality to build a water database that can be used in the future, among other things, to defend itself against the different threats from outside the municipality that are jeopardizing the quantity and quality of surface and groundwater in the area. Figure 10.2 summarizes the most pressing water monitoring requirements in the area. Note that the monitoring programme was devised as the minimal necessary to achieve useful results at a cost-effective price. Higher monitoring frequencies or additional sampling locations would nevertheless improve the quality of data obtained.

	QUANTITY	QUALITY
Surface Water (Damour River)	***Objective***: monitor the quantity of surface water available for irrigation ***Means***: installation of device at the main irrigation canals leading to the coastal plain to monitor water level (pressure transducer) ***Frequency***: continuous ***Investment cost***: 2 pressure transducer with datalogger and accessories = USD 5,000 ***O&M***: one staff from municipality to retrieve data from device and for analysis	***Objective***: monitor the quality of the river water reaching the coastal plain and its suitability for irrigation ***Means***: regular sampling of river water and analysis of specific parameters: pH, fecal coliforms, nitrates, SAR, TDS, COD ***Frequency***: bi-weekly or monthly sample taken at the main irrigation channel ***Investment cost***: none ***O&M***: one staff for sampling; laboratory analysis costs = USD 50 per sample
Groundwater	***Objective***: monitor the quantity of water being exploited from the aquifers and the losses in the networks ***Means***: 1) sharing of data with Beirut and Ain El Delbe Water Authorities; 2) installing water meters in domestic water supply networks ***Frequency***: Continuous ***Investment cost***: 1) none; 2) USD 100,000 – 120,000 to install meters in Damour (cost per meter: USD 300) ***O&M***: municipality staff to monitor the meters and assess water consumption and losses	***Objective***: monitor saltwater intrusion and potential bacteriological contamination ***Means***: coordination with Beirut and Ain El Delbe Water Authority + groundwater sampling and analysis (chlorides, TDS, and fecal coliforms) ***Frequency***: Monthly ***Investment cost***: none ***O&M***: one staff for coordination with authority and sampling; laboratory analysis costs = USD 35 per sample

Figure 10.2. Pressing Water Monitoring Requirements in Damour

The proposed monitoring activities would present several benefits to the municipality of Damour in terms of water resources management:

- Generation of actual data concerning the upstream utilization and potential pollution of the Damour River that could be used by the Damour municipality in future negotiations with upstream users with respect to the Damour river water rights based on a basin-wide water allocation scheme;
- Increased coordination with the concerned water authorities with respect to the exploitation of the area's groundwater;
- Setting the framework to monitor water losses in the networks and to reform the water pricing structure to encourage water savings.

10.2.2 Conflict Resolution

Two major conflicts among water users exist in the area involving: 1) Beirut Water Authority and Damour municipality; and 2) Damour municipality and upstream users of Damour river. Table 10.1 provides elements for conflict resolution and hence decreasing conflicts among competing water users.

Table 10.1. Elements for Potential Conflict Resolution in Damour

Conflict	*Conflict Resolution Elements*
Beirut and Ain El Delbe Water Authorities exploit a significant quantity of groundwater from Damour; groundwater quality has been deteriorating because of excessive pumping, leading to concerns among the Damour population and the municipality	Damour municipality should seek increased coordination with the BWA and data sharing as a means to improve partnership; Damour municipality should initiate negotiations with BWA to reduce the exploitation level; it should base its arguments on scientific basis and on studies showing the increased level of salinity in the aquifer
The Damour municipality suffers from reduced surface water reaching its coastal plain and increase water pollution due to upstream polluting activities	This is a typical conflict in a water basin where there is no coordination among the different water users. The Damour municipality should initiate discussions with upstream villages and stakeholders to form a Damour Water Basin Committee. Such a committee would be responsible to : - Conduct, with the assistance of water resources consultants, a comprehensive study for the water allocation in the basin - Provide a coordination mechanism among the different users - Monitor the quantities of water provided to the different users based on the water allocation study - Monitor and control environmental violations in the basin - Ensure coordination with the public authorities - Promote awareness and capacity building in the basin

10.2.3 Water Quality Protection

Four major sources of water pollution predominate in Damour: 1) over exploitation of the aquifer leading to seawater intrusion; 2) upstream violations leading to river pollution; 3) agricultural practices; and 4) lack of a complete sewer network and wastewater treatment plant.

The first two sources of water quality deterioration originate from outside the boundaries of the Damour municipality, and should be dealt with based on the previous recommendations, which focus on water quality monitoring, improved coordination, and the formation of a River Basin Committee.

The key towards minimizing water pollution from agriculture practices is to inform and train the farmers on best management practices (BMP) related to the use and application of agro-chemicals, their timing and quantities. Since Damour hosts one of the major remaining coastal agricultural plains, it could setup a regional information center for farmers to obtain data on BMPs. This could be done also in collaboration with academic institutions, the MoE, the MoA as sources of information and technical support.

The issue of domestic wastewater treatment is very important and should be given a high priority by the municipality. Disposal of untreated sewage is further threatening both groundwater and surface water in the area. The Damour sewage network should be connected to one of the planned coastal wastewater treatment plants in the National Management Plan for wastewater. Municipalities should have a more proactive approach towards the problem and should not simply wait for the government to secure funds and execute the projects, which is a process that is typically taking very long. The Damour municipality should constantly seek for updated information from the government and show the importance the municipality has set for the problem.

Several municipalities in the country have already taken the initiative, and with the assistance of international donors (USAID, USDA, EC), have implemented rural-based wastewater treatment plants. This could eventually be an option for Damour. In this case however, the sustainability of the projects needs to be assessed at the early stages of project concept and implementation. The municipality should be aware from the beginning of the operation and maintenance requirements of the plant, and should be able to secure the resources needed to operate the plant.

10.2.4 Community Participation

The local community in Damour should become more involved in the water-related activities of the municipality. It is important first that the community builds a sense of identity, pride, accomplishment and ownership so that the local residents get more involved in the management of natural resources.

Initial activities in this sense were conducted during the participatory workshop conducted in Damour (Appendix E). One of the working sessions during the workshop was dedicated to community participation. The participants proposed several activities to increase the participation of the community as shown in the Appendix E. These will be related primarily to promotion of awareness, capacity building, and the formation of a committee to follow-up water-related issues. Several meetings were held after the workshop, which is a good indicator of progress. It is essential that regular meetings be hold and that the action plan prepared be followed. The community can help in many aspects such as:

- Awareness on the importance of placing water meter devices to monitor water consumption and losses;
- Awareness on water conservation needs and methods;
- Organizing the establishment of the information center for agricultural practices, which could be expanded to cover other water/environment-related topics;
- Promotion of the formation of a water basin committee for the management of the basin's water resources and monitoring of environmental violation;
- Follow-up on the wastewater treatment issue (identification of sources of funds, treatment technologies);
- Encouraging coordination of the municipality with the BWA;
- Assisting in conflict resolution.

11. IWRM IN THE MUNICIPALITY OF SARAFAND

The recommendations presented in this section should facilitate the transition towards a better water management system in the Sarafand municipality, which incorporates some practical elements of an IWRM strategy. The section first presents the SWOT analysis for water management at the municipality before providing recommendations for improved water protection and management.

11.1. SWOT ANALYSIS FOR WATER MANAGEMENT IN SARAFAND

The SWOT analysis presents the strengths and weaknesses of the Sarafand municipality in terms of water management, as well as the opportunities and threats that could promote or disfavor, respectively, a sound water management in the area (Figure 11.1).

Strengths	**Weaknesses**
Available water infrastructure Good coordination with relevant water authority (Nabaa El Tasseh) Active municipal members Increased awareness of farmers (use of trickle irrigation in the area)	Poor availability of local water resources Relatively high population density Incomplete sewage infrastructure and lack of domestic wastewater treatment Limited financial resources High reliance on private wells for domestic consumption Lack of monitoring in water consumption Inadequate water pricing to promote efficient water use (on a lump sum basis for domestic and area of land basis for irrigation) Water pollution (bacteriological and agricultural pollution)
Opportunities	**Threats**
Available water resources from Brake and Teffahta well fields Nabaa El Tasseh water authority project to distribute water meter devices Council for the South as a source of financing and implementation of water-related projects	Further uncontrolled development of the area (increase in population density, additional industries, agriculture areas)

Figure 11.1. SWOT Analysis for Water Resources Management in Sarafand

11.2. IWRM IN SARAFAND

This section provides recommendations for the protection and better management of the water resources in Sarafand according to IWRM principles, and based on the SWOT analysis as well as the results from the participatory workshop conducted in Sarafand (Appendix E). The recommendations are classified in four major categories: 1) water monitoring; 2) water quality protection; 3) conflict resolution; and 4) community participation.

11.2.1 Strengthening Monitoring Capabilities

Water monitoring needs in Sarafand can be grouped into three categories: 1) monitoring water consumption; 2) monitoring water quality; and 3) monitoring private wells. These needs are discussed in Table 11.1. Note that the monitoring programs are devised keeping in mind the financial limitations of the municipality.

Table 11.1. Pressing Water Monitoring Needs in Sarafand

Monitoring Need	Recommended Actions
Domestic water consumption	***Objective***: Monitoring domestic water consumption is important to control water losses in the networks and as a tool to enforce more effective pricing schemes that promote water conservation. ***Means***: Installation of a metering system covering the main lines and housing connections. ***Investment cost***: The average cost of an installed meter is USD 300; if economies of scale are considered, installing a comprehensive metering system in Sarafand would cost more than USD 500,000; at the same time the socio-economic situation in the area does not allow to place this cost on the population; the municipality is encouraged to coordinate with the water authority, which is planning to install a metering system in their networks; a proactive approach from the municipality is important in this issue. ***O&M***: Once the metering system is connected, the municipality will secure, in coordination with the water authority, enough staff to monitor the counters and report the results.
Water quality	***Objective***: Monitoring the quality of groundwater in the area with especial emphasis on bacteriological pollution, agriculture pollution, and salt water intrusion. ***Means***: Sampling and analysis of specific samples and parameters; Recommended Sampling Program: 1) Springs Ain Hemma, Ain Quantara and Ain Bou Daynan Parameter: fecal coliforms 2) Spring Ain Quantara and Irrigation well (S1) Parameters: nitrates 3) Municipality well Parameters: chlorides, TDS ***Frequency***: monthly sampling programme as a minimum ***Investment costs***: none ***O&M***: one staff for sampling; transportation costs for samples; Sampling analysis costs: 1) 15,000 LL per sample 2) 15,000 LL per sample 3) 30,000 LL per sample Monthly sampling analysis cost: 105,000 LL (USD 70)
Private wells	***Objective***: monitor the illegal sources of abstraction of groundwater in the area and promote centralization of the domestic and irrigation water supply systems ***Means***: maintaining and updating a list of wells in Sarafand; Recommended actions: 1) update the list of wells prepared during this study; 2) perform an yearly update of the list to monitor changes ***Investment cost***: comprehensive survey campaign to update list of wells (USD 2,000) ***O&M***: municipality staff for yearly monitoring

Monitoring water quantities used for irrigation is also a very important monitoring need in the area; this would set the framework to introduce more effective pricing structures based on volume of water consumed in order to promote an efficient use of the water; this should however be coordinated with the LRA, which is currently responsible for providing irrigation water to the area; the LRA believes that it is technically difficult to install and monitor water discharge systems in the irrigation canals used by the subscribers of the service

11.2.2 Water Quality Protection

Water quality protection measures should focus on the following areas: 1) stopping pollution from domestic sewage; 2) minimizing pollution from agricultural practices; and 3) controlling pumping from groundwater. These are further discussed in Table 11.2.

Table 11.2. Recommended Water Quality Protection Measures in Sarafand

Water Quality Issue	Recommended Measures
Bacteriological contamination of groundwater from untreated domestic sewage	***Short term measure***: stop contamination of spring Bou Daynan 1) halt consumption of Bou Daynan resource until source of pollution is contained 2) provide alternative source of water to local community using the spring 3) divert the sewage coming from Hay El Sarassir which is contaminating Bou Daynan spring ***Long-term measure***: complete sewage infrastructure in Sarafand and prioritize construction of a domestic wastewater treatment plant
Groundwater pollution from agricultural practices	Pollution from agriculture activities originate primarily from inadequate use of fertilizers and agro-chemicals; the municipality should promote best management practices (BMPs) to farmers; it is important to setup an information center where farmers can learn about the use of agro-chemicals (quantities to use, application timing, etc.); this should be organized by the farmers union of the area
Saltwater intrusion in aquifer from uncontrolled pumping	The amount of water pumped from the local aquifers should be regulated to avoid further deterioration of groundwater quality; a centralized water supply system should be promoted in Sarafand since the water supply network is available and the water authority can provide the required water; the fees issue remains to be solved yet

The major challenge towards controlling domestic wastewater pollution is to secure the funds to build a wastewater treatment plant; the GoL is planning to build a treatment plant in the area of Sarafand; no specific time table is however set for the project since funds were not yet secured. The municipality should therefore adopt a proactive approach towards the problem by insisting with the government on the urgency of the matter, while at the same time exploring the possibility of building its own treatment plant upon securing the necessary funds. The municipality needs therefore to seek assistance from international donors such as USAID and bilateral donors; the MoE maintains a roster of funding agencies that could possibly be of assistance; coordination with the MoE is hence strongly recommended.

11.2.3 Conflict Resolution

Two major conflicts related to water use were identified in the Sarafand area involving: 1) Nabaa Tasseh Water Authority and local residents; and 2) LRA and local farmers. As such, the existing conflicts are of the type supplier-user, whereby the user faces a problem regarding the existing water service. These conflicts and possible resolution elements are discussed in Table 11.3.

Table 11.3. Conflict Resolution in Sarafand

Type of Conflict	Conflict Resolution Elements
Nabaa El Tasseh and local residents	***Issue***: only a fraction of the households in Sarafand is connected to the Nabaa Tasseh water authority service; despite the fact that the water authority is able to provide a good quality domestic water, local residents claim that the fees are not affordable, and prefer to use private wells instead. ***Conflict resolution***: it is recommended that the Sarafand municipality takes the lead in solving this issue; it is desirable that all the households be connected to the water authority service to: 1) control groundwater abstraction from private wells and prevent further deterioration of the water quality; 2) ensure a safe water quality to the residents; and 3) set the stage for future water pricing schemes that would promote water conservation. Unfortunately, the water authority can not provide payment facilities as a means to alleviate the problem and encourage the residents to subscribe to the service. There are two options in this sense: 1) either the municipality obtains a loan, settles the required amount with the authority, and provides payment facilities to the residents; or 2) or the municipality delegates the issue to the private sector (a bank for example). This situation also reveals a lack in awareness that should be provided to the community to facilitate the conflict resolution process.
LRA and local farmers	***Issue***: the local farmers claim that they to do not always receive water when they need, and that delays occur quite often; on the other hand, the LRA states that their service is of the highest quality. ***Conflict resolution***: a local committee should be formed to reach a consensus on this issue and adjust the situation; the municipality could organize the formation of this committee and coordinate the efforts.

The conflict between the Nabaa El Tasseh Water Authority and Sarafand local residents highlights one important issue that needs to be considered seriously by GoL if the process of privatization of the water sector is successful: the socio-economic situation of different areas affects the pricing of the water service. The water service needs to be affordable to everyone. This is one of the major challenges in treating water as an economic product rather than a commodity: how to provide facilities to the less privileged communities.

11.2.4 Community Participation

The local community in Sarafand should become more involved in the water-related activities of the municipality. It is important first that the community builds a sense of identity, pride, accomplishment and ownership so that the local residents get more involved in the management of natural resources.

Initial activities to promote the involvement of the local community in the management of natural resources were conducted during the participatory workshop held in Sarafand (Appendix E). One of the working sessions during the workshop was dedicated to community participation. The participants proposed several activities to increase the participation of the community as shown in the Appendix E. These will be related primarily to promotion of awareness, capacity building, and the formation of a committee to follow-up on water-related issues. The community can help in many aspects such as:

- Awareness on the importance of placing water meter devices to monitor water consumption and losses;
- Awareness on water conservation needs and methods;
- Follow-up water protection and monitoring activities; for instance, the committee would ensure that sewage is diverted from Bou Daynan Spring;
- Organizing the establishment of an information center for agricultural practices, which could be expanded to cover other water/environment-related topics;
- Follow-up on the wastewater treatment issue (identification of sources of funds, treatment technologies);
- Assisting in conflict resolution.

12. IWRM IN THE MUNICIPALITY OF NAQOURA

The recommendations presented in this section should facilitate the transition towards a better water management system in the Naqoura municipality, which incorporates some practical elements of an IWRM strategy. The section first presents the SWOT analysis for water management at the municipality before providing recommendations for improved water protection and management.

12.1.SWOT ANALYSIS FOR WATER MANAGEMENT IN NAQOURA

The SWOT analysis presents the strengths and weaknesses of the Naqoura municipality in terms of water management, as well as the opportunities and threats that could promote or disfavor, respectively, a sound water management in the area (Figure 12.1).

Strengths	**Weaknesses**
Availability of groundwater Available water infrastructure Available sewage network Increased awareness of farmers (relatively efficient use of water) Limited development in the area	Lack of domestic wastewater treatment Limited financial resources Lack in human resources Lack of monitoring in water consumption Inadequate water pricing to promote efficient water use (on a lump sum basis for domestic and area of land basis for irrigation) Weak institutional setup leading to uncontrolled exploitation of groundwater resources
Opportunities	**Threats**
Council for the South as a source of financing and implementation of water-related projects External sources of fund for construction of wastewater treatment plant Possible exploitation of Hamoul river for irrigation	Uncontrolled development of the area Geo-political situation in the region Water sharing with neighboring country

Figure 12.1. SWOT Analysis for Water Resources Management in Naqoura

12.2.IWRM IN NAQOURA

This section provides recommendations for the protection and better management of the water resources in Naqoura according to IWRM principles, and based on the SWOT analysis as well as the results from the participatory workshop conducted in the municipality (Appendix E). The recommendations are classified in four major categories: 1) institutional setup, 2) water monitoring; 3) water quality protection; and 4) community participation.

12.2.1 Institutional Setup

The institutional setup with respect to the management of the water resources in Naqoura is not yet fully operational. This is mainly due to the relatively recent formation of the municipality and the long period of military occupation in the area. This has led to the multiplication of the sources of water used in the area and the non-controlled exploitation of the aquifer for both domestic and irrigation uses. This issue is further detailed in Table 12.1.

Table 12.1. Proposed Organizational Structure for Water Resources Management in Naqoura

Water Use	Proposed Management Scheme
Domestic	***Issue***: Although the municipality water supply network is connected to most of the housing units of the village, other sources of water are used in several areas of Naqoura, including private wells and springs; there is no control on the quantity of water or the quality of the water supplied through these sources. ***Recommendation***: The municipality, in coordination with the South Lebanon Water Establishment, would take in charge the supply of domestic water; this includes coordination with the persons responsible for other sources of water supply to reach a common agreement; in this way, the municipality will be able to control the quantities of water exploited and monitor losses.
Irrigation	***Issue***: There is no institution currently responsible for providing irrigation water in Naqoura; as such, private wells and springs are used for irrigation without any control of the quantities used and the quality of water. ***Recommendation***: provision of irrigation water to local farmers should be the responsibility of one institution; there is a draft law that sets the LRA as the national authority for irrigation in Lebanon; in that case, the LRA would be the coordinating body with the assistance of the Naqoura municipality; upon construction of the Hamoul dam, which may be financed by the MoEW, the Hamoul river could serve as the major source of irrigation water, hence alleviating the pressure on the groundwater

12.2.2 Strengthening Monitoring Capabilities

It is essential that the Naqoura municipality strengthen its water resources monitoring capabilities. Pressing monitoring needs are in the areas of: 1) water consumption; 2) water quality; 3) losses in canalization; and 4) private wells. These are further discussed in Table 12.2.

Table 12.2. Pressing Water Monitoring Needs in Naqoura

Monitoring Need	Recommended Actions
Water consumption	***Objective***: Monitoring water consumption is important to control water losses in the networks and as a tool to enforce more effective pricing schemes that promote water conservation. ***Means***: Installation of a metering system covering the main lines, housing connections and wells (especially the irrigation wells). ***Investment cost***: The average cost of an installed meter is USD 300 for a housing/well connection and USD 500 for a main line; th estimated total investment in Naqoura would range between USD 75,000 and 90,000. ***O&M***: Once the metering system is connected, the municipality will secure, in coordination with the water authority, enough staff to monitor the counters and report the results.
Water quality	***Objective***: Monitoring the quality of groundwater in the area with especial emphasis on bacteriological and agriculture pollution. ***Means***: Sampling and analysis of specific samples and parameters; Recommended Sampling Program: 1) Municipality well Parameters: full chemical and bacteriological analysis 2) Municipality well, El Ain Spring and Iskandarouna spring Parameter: Fecal coliforms 3) Hamoul spring Parameter: nitrates ***Frequency***: bi-annual for full analysis in municipality well, and monthly sampling programme for others ***Investment costs***: none ***O&M***: one staff for sampling; transportation costs for samples; Sampling analysis costs: 1) 180,000 LL per sample 2) 15,000 LL per sample 3) 15,000 LL per sample Yearly sampling analysis cost: 1,080,000 LL (USD 720)
Private wells	***Objective***: monitor sources of abstraction of groundwater in the area and promote centralization of the domestic and irrigation water supply systems ***Means***: maintaining and updating a list of wells in Naqoura; Recommended actions: 1) update the list of wells prepared during this study; 2) perform an yearly update of the list to monitor changes ***Investment cost***: none ***O&M***: municipality staff for yearly monitoring
Losses in canalization	***Objective:*** minimize losses in canalization ***Means***: field checking of canalization and networks in the area to control losses and leakages ***Investment cost***: none for checking; rehabilitation costs will raise when necessary; rehabilitation works could be performed by the Council for the South or the MoEW ***O&M***: municipality staff to perform routine checking

12.2.3 Water Quality Protection

The Naqoura municipality should take advantage from the still limited level of development in the area, and therefore the limited number of sources of pollution to promote a fully preventive approach towards water quality protection. This preventive approach should be based on the following major pillars: 1) construction and operation of a domestic wastewater treatment plant; 2) careful examination of every proposed activity in the area using tools such as EIA; 3) conducting a comprehensive environmental awareness campaign in the area. These items are discussed in Table 12.3.

Table 12.3. Preventive Approach towards Water Quality Protection in Naqoura

Water Quality Protection Measure	Comments
Build and operate domestic wastewater treatment plant	Construction and operation of a sustainable wastewater treatment plant will minimize the risks of bacteriological pollution of the groundwater resources. Prior to selecting and building the plant it is recommended to: - prepare an EIA that will include an analysis of alternatives, impact assessment, mitigation and monitoring plans. - fully understand the operation and maintenance requirements of the plant (financially and technically) to ensure that the municipality can secure its sustainability
Promote environmental management systems	All projects proposed in the area should undergo an EIA or IEE to ensure that the project will not lead to severe environmental impacts; it would be interesting to undergo a Strategic Environmental Assessment (SEA) for the local master plan to evaluate the sustainability of the proposed urban plan; coordination with the MoE should be promoted; the MoE is currently undergoing a project to promote SEA in Lebanon; Naqoura could serve as a case study for the project for its demonstration activity.
Conduct a comprehensive environmental awareness campaign	Raising the environmental awareness of the local population would facilitate the cooperation of the local community in the fight against pollution. The awareness campaign should cover issues related to water conservation, natural resources protection, and BMPs in agriculture. This activity should be initiated by the municipality with the contribution of active local community representatives.

12.2.4 Community Participation

The local community in Naqoura should become more involved in the water-related activities of the municipality. It is important first that the community builds a sense of identity, pride, accomplishment and ownership so that the local residents get more involved in the management of natural resources.

Initial activities to promote the involvement of the local community in the management of natural resources were conducted during the participatory workshop held in Naqoura (Appendix E). One of the working sessions during the workshop was dedicated to community participation. The participants proposed several activities to increase the participation of the community as shown in the Appendix E. These will be related primarily to promotion of awareness, capacity building, and the formation of a committee to follow-up on water-related issues. The community can help in many aspects such as:

- ♦ Awareness on the importance of placing water meter devices to monitor water consumption and losses;
- ♦ Awareness on water conservation needs and methods;
- ♦ Awareness in schools
- ♦ Follow-up on the wastewater treatment issue (especially the sustainability issues);
- ♦ Promoting environmental protection in the area in general;
- ♦ Coordinate with the municipality on issues related to water resources and environmental protection.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

13. Conclusions and Recommendations

13.1. Conclusions

This report presents the work conducted as part of the CAMP Project for Lebanon, and in particular the assessment and results of the Integrated Water Resources Management (IWRM) thematic activity. The main objective of the IWRM component of the project was to assess the integration of IWRM principles and tools in Lebanon that would favor a sustainable water resources management system by taking the CAMP area, which is defined by the coastal stretch ranging from Khalde till Naquoura and extending 8 km inwards, as a case study area and three coastal municipalities, namely Damour, Sarafand and Naqoura, as pilot municipalities.

Water resources management in Lebanon faces difficulties at all levels, including institutional, legal and technical levels. At the institutional level, several institutions are involved in water resources management, but yet, the responsibilities of these institutions many times overlap, leading to the lack of proper implementation of their mandates. These include primarily the Ministry of Energy and Water (MoEW), the newly established water and wastewater establishments, the Council for Development and Reconstruction (CDR), the Ministry of Environment (MoE), the Ministry of Public Health (MoPH), and the Ministry of Public Works and Transport (MoPWT). In addition, the regional water and wastewater establishments are based on jurisdiction boundaries rather than watersheds, and do not facilitate the implementation of IWRM principles, which advocate a participatory approach to water management among common water users and competing uses. A formal participatory mechanism does not exist.

The legal framework for water resources management also needs review, consolidation and updating to allow for a better and more efficient distribution and allocation of water resources. Numerous duplications and gaps in the responsibilities of the different institutions and stakeholders of the water management sector are still prevailing. There is no comprehensive legal framework for water resources management that clearly identifies the roles of the different stakeholders and overall strategy for sustainable water management.

At the technical level, water supply infrastructure is relatively old, inadequately maintained, hence leading to water losses most of the times in excess of 50 percent; skilled staff is not readily available; monitoring activities are almost inexistent; water and particularly wastewater treatment plants are insufficient, leading to surface and groundwater pollution; and incentives as well as awareness towards more efficient use of the water resources (domestic, agriculture and industrial) are almost totally missing. For instance, water pricing structures still based on lumpsum values that do not reflect the true value of water, favor water losses and abuse.

In this context, local communities in Lebanon have an important role to play. These communities are called to act in a proactive way in managing their water resources, in close coordination with the relevant authorities. Such a proactive attitude can be promoted through the increase of local awareness with respect to the problems related to water resources and environment in general.

The added-value of the CAMP project lies in its inherent participatory approach and the work in three pilot municipalities, rather than a general assessment of water resources management in the country or a specific region. Lebanese municipalities can have a significant role to play in the protection and management of natural resources, as long as they are provided with the opportunity of learning and understanding their value and importance.

13.2. RECOMMENDATIONS

This last section of the report provides recommendations and actions that need to be taken in the short term at the national, regional, and local levels in order to shift current practices towards sustainable water resources management, whereby water supply, water demand and water quality are in perfect harmony. The following recommendations are made:

At the National Level:

- Draft the "Water Code", clearly defining the responsibilities of the different institutions/agencies having a role in water management, eliminating gaps and duplications in existing legislation, and promoting principles of IWRM; accompanying necessary application decrees are also prepared to ensure enforcement of the legal framework;
- Mechanisms to finance water management activities, in particular with the introduction of the water pricing policy reform, and eventually through privatization of water services, should be put in place.

At the Regional Level:

- At the river basin levels or catchment zones (to be identified and decided upon), regional master plans should be prepared clearly identifying water supply options, water needs, sources of pollution, future requirements, and assessing options to meet these requirements, not only through water supply management, but also working on the demand side management, and with concrete actions to protect water quality; transboundary issues should be considered, especially given the karstic nature of the Lebanese major aquifers; best option should consider environmental, social and economic conditions, in line with the principles of sustainable development and strategic environmental assessment;
- The capacity of water authorities staff should be improved to strengthen the human resources in different issues related to water management;

- Participatory mechanisms should be created to assist in the implementation of the regional master plans; this should be done in close relation with the established Water Code, according to the set responsibilities of each stakeholder; a participatory mechanism should allow the involvement of the major stakeholders and water users in the management of the water resources;
- Specific measures should be identified to mitigate the salt water intrusion in coastal aquifers; for instance, a mechanism to stop illegal pumping should be put in place.

At the Local Level:

- Awareness of local communities on importance of water conservation and protection should be raised; the participatory mechanism formed at the regional level could help build such awareness;
- The role of local communities in water resources management should be emphasized, so that these become committed and encouraged to actively participate in the promotion of sustainable water management.
- Local committees could be created to deal with localized water issues, build local awareness, and build partnerships and coordination with other stakeholders.

These very specific recommendations, if implemented, will set-up the necessary framework for sustainable water resources management, since the legal, institutional, and human aspects (capacity building and awareness) of water management will be strengthened, and these the foundations for the identification and implementation of all other activities in the medium and long-term horizons.

REFERENCES

Al Majzoub T, 2003. *Personal Communication*, Doctor in law, expert in international water issues.

ARD (Arab Resources Development), 1997. *Focused Hydrogeological Investigation Doha Hills Development Project*.

ARD (Arab Resources Development), 1999. *Geological and Hydrogeological Investigation of Mouafca Property-Damour River*.-

ARD (Arab Resources Development), 2000. *Well Rehabilitation Report Saida Wells,* Report submitted to OTV.

ARD (Arab Resources Development), 2001. *Ground Water Resources Investigation Brake Well Field*, Submitted to the Council for the South.

Arkadan A., 1999. *The Geology, Geomorphology and Hydrogeology of the Damour-Awali Area Coastal and Hinterland*. Thesis, American University of Beirut.

Bolt E., Bury P., Lammerink M. 2001. *An Introduction to Participatory Action Development.* IRC International Water Sanitation Centre, The Netherlands. [Online]. Available: http://www.irc.nl/products/planotes35/pnts6.html .

Biswas K., Thanh N.C., *Environmentally Sound Water Management.* Oxford University Press, Bombay Calcuta Madras, Delhi.

Canaan G., 1992. *The hydrogeology of Western Slopes and coastal Plain of Zahrani-Awali Region*. Msc. Thesis, American University of Beirut.

Dar Al-Handasah, 1996. *Feasibility Study for Water Supply of the Area Between Damour River and the Southern International Boundary Up to Elevation 600m*, Master Plan Report.

Direction de l'aviation civile, Direction générale des transports, Ministère des travaux publics et des transports, République libanaise, 1966. "Atlas Climatique du Liban, Tome I: Pluie, Températures, Pressions, Nébulosité", Cahier I-A (Texte). Publié par le Service Météorologique du Liban avec l'aide de l'Observatoire de Ksara. Presse de l'imprimerie catholique à Beyrouth.

Direction de l'aviation civile, Direction générale des transports, Ministère des travaux publics et des transports, République libanaise, 1966. "Atlas Climatique du Liban, Tome II: Humidité Atmosphérique, Statistiques Diverses de Fréquence", Cahier II-A (Texte). Publié par le Service Météorologique du Liban avec l'aide de l'Observatoire de Ksara. Presse de l'imprimerie catholique à Beyrouth.

Direction de l'aviation civile, Direction générale des transports, Ministère des travaux publics et des transports, République libanaise, 1966. "Atlas Climatique du Liban, Tome III : Les Vents", Cahier III-A (Texte). Publié par le Service Météorologique du Liban avec l'aide de l'Observatoire de Ksara. Presse de l'imprimerie catholique à Beyrouth.

Garcia L., Cooredor J.M, Nolet G., Echeverria R., Figueroa E., Fortin Ch., Lemay M., Millan J., Quiroga R., Tuazon R., Vaughan W, 1998. *Strategy for Integrated Water Resources Management.* N◦ ENV-125, Washington, D.C.

Guerre, 1973. *Carte Géologique Détaillée, Feuille de Tyr-Nabatiye*, 1:50 000. FAO.

Hamzeh M., 2000. *Groundwater Conditions in South Lebanon between the Awali and Litani Rivers*. Msc. Thesis, American University of Beirut.

Howard Humphreys & Partners, 1995. *Identification of Sources Protection Works*. Stage 1 Study.

IRC, International Water and Sanitation Centre 2002. *Community Integrated Water Resource Management- Accepting the Challenge*. International Water and Sanitation Centre, Delft, The Netherlands.

Litani River Authority, FAO & UNDP, 1972. *Le milieu physique du sud du Liban. Etude préliminaire, rapport* HG-002, unpublished.

Litani River Authority, FAO & UNDP, 1973. *Bilan des Eaux souterraines Enquete de 1972*. Raport HG-109, unpublished.

Litani River Authority, FAO & UNDP, 1974. *Hydrogeologie de la Region Litani-Aouali. Rapports* HG-114, unpublished.

MAP/PAP, PNUE, 1998. *Directives pour l'Approche Intégrée au Développement, la Gestion et a l'Utilisation des Ressources en Eau.*

Margeta J., Trumbic I..*Land and Water Resources Management in the Mediterranean Region: UNEP-MAP/PAP Experience.* University of Split Croatia, Centre for the Priority Actions Programme MAP UNEP, Kraj sv. Ivana 11, 58000 Split, Croatia.

Nizam A., 2003. Director General, South Lebanon Water and Wastewater Establishment, personal communication.

Service Métérologique du Liban, 1970. *Atlas Climatique du Liban*, *Volume III*, Lebanese Republic, Ministry of Public Works, General Directorate of Civil Aviation, Meteorological Service.

Smith, M. 1992. CROPWAT A Computer Program for Irrigation Planning and Management. Food and Agricultural Organization of the United Nations (FAO). Irrigation and Drainage Paper. #46. Rome, Italy: FAO.

UNDP, 1970. *Liban: Etude des Eaux Souterraines*, Programme des National Unies pour le Development, N. Y.

UNEP, International Water Association, 2002. *Industry as a Partner for Sustainable Development: Water Management.*

APPENDIX A
GEOLOGICAL MAPS

Plate A1: Geological Map of CAMP Area
Plate A2: Geological Map of Damour
Plate A3: Geological Map of Sarafand
Plate A4: Geological Map of Naqoura

APPENDIX B
WELL SURVEY

APPENDIX C
FIELD QUESTIONNAIRES

APPENDIX D
CALCULATION OF GROSS IRRIGATION REQUIREMENTS IN PILOT MUNICIPALITIES

APPENDIX E
PARTICIPATORY WORKSHOPS IN THE PILOT MUNICIPALITIES

APPENDIX F
LIST OF WATER RELATED LEGISLATION IN LEBANON

APPENDIX G
WATER RESOURCES FEATURES IN THE PILOT MUNICIPALITIES