LEBANON

COST ASSESSMENT OF WATER RESOURCES DEGRADATION OF THE LITANI BASIN

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.....Water is too precious to Waste

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A workshop was organized on December 12, 2013 at the Golden Tulip Hotel in Beirut and was open by Mr. Fadi Comair. The list of participants and the evaluation of the validation workshop are attached as Annex I.

We would also like to thank Maciej Madalinsky, former Head of Sustainable Development Section and Cyril Dewaleyne, Program Manager at the European Union delegation in Lebanon for their guidance as well as Mrs. Barbara Tomasini for her help and advice during the identification mission and workshop validation.

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TABLE OF CONTENTS

Exchange Rate:
€ 1 = Lebanese Pound (LP) 1,982.2 (December 2012)
€ 1 = Lebanese Pound (LP) 2,051.3 (December 2013)
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US$ 1 = Lebanese Pound (LP) 1,507.5 (December 2013)
Source: <www.oanda.com>

ACRONYMS

BA ....Benefit Assessment

B/C..........................Benefit/Cost

BCA ....Benefit/Cost Analysis

BCM ....Billion cubic meter

BFT..........................Benefit Function Transfer

CAS..........................Central Administration for Statistics

CAWRD ....Cost Assessment of Water Resources Degradation

CBD ....Convention on Biological Diversity

CH_4..........................Methane

CO_2..........................Carbon Dioxide

COED......................Cost of Environmental Degradation

CV ....Contingent valuation

DALYs.....................Disability Adjusted Life Years

DCCV......................Dichotomous choice contingent valuation

EC............................European Commission

E. coli ....Escherichia Coli

EDL.........................Electricité du Liban

EPA.........................Environmental Protection Agency of the United States

EU ....European Union

FAO ....Food and Agriculture Organisation

GES..........................Good Ecological Status

GDP.........................Gross Domestic Product

GIS ....Geographical Information System

GiZ...........................Gesellschaft für Internationale Zusammenarbeit (previously GTZ)

Ha ....Hectare

IRR ....Internal Rate of Return

Kg............................Kilogram

Km..........................Kilometre

Km^2 ....Square Kilometre

kTOE ....Kiloton of oil equivalent

LLB ....Lower Litani Basin

LP ....Lebanese pound

m............................Meter

m^2 ....Square meter

m^3 ....Cubic meter

MCM......................Million cubic meter

mm ....millimeter

MOA ....Ministry of Agriculture

MOE.......................Ministry of Environment

MOEW ....Ministry of Energy and Water

MOF.......................Ministry of Finance

MOIM ....Ministry of Interior and Municipalities

MOPH ....Ministry of Public Health

MSW......................Municipal Solid Waste

NOx........................Nitrogen Oxides

NPV........................Net Present Value

O&M ....Operations and Maintenance

PV.......................... Present Value

SOx.........................Sulphur Oxides

SO_2 ....Sulphur Dioxide

TEEB.......................The Economics of Ecosystems and Biodiversity

TEV.........................Total economic value

TOE ....Ton of oil equivalent

ULB ....Upper Litani Basin

UNFCCC ....United Nations Framework Convention on Climate Change

UNDP ....United Nations Development Programme

UNEP......................United Nations Environment Programme

USAID.....................United States Agency for International Development

VSL.........................Value of Statistical Life

WE ....Water Establishment

WFD ....EC Water Framework Directive

WHO ....World Health Organisation

WTP ....Willingness to Pay

WWTP....................Waste water treatment plant

PREAMBLE

Lebanon and more specifically the Beqaa Valley is home to a growing number of Syrian refugees since 2012 due to the unfortunate events in Syria. The refugees are putting more strain on Lebanon's human, social, natural, cultural and capital assets. However, the impact of the refugees on the Upper Litani Basin is not considered in the analysis but we trust that the qualitative and quantitative results of this study will help shape the political economy of improving sustainable management and the quality of life in Lebanon.

EXECUTIVE SUMMARY

With a population of 4.4 million inhabitants (2012) and a GDP of US$ 43 billion (2012), Lebanon has 926 m^3/capita of water availability in 2009 according to FAO Aquastat classifying it as the fourth best endowed country among the Middle East and North Africa Region. Despite this, there are still continued pressures on Lebanon natural resources especially in water, land use and forestry which could be further compounded by the increased intensity and frequency of the effects of the natural disaster-climate change continuum (floods, droughts, higher temperatures, forest fires, etc.).

The Government of Lebanon is fully conscious of the water challenges in Lebanon. Despite its overall political instability, sluggish economic performance and frequent changes of the Council of Ministers, there have been significant efforts in the past five years to initiate a series of reform in the water and wastewater sectors. The Ministry of Energy and Water (MOEW) has completed the draft of the Water Code with the assistance of the Agence française de Développement, which is still awaiting the Government approval. The code calls for: (i) the establishment of a National Water Council (NWC), chaired by the President of the Council of Ministers and comprising all institutional actors in the sector; (ii) mandating the preparation of a six-year development plan for the water sector by the line ministry; (iii) re-stating the need to apply the “user pays” and “polluter pays” principles consistently to the water sector; and (iv) restricting the use of government subsidies to the financing of capital investments with high social or environmental benefits.

The Council of Ministers has adopted in March 2012 the National Water Sector Strategy (NWSS). The overall goal of the strategy is “to ensure water supply, irrigation and sanitation services throughout Lebanon on a continuous basis and at optimal service levels, with a commitment to environmental, economic and social sustainability. The NWSS has included 11 initiatives of which the following initiatives are relevant to this study namely: (a) Sustainable water resources management and allocation to priority uses through the improvement on the operating model between Water Establishments (WEs) and MOEW to ensure an integrated management of water resources and improve/refine climate change knowledge, and particularly its implications on the water sector and its vulnerability; (b) Involve stakeholder participation in the design and management of projects to ensure sustainability according to best practices, through inter alia, creation of formal Water Users Associations (WUAs) to replace the different organizations currently in charge of O&M of irrigation schemes; (c) putting wastewater on a sustainable footing and protecting the environment; and (d) undertake profitable and sustainable irrigated agriculture. The NWSS called for a total of US$ 2.45 billion ongoing, committed or planned from 2011-2015, through the government and international financing institutions of which US$ 1.6 billion will be spent on new projects. MOEW has also completed a strategy in 2012 for the wastewater sector which complements the NWSS. The strategy proposes that 85% of the municipal and industrial wastewater be collected and treated at preliminary level by 2015 and 95% by 2020. It also proposes that all wastewater be treated at the secondary level and reused by 2020, and that a wastewater tariff estimated at 25% of the water supply tariff (US$ 36.5 per household per year) be introduced on a pilot phase in 2011 for customers that are connected to a sewer network and to a WWTP.

The regional study on the cost assessment of water resources degradation (CAWRD) of river basin fits in the overall context of SWIM-SM program funded through a € 7 million grant from the European Union. The overall objective is to assist national and local decision-makers in identifying concrete actions to improve watershed management in selected Partner Countries through the potential for financing projects that will derive environmental benefits and reduce negative externalities. To achieve the overall objective, there is a need to improve the investment opportunities of the government at the sub-national or basin level in order to effectively curb water degradation.

Lebanon through its national Focal Point, has requested assistance from SWIM-SM to estimate the degradation cost of water resources in the Litani watershed. This basin was selected based on the following reasons:

a) The Litani River is considered the most important and longest river of Lebanon. It originates at an elevation of 1,000 m near the city of Baalbeck (in the east), crosses most of the Bekaa plain and the south of Lebanon, and then flows into the Mediterranean Sea at Kassmieh, north of the city of Tyre. The Litani River is about 170 km long and has a watershed of some 2,181 km^2.

b) The watershed is home to a population exceeding 1 million living in 11 *caza* (administrative units) and home to 160 villages which are mostly of rural and agricultural character.

c) The average water flow is about 770 MCM/year, accounting for some 30% of the water availability in the country. The Upper Litani comprising the area where the river drops from its springs (1,000 m elevation) to the Qaraoun Dam; with a storage capacity of 220 MCM of which 160 MCM are used annually for irrigation and hydropower generation and 60 MCM are used for water storage during the dry season.

d) The basin is experiencing a number of problems relating to natural resources and linked to erosion, salinity, drought, floods and to a lesser extent dam siltation as well as serious problems linked to agricultural, municipal and industrial pollution. It is thought to be a representative basin for a thorough analysis of costs and benefits related to the degradation and restoration of water resources in Lebanon.

The main objective is to value the cost of water resource degradation in the Litani watershed to assist decision-makers at national and local levels to identify and prioritize specific actions to improve the management of this basin through potential funding of projects related to environmental benefits and the reduction of externalities. The expected results are: (a) an overview of the economic aspects of watershed management problems in Lebanon; (b) an assessment of the cost of the environmental degradation in the Litani River basin to encompass environmental health and ecological degradations; (c) a valuation of the main benefits linked to different response alternatives (in the selected watershed); (d) an economic analysis of these response alternatives; (e) concrete recommendations to internalize environmental benefits and improve watershed management.

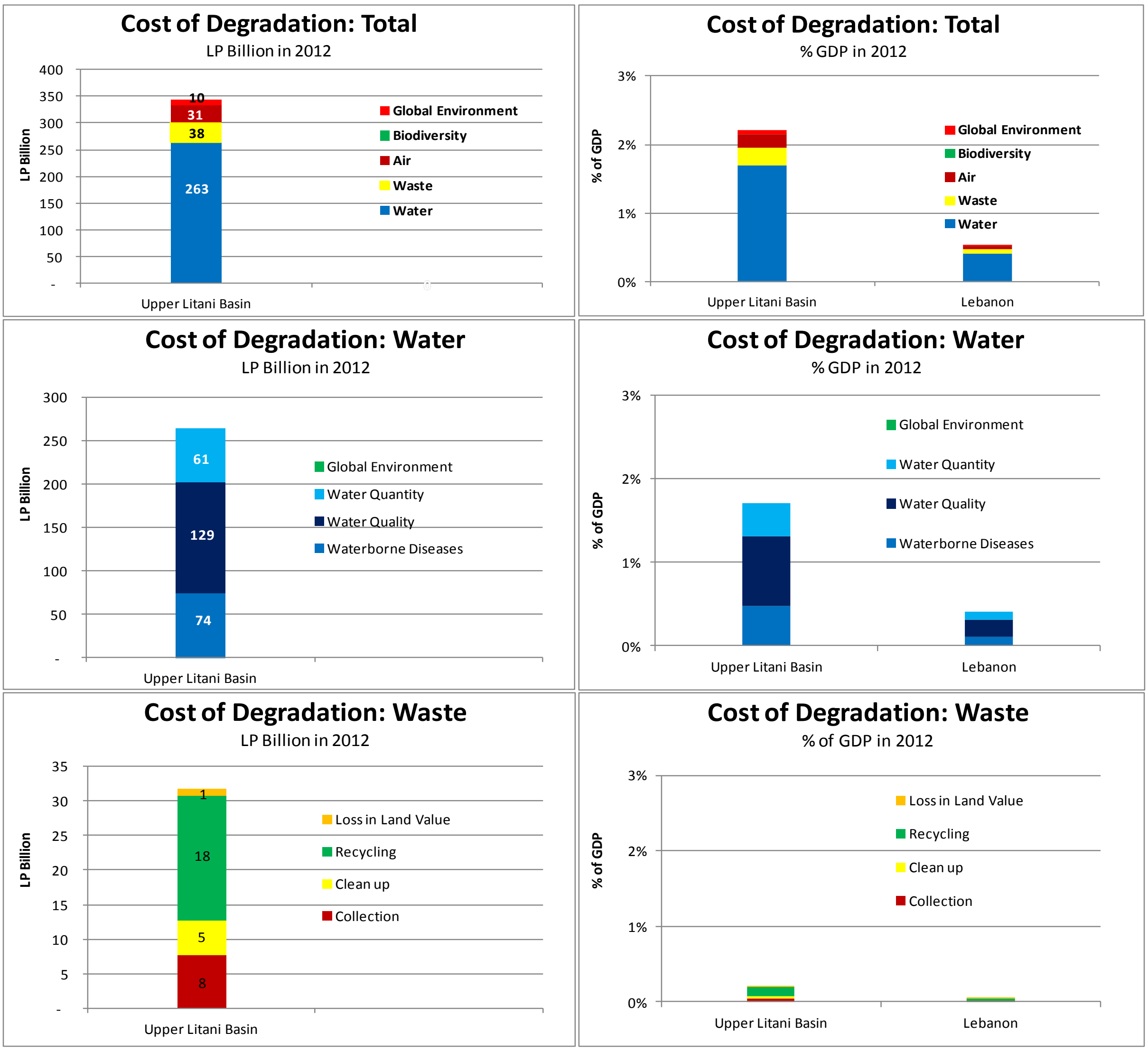
The CAWRD of the ULB reaches LP 342 billion (US$ 227 million) in 2012 with a variation between LP 283 and 404 billion equivalent on average to 2.2% of GDP in the ULB and 0.5% of GDP current national of Lebanon in 2012. Degradation cost associated to human health reached LP 102 billion in 2012 or 30.6% of the CAWRD of the ULB with LP 74 billion for waterborne diseases and LP 28 billion for respiratory diseases in the region of Zahleh and Baalbeck (Table 1 and Figure 1). Air pollution was covered as it affects water resources in terms of reducing agricultural productivity (smog requiring additional fertilizers that could indirectly increase run-off) and particulate wash off into water resources during the rainy season.

Table 1 : CAWRD of the Upper Litani Basin, 2012, in LP billion

Category	Upper Litani Basin	%	Lower bound	Upper bound
Water	263.5	77%	218.8	312.2
Solid Waste	37.8	11%	29.5	44.3
Air (Baalbeck and Zahleh)	31.3	9%	26.6	36.0
Biodiversity	0.3	0%	0.2	0.3
Natural Disaster and Global Environment	9.8	3%	8.0	11.6
Total	342.6	100%	283.0	404.3
% GDP Upper Litani Basin	**2.2%**			
% GDP Lebanon	**0.5%**			

Source : Authors.

Figure 1: CAWRD of the Upper Litani Basin, 2012 and in LP billion



Source : Authors.

Broken down by category, the water degradation is the most significant in the ULB with a relative value with 77% of the total in 2012. Waste ranks second with 11% followed by air pollution with 9%, then by natural disasters and the global environment including flood disruption and forest loss that occurred in the region of the basin in 2012 with 3% and finally biodiversity coming last with 0.1%.

Broken down by the water subcategory (LP 264 billion in 2012), water quality represents almost half the degradation costs of the ULB (LP 129 billion and 49%), followed by water-borne diseases (LP 74 billion and 28%) and finally water quantity (LP 61 billion and 23%). This category has a small impact on the global environment but costs have not been calculated.

The estimated cost of the degradation of water resources has confirmed what the previous studies have indicated in qualitative terms that: (a) the Upper Litani Basin is heavily polluted; (b) the quality of the water in the Basin is poor and that the services and utilities are not performing efficiently. This study has estimated in monetary terms the degradation due to poor water quality and quantity as well as the effect of this degradation on public health and the quality of the services as follows:

- Poor water service in terms of quality and quantity (23% of the total CAWRD) and waterborne diseases (20%) represent together more than half the CAWRD in the ULB. The 2 sub-categories are followed by significant efficiency losses in the drinking water and irrigation networks (13%). The lack of storage optimization is also penalizing the ULB in terms of forgone agricultural production and electricity generation. It is interesting to note that the CAWRD is 50% of the total water resources degradation for Lebanon given that the area of this basin is only one fifth of Lebanon's area.
- Lack of waste treatment and proper landfilling is disfiguring the ULB where the riverbed is filled with waste, trash and, in certain areas, stone debris that exacerbate the already poor quality of water resources that are subject to municipal, industrial and agricultural pressures.
- Sedimentation, the drawdown of the water table, soil/water salinity and natural disasters are prevalent to a lesser extent but should nevertheless be addressed. The increasing prevalence of evapotranspiration was neither quantified nor valued but deserves additional research as agricultural practice and cropping pattern evidence shows that there is no irrigation water return flow to the Litani River but possible infiltration to the ground water.
- Air pollution is affecting both Zahleh and Baalbeck and could affect the growing suburbs of these 2 towns although the air pollution impact on water resources from particulate wash off during the rainy season and the impact on the agricultural productivity reduction were not quantified and valued.

Based on these findings, a number of priorities emerged but only 3 are considered for the remediation analysis in the short and medium term:

- Improving water services in terms of quality and quantity, reducing the losses of drinking water and irrigation supply systems, and rebuilding the trust between the utility and dwellers;
- Increasing improved access to water and sanitation and provide hygiene practices where needed;
- Tackling all 4 sources of pollution, which covers the 2 above-mentioned priorities, by speeding up the implementation of projects addressing municipal and industrial effluents, solid waste management and agriculture runoff.

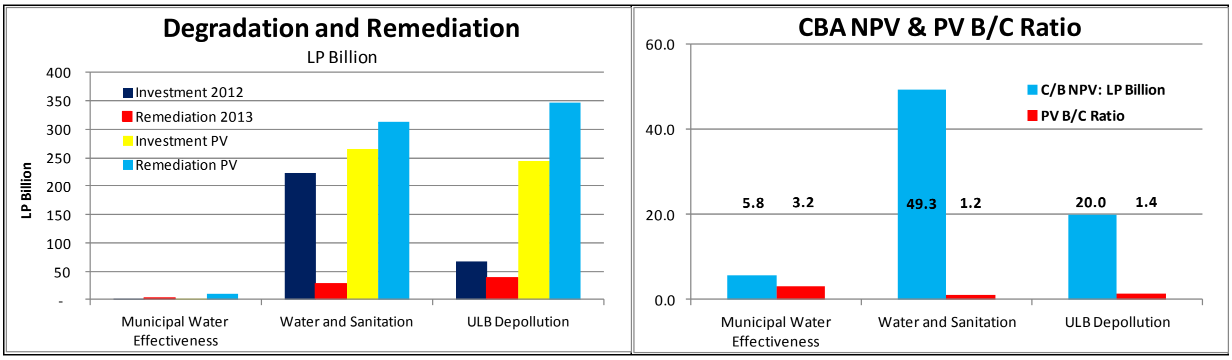
Three priority remediation interventions were considered and valued in ULB: improvement efficiency of municipal water; improved drinking water and sanitation that improve health; and Qaraoun Depollution based on Government/Development Partner ongoing project and suggested MOE/UNDP/ElArd additional investments needed to bring water resources parameters within acceptable international and national standards. Alternatively, a cost/benefit analysis should be performed for each ongoing and planned intervention by the Government/Development Partners and MOE/UNDP/ElArd to prioritize and sequence investments based on their efficiency.

Table 2: Cost/Benefit Analysis of Upper Litani Basin Selected Interventions, 2012, in LP Billion, 2012, LP Billion

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario A1 Municipal Water leakage 5% of Household Incremental Spending	Scenario B3 Improved Water and Sanitation	Scenario C2 Stand-alone additional investments that assumes that ongoing and planned investments were implemented and are efficiently operated
NPV (LP Billion)	>0	5.8	49.3	20.0
IRR (±%)	≥10%	39%	13%	12%
PV Benefit/Cost Ratio	>1	3.2	1.2	1.4
Project Viability		Yes	Yes	Yes

Source: Authors.

Figure 2: Priority Remediation Cost of the Upper Litani Basin, 2012, in LP Billion



Source: Authors.

The most relevant scenarios were selected and are shown in Table 2 and Figure 2. Two scenarios were considered for improvement efficiency of municipal water where: (A1) costs were based on 5% incremental cost incurred by households; and (A2) cost were based on optimal incremental cost incurred by households that is the switch off point that would justify the investment. For water and sanitation, three scenarios are suggested: (B1) improved drinking water supply exists but the connection to the sewer system does not exist, (B2) improved drinking water and sewer connection access do not exists, and B3 where B1 and B2 are both considered collectively. Two scenarios were considered for the ULB depollution to reach water resource quality standards where: Scenario C1 being the combined cost of ongoing, planned and additional investments as reported by the Government/Development Partners and MOE/UNDP/ElArd; and Scenario C2 being Stand alone additional investments as suggested by MOE/UNDP/ElArd. In other words, the full benefits of

Scenario C2 cannot materialize without the full implementation and operationalization of the Government/Development Partner ongoing and planned investments. The results are a very preliminary estimate that need to be refined should the Government decide to move ahead with this ambitious project. Alternatively, a cost/benefit analysis should be performed for each ongoing and planned intervention by the Government/Development Partners and MOE/UNDP/ElArd to prioritize and sequence investments based on their efficiency.

The analysis of the remediation cost is based on the net present value (NPV) of the investment over 20 years with a 10% discount rate, the internal rate of return (IRR) PV of the B/A ratio helped identify the most efficient investments (See Annex VI for calculations details):

- For domectic water leakage, the BCA shows a positive NPV of LP 5.8 billion, an IRR of 39% and the PV B/C ratio of 3.2.
- For improved water and sanitation, the BCA shows a positive NPV of LP 49.3 billion, an IRR of over 10% and the PV Ratio B/C greater than 1.
- For the Depollution of the ULB, the BCA shows a positive NPV of LP 20 billion, an IRR of 12% and the PV B/C ratio of 1.4. However, when the combined ongoing, planned and additional investments are considered under Scenario 2, the project is no longer viable and require a series of BCA to prioritize the most efficient investments.

In a nutshell, the municipal water leak and illegal taping reduction are pressing issues from a societal point of view as the most salient point is that the cost of investment to reduce the 7.2 MCM leakage represents only 1.5% of the actual annual incremental cost already paid by households to supplement water for their domestic use. Improved water and sanitation interventions is viable when all households without coverage are targeted. When considering the additional Qaraoun Depollution Project as a stand-alone project, the preliminary results suggest that the investment is viable provided that the Government/Development Partner ongoing and planned investments were fully implemented and efficiently operated. Finally, the Government/Development Partners ongoing and planned investments to which is added the additional Qaraoun Depollution Project of the ULB is not viable and requires an in-depth economic analysis to prioritize the most efficient interventions. All these results are built on the assumptions that all investment projects will be run efficiently in the future to bring ULB water parameters to acceptable standards and help most ecosystem services to regain their strength.

The diagnosis and analysis developed in the previous sections helped reach the following conclusions:

- The environment neglect of the Litani Basin is becoming a burden on the Lebanese Economy.
- The environmental health bill due to the burden of waterborne diseases is also high and was estimated at LP 74 billion/year (US$ 49 million) or 0.7% of the ULB GDP.
- Physical losses and other non-revenue water are excessive and was estimated at 50% for domestic water and 30% for irrigation.
- Water resources allocation does not reflect the reality of the socioeconomic conditions in the Litani Basin.

- Too little attention was given to the Lower Litani Basin and its development opportunities were not fully explored.
- The fragmented responsibilities between the MOEW, MOE, LRA, and the WEs are contributing to poor environmental performance in terms of monitoring and enforcement and have prevented the efficient development and management of the water and wastewater services.

On the basis of these challenges, five axes of intervention are recommended:

a) **Support the River Basin Agency Concept to be implemented by the Litani River Authority (LRA).** The underlying issues of the Litani Basin and its socio-political impacts are so complex that the present status quo of the present fragmented responsibilities will not ensure the environmental sustainability of this important basin. There is an urgent need to establish an integrated river basin management at LRA in which water management should be made at the basin level for water allocation, monitoring, compliance and enforcement and closer interactions with water users and operators. MOEW strategic role in developing water policies, regulating the regional water establishment and planning and financing large hydraulic infrastructures will certainly be maintained.

b) **Focusing first on "the low hanging fruits" for reduction of the water losses and for non-revenue water in the water and irrigation networks as well as practices**. The cost of remediation showed for instance that the reduction of 7.2 MCM/year leakage represents only 1.5% of the actual annual incremental cost already paid by households to supplement water for their domestic use. In this regard, it will be important to implement the first elements of the NWSS Infrastructure initiative investment # 1.4 related to water supply transmission and distribution. This intervention is both economically feasible and will contribute to job creation. This will require:

i. Preparation of an inventory and an action plan with costs for the rehabilitation of the water, wastewater, and irrigation networks and the establishment of outcome-based technical and financial targets for reducing losses in these systems.

ii. Implementation of the action plans using the local manpower for replacing existing old transmission and distribution of potable water and irrigation systems.

iii. Establishment and maintenance a leak detection system and irrigation techniques, cropping patterns, surfacing soil, drainage systems, etc. as well as establishing specific indicators of management and performance for the water and irrigation systems to be contracted out to professional engineering firms.

Improving the programming, investment efficiency and the maximization of environmental benefits in the wastewater sector. At present the investments programmed by the Government and the Development Partners in the wastewater sector will not cover the entire population of the Litani Basin. The remaining population will not have access to any improved sanitation let alone that their effluents will not be treated before being discharged or percolate in the water bodies. Furthermore for the population which has access to improved sanitation and for which municipal wastewater is being treated in WWTPs, the major constraint lies in the weak coverage, low installed capacity and lack of O&M and qualified staff to operate the plants. The proposed intervention will be:

i. To improve first the sanitation in rural and urban poor areas to cover about 688,000 inhabitants by 2032 that could not have access to improved sanitation, through the adoption of low cost technologies and subsidized capital and operation and maintenance costs.

ii. To increase also the coverage and the treatment capacities of the existing wastewater treatment plants which are either not functional or not operating at their initial installed capacity. These measures will have to be undertaken within an effective reprogramming and sequencing of investments which take into account the capital and the operation and maintenance costs as well as the operation of these plants by qualified utilities firms.

c) **Reducing environmental threats due to the 4 pollution pressures in the ULB.** The preliminary results of the ongoing and planned Government and Development Partners investments to which is added the additional investments suggested by the MOE/UNDP/ElArd Qaraoun Depollution project so that water resources parameters will reach acceptable standards is not economically viable. In order to proceed with the suggested investments, the following recommendations are proposed:

i. To conduct additional pre-feasibility and economic studies to prioritize investments based on efficiency out of a long list of interventions proposed in this program regarding municipal wastewater discharge, industrial effluents, solid waste leachate and agricultural runoff.

ii. To adopt, based on results of these pre-feasibility and economic studies, a structured and sequenced approach to pollution control by investing in: (a) building, densification and calibration of the sewer network and connect it to the operating and planned WWTPs and set up check and balances to monitor the efficient management of the system; (b) the in situ treatment of industrial effluents; (c) closing/rehabilitating open dumps near by the Litani River and its tributaries with high pollution risks as identified in the 2011 MOE/UNDP/ElArd study and establishing municipal treatment facilities in major cities using the model established in Zahleh and its neighbouring municipalities; and federate under the Ministry of Agriculture tutelage all the efforts to optimize the utilization of fertilizers, fungicides and pesticides in ULB.

iii. To reinforce the monitoring and enforcement and compliance system by ensuring that polluting enterprises would comply with auto-control and self-monitoring as required by the Framework of the Environment Protection Law 444 and the environmental compliance certification system (Decree 8471-2012) and by outsourcing regular inspections to certified laboratories or universities to enable the MOE to take the necessary legal actions against polluters in conjunction with both the MOEW and Ministry of Industry.

d) **Strengthening the knowledge on the development of water resources in the Lower Litani Basin (LLB) and future transfers by:**

i. Institutionalizing the water quality and quantity monitoring system which was developed under the LRBMS.

ii. Conducting a strategic regional environmental assessment of the LLB to evaluate the environmental consequences and impacts of transferring the polluted water from the ULB to the LLB, canal 800 that is under construction for mainly irrigation purposes in Southern Lebanon, and Beirut through the planned conveyor.

1. Introduction: The Water Sector in Lebanon

1. With a population of 4.4 million inhabitants (2012) and a GDP of US$ 43 billion (2012),[1] Lebanon has 926 m^3/capita of water availability in 2009 according to FAO Aquastat classifying it as the fourth best endowed country among the Middle East and North Africa Region.[2] Despite this, there are still continued pressures on Lebanon natural resources especially in water, land use and forestry which could be further compounded by the increased intensity and frequency of the effects of the natural disaster-climate change continuum (floods, droughts, higher temperatures, forest fires, etc.).

2. The annual water resources available in Lebanon are estimated at 2.7 billion cubic meter (BCM) of which 2.2 BCM is surface water and 0.5 BCM is for groundwater.[3] However, the preliminary results of the ongoing *Groundwater Assessment and Database* studies due by mid-2014 suggests that groundwater availability is more important than previously assessed.[4] Still, the water resources are not evenly distributed among the different Lebanese regions and are also affected by seasons. Groundwater is severely exploited; they are 42,824 wells, pumping 0.35 BCM annually leading to a drop in the aquifer levels. Lebanon is using 2/3 of its available water resources. The present annual demand was estimated at 1.5 BCM of which irrigation requires 0.8 BCM (53.4%), domestic water of 0.5 BCM (33.4%) and industry at about 0.2 million cubic meter (MCM --13.2%). It is expected that this figure would rise to about 1.8 MCM. If no actions are taken to improve efficiency and increase storage capacity, it is estimated that the seasonal imbalance of water resources will lead to chronic water shortages by as early as 2030 for which water demand would exceed the water resources supply by 190 MCM reaching 665 MCM in 2040.[5] More alarming is the negative trend of precipitation as results of comparative analysis revealed a clear regression in the amount of available water from different sources in Lebanon. These sources, which are under the impact of human like rivers and groundwater, showed a 23–29% decrease in the amounts of water since 1970.[6]

3. Cultivable land is limited to 250,000 ha of which approximately 100,000 ha is irrigated. Lebanon's per capita land availability is among one of the lowest in the world at 0.24 ha/capita. The most fertile areas are located in the Bekaa valley and along the narrow coastal strip in Akkar. Main crops include cereals (mainly wheat and barley), fruits and vegetables, olives, grapes, and tobacco, along with sheep and goat herding. Agriculture GDP is currently accounting for only 5% of total[7] GDP and only 2% of the population is employed in agriculture when seasonal workers are not considered. Nevertheless, the agriculture sector continues to be an important source of income for 20 to 30% of the population.[8] The irrigation sector is characterized by inadequate water storage capacity, lack of proper maintenance and a heavy reliance on hydropower cross-subsidies. Dam capacity accounts for only 6% of total

[1] World Bank website: <http://data.worldbank.org/country/lebanon>.
[2] World Bank. 2012. Lebanon: Country Water Sector Assistance Strategy. Washington, D.C.
[3] Basil, G. 2010. Ministry of Energy and Water: National Water Sector Strategy, Baseline and Key findings. Beirut.
[4] Lebanon UNDP website: <www.undp.org.lb/ProjectFactSheet/projectDetail.cfm?projectId=157>.
[5] Comair, F. 2012. L'efficience d'utilisation de l'eau et approche économique, Plan Bleu. Sophia Antipolis.
[6] Shaban, A. 2009. Indicators and Aspects of Hydrological Drought in Lebanon. Water Resources Management (2009) 23:1875-91.
[7] IFAD website : <www.ifad.org/events/gc/34/nen/factsheet/lebanon.pdf>.
[8] World Bank. 2003. Lebanon: Policy Note on Irrigation Sustainability, Report No. 28766 - LB. Washington, D.C.

renewable water resources in Lebanon[9] and is a constraint for irrigation water demand, which accounts for more than 50% of total water consumption.[10]

4. Despite relatively high connection rates reaching 100% in the urban areas, continuity of water supply is low and reaches as little as 3 hours per day in the Beirut Mount Lebanon region, which houses about 40% of the Lebanese population. Households pay three times more the price of water from private suppliers than for the water provided by the government. The seasonal water imbalance is primarily caused by the very low water storage capacity, the high amount of water lost to the sea, the growing demand for water and the deficiency of the existing water networks. Average technical and financial water losses are as high as 40% and further aggravate supply intermittency. In this context, private water supply activities have proliferated, but are lacking so far regulation especially when it comes to bulk water (contamination).

5. By contrast, only 65.7%[11] of the population in 2007 is connected to the sewer network which is often old and either damaged or undersized. Lebanon is generating a large amount of domestic and industrial wastewater estimated at 348 MCM per year in 2010 of which approximately 92% is discharged directly to the sea or in the inland wadies and rivers without any pre-treatment or disposal. About 8% is currently treated compared to an average of 32% in Middle East and North Africa (MENA) Region. The Council for Reconstruction and Development (executing arm of the Government of Lebanon) has 52 wastewater treatment plants (WWPTs) in the pipeline (12 considered, 21 under preparation, 12 under construction and 7 completed) of which about 28 WWTPs are considered a priority with a design capacity of 360 million m^3 per year, and which are already constructed, under construction or planned. To date, there are about 11 operating WWTPs (4 in Beirut and Mount Lebanon, 2 in South Lebanon, 1 in North Lebanon and 5 in Baalbeck and Bekaa) and 5 constructed WWTPs (Chekka, Batroun, Jbeil, Ras Nabi Younes/Jiyeh and Nabatiyeh) of which 4 along the coast that are not yet connected to the network.[12] In the coastal cities which services 65% of the population, three wastewater treatment plants (pre-treatment in Saida, pre-treatment in Ghadir south of Beirut and secondary treatment in Tripoli working at 10% of its capacity) are operational, and four others (Chekka, Batroun, Jbail and Ras Nabi Younes/Jiyeh) are not working because they are not connected to networks. In the Bekaa, the Baalbeck WWTP is operating well below capacity (10% of its capacity because the network is not entirely connected to the WWTP), the Yammouneh WWTP (50%), the WWTP Qaraoun/Aitanit, Fourzol and Ablah have recently been under operation (54%) whereas a number are under construction and planned albeit others small scale WWTP built in the late 1990s were abandoned.[13]

6. The Government of Lebanon is fully conscious of the water challenges in Lebanon. Despite its overall political instability, sluggish economic performance and frequent changes of the Council of Ministers, there have been significant efforts in the past five years to initiate a series of reform in the water and wastewater sectors. The Ministry of Energy and Water (MOEW) has completed the draft of the Water Code with the assistance of the Agence française de Développement, which is still awaiting the Government approval. The code calls for: (i) the establishment of a National Water Council (NWC), chaired by the President of the Council of Ministers and comprising all institutional actors in the sector;

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[9] Basil, G. 2010. Ministry of Energy and Water: National Water Sector Strategy, Baseline and Key findings. Beirut.
[10] World Bank. 2010. Public Expenditure Review for the Water Sector, Washington, D.C.
[11] World Bank. 2011. Lebanon: Country Environment Analysis. Washington, D.C.
[12] Doumani and Mucharrafiyeh. 2011. EU Benefit Assessment, Lebanon Report. Brussels. <www.environment-benefits.eu>.
[13] World Bank. 2012. Lebanon Country Water Sector Strategy (2012-2016). Washington, D.C.

(ii) mandating the preparation of a six-year development plan for the water sector by the line ministry; (iii) re-stating the need to apply the "user pays" and "polluter pays" principles consistently to the water sector; and (iv) restricting the use of government subsidies to the financing of capital investments with high social or environmental benefits.

7. The Council of Ministers has adopted in March 2012 the National Water Sector Strategy (NWSS). The overall goal of the strategy is "to ensure water supply, irrigation and sanitation services throughout Lebanon on a continuous basis and at optimal service levels, with a commitment to environmental, economic and social sustainability. The NWSS has included 11 initiatives of which the following initiatives are relevant to this study namely: (a) Sustainable water resources management and allocation to priority uses through the improvement on the operating model between Water Establishments (WEs) and MOEW to ensure an integrated management of water resources and improve/refine climate change knowledge, and particularly its implications on the water sector and its vulnerability; (b) Involve stakeholder participation in the design and management of projects to ensure sustainability according to best practices, through inter alia, creation of formal Water Users Associations (WUAs) to replace the different organizations currently in charge of O&M of irrigation schemes; (c) putting wastewater on a sustainable footing and protecting the environment; and (d) undertake profitable and sustainable irrigated agriculture. The NWSS called for a total of US$ 2.45 billion ongoing, committed or planned from 2011-2015, through the government and international financing institutions of which US$ 1.6 billion will be spent on new projects.[14] MOEW has also completed a strategy in 2012 for the wastewater sector which complements the NWSS. The strategy[15] proposes that 85% of the municipal and industrial wastewater be collected and treated at preliminary level by 2015 and 95% by 2020. It also proposes that all wastewater be treated at the secondary level and reused by 2020, and that a wastewater tariff estimated at 25% of the water supply tariff (36.5 US$ per household per year)[16] be introduced on a pilot phase in 2011 for customers that are connected to a sewer network and to a WWTP.

8. The Ministry of the Environment (MOE) at the request of the Council of Ministers, and the Environmental Parliamentary Commission has completed the preparation of the Business Plan for Combating Pollution of the Qaraoun Lake on the upper Litani River. The purpose of this study is to identify the pollution sources of the Qaraoun lake and propose mitigating measures in the form of a business plan.

9. Based on the above, and consistent with the NWSS, which required to manage water resources in an integrated and participatory manner, that more specific prioritisation may be required at the watershed level and identified based on the cost and benefit of interventions which would lead towards the sustainability of the water sector in Lebanon.

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[14] Basil, G. 2010. Ministry of Energy and Water: National Water Sector Strategy, Sector Enabling Environment and 2011-2015 Investment Plan. Beirut.
[15] World Bank. 2012. Lebanon Country Water Sector Strategy (2012-2016). Washington, D.C.
[16] World Bank. 2011. Lebanon: Country Environment Analysis. Washington, D.C.

2. Sustainable Water Integrated Management–Support Mechanism (SWIM-SM)

2.1 General overview

10. Responding to the integrated water sector management challenge that SWIM[17] has agreed to support a regional program on the cost assessment of water resources degradation (CAWRD) at the basin level.

11. SWIM is a Regional Technical Support Program that includes the following Partners Countries (PCs): Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, the occupied Palestinian territory, Syria and Tunisia. The Program is funded by the European Neighborhood and Partnership Instrument (ENPI) South/Environment. The project complements and adds value to the Horizon 2020 Initiative to de-pollute the Mediterranean Sea by addressing in particular water issues, in synergy with three relevant EC funded Programs, namely the Mediterranean Hot Spots Investment Program - Project Preparation and Implementation Facility (MeHSIP-PPIF), the Capacity Building/Mediterranean Environment Program (CB/MEP) and the ENPI Shared Environmental Information System (ENPI/SEIS).

12. Its overall objective is to promote actively the extensive dissemination of sustainable water management policies and practices in the region given the context of increasing water scarcity, combined pressure on water resources from a wide range of users and desertification processes, in connection with climate change.

13. The specific objectives of the SWIM-SM are to: (i) raise the decision-makers and stakeholders' awareness in the Partner Countries on existing and upcoming threats on water resources, on the necessity to switch to more viable water consumption models as well as on possible solutions to face the challenges; (ii) to support the Partner Countries in designing and implementing sustainable water management policies at the national and local levels, in liaison with on-going relevant international initiatives; and (iii) contribute to institutional strengthening, to the development of the necessary planning and management skills and to the transfer of know-how. SWIM-SM has now included among its four pillars, the economic valuation of water resources at the basin level.

14. SWIM-SM has included in its work package # 1, a regional activity on the CAWRD at the basin level. The overall objective is to assist national and local decision-makers in identifying concrete actions to improve watershed management in selected Partner Countries through the potential for financing projects that will derive environmental benefits and reduce externalities. To achieve the overall objective, there is a need to improve the investment opportunities of the government at the sub-national or basin level in order to effectively curb water degradation.

15. Lebanon through its national Focal Point, has requested assistance from SWIM-SM to estimate the degradation cost of water resources in the Litani watershed This basin was selected based on the following reasons:

a) The Litani River is considered the most important and longest river of Lebanon. It originates at an elevation of 1,000 m near the city of Baalbeck (in the east), crosses most of the Bekaa plain

[17] SWIM website: <www.swim-sm.eu>.

and the south of Lebanon, and then flows into the Mediterranean Sea at Kassmieh, north of the city of Tyre. The Litani River is about 170 km long and has a watershed of some 2,181 km^2.

b) The watershed is home to a population exceeding 1 million living in 11 *caza* (administrative units) where about 160 villages can be found and which are mostly rural and agricultural character.

c) The average water flow is about 770 MCM/year, accounting for some 30% of the water availability in the country. The Upper Litani comprising the area where the river drops from its springs (1,000 m elevation) to the Qaraoun Dam; with a storage capacity of 220 MCM of which 160 MCM are used annually for irrigation and hydropower generation and 60 MCM are used for water storage during the dry season.[18]

d) The basin is experiencing a number of problems relating to natural resources and linked to erosion, salinity, drought, floods and to a lesser extent dam siltation as well as serious problems linked to agricultural, municipal and industrial pollution. It is thought to be a representative basin for a thorough analysis of costs and benefits related to the degradation and restoration of water resources in Lebanon.

16. The Litani Basin has been the subject of extensive reports, scientific applied science and technical information which will be used for this study notably starting with the USDI Point-4 Development Plan for the Litani River in 1954 and the World Bank Litani Power and Irrigation Project in 1955 to more recently with the MOE Environmental Master Plan for Litani River and Lake Qaraoun Catchment Area in 2000, the USAID Litani Basin Management Advisory Services (BAMAS) in 2005, the IDRC Towards an Ecosystem Approach to the Sustainable Management of the Litani Watershed in 2007, the EU SPI Water Description of the Litani in 2007, the MOE/UNDP/ElArd Business Plan for Combating Pollution of the Qaraoun Lake in 2011, which is currently used by the World Bank to prepare a Depollution Project, and the USAID Litani River Basin Management Plan (LRBMP) in 2013. Moreover, the MOEW has commissioned a study in 2009 on the "Furure Water Management Planning for Litani and Awali Basins" that details water use allocations with the new transfers planned.

2.2 Objective of the Study

17. The main objective is to value the cost of water resource degradation in the Litani watershed to assist decision-makers at national and local levels to identify and prioritize specific actions to improve the management of this basin through potential funding of projects related to environmental benefits and the reduction of externalities.

18. The expected results are:

a) An overview of the economic aspects of watershed management problems in Lebanon

b) An assessment of the cost of the environmental degradation in the Litani River basin to encompass environmental health and ecological degradations.

c) A valuation of the main benefits linked to different response alternatives (in the selected watershed);

[18] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.

d) An economic analysis of these response alternatives;

e) Concrete recommendations to internalize environmental benefits and improve watershed management.

19. The CAWRD can be understood as a measure of the lost welfare of a nation due to water resources degradation. A loss in welfare includes but is not necessarily limited to:

- Loss of healthy life and well-being of the population (e.g., burden of disease);
- Economic losses (e.g., efficiency losses, competitiveness, forgone revenues); and
- Loss of environmental opportunities (e.g., loss of tourism, fisheries, biodiversity).

3. The Litani Basin

3.1 General Overview

20. With a length of 170 km, the Litani River drains about one fifth of Lebanon's waters with an area of 2,168 km^2, representing 21% of the total area of the country (Figure 3.1). The Litani Basin covers three major mohafazat or governorates (Bekaa, Nabatiyeh, and South Lebanon) and 11 casas or districts.[19] The Litani Basin is divided into the Upper Litani Basin (ULB), which is located upstream to the Qaraoun Lake covering an area of 1,468 km^2 and the Lower Litani Basin (LLB) covering 700 km^2, which is downstream to the Qaraoun Dam. The main tributaries of the upstream Litani Basin is the Ghozayel River and the Bardaouni River. The source of the Ghozayel river is the Haouch Moussa in the Anjar area, and this river connect to the ULB above the village of Charreqiye. The source of the Bardaouni river is the Mount Sannine that flows through the city of Zahleh and connect to the Litani River in the town of Bar Elias. The river flows southward parallel to Mount Lebanon up to the Qaraoun Dam creating an artificial lake called the Qaraoun Lake but also known as the Albert Naccache Lake. The construction of the Qaraoun Dam (see below) has created major hydrological changes to the Litani River Basin, where the water flows from above Qaraoun Lake are diverted through a system of tunnels, conveyors, and canals to produce hydropower instead of being discharged into its original natural tail water. These changes have resulted in the effective hydrological separation between the ULB and the LLB in which the Litani River is considered a separate river system[20] as it is fed by various springs and a major tributary the Wadi El Debbe.[21] The lower Litani River enters into a very narrow gorge for 30 km and then deviates sharply westward in a V valley shape south of Marjayoun and discharges to the Mediterranean Sea at 7 km north from the city of Tyre (Sour). Nevertheless, discharge from the ULB from the Qaraoun Lake to the LLB occurs only during periods when the water supply in the Lake exceeds that required for power generation, usually during winter time.[22]

Box 3.1 : Main Characteristics of the Litani Basin

Length of the river: 170 km.
Surface area: 2,168 km^2, 20.6% of the Lebanon's area and reached 2,371 km^2 when the Baalbeck region and the Yammounh are added the basin.
Population of ULB: 1.04 in 2010 and approximately 1.06 million in 2012 when Upper Litani Basin extends to Yammouneh and the Baalbeck area.
Dam: The Qaraoun Dam with an artificial lake covering a 12.3 km^2 area where the total static volume is 220 MCM of which 160 MCM is dynamic with 10 MCM for Canal 900, 20 MCM for the Qasmiyeh for irrigation and 130 MCM for hydropower.

Hydropower plants (190 MW): through a system of tunnels, conveyors, canals and small lakes, water is transferred from the Qaraoun Lake to Markaba (34 MW), then under Mount Lebanon to Awali (108 MW) and Joun (48 MW),[23] and then released into the Awali River where a Beirut conveyor is planned to transfer drinking water to Beirut.

[19] USAID. 2003. Water Quality Assessment of the Upper Litani River Basin and Lake Qaraoun. Beirut.
[20] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut.
[21] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut.
[22] IDRC. 2007. Ecosystem Approach to the Litani River.
[23] Litani River Authority website : <www.litani.gov.lb>.

Agriculture : 87,720 ha of which 57,000 ha are actually used for agriculture in the Upper Litani Basin; and 36,000 ha in the South of Lebanon, and it is the most fertile region in Lebanon.
Potable Water: Major source of potable water for 1.04 million habitants in the Litani Basin in 2012.

Wastewater Treatment Plant: According to CDR and USAID, 5 are operational in ULB but not at full capacity (World Bank-funded Baalbeck, GOL-funded Yammouneh and USAID-funded Aitanit, Fourzol and Ablah); 6 are under construction of which 3 in ULB and 3 in LLB; and 2 are planned in ULB. Moreover, a number of WWTP are not operational due to technical and operations and maintenance shortcomings.

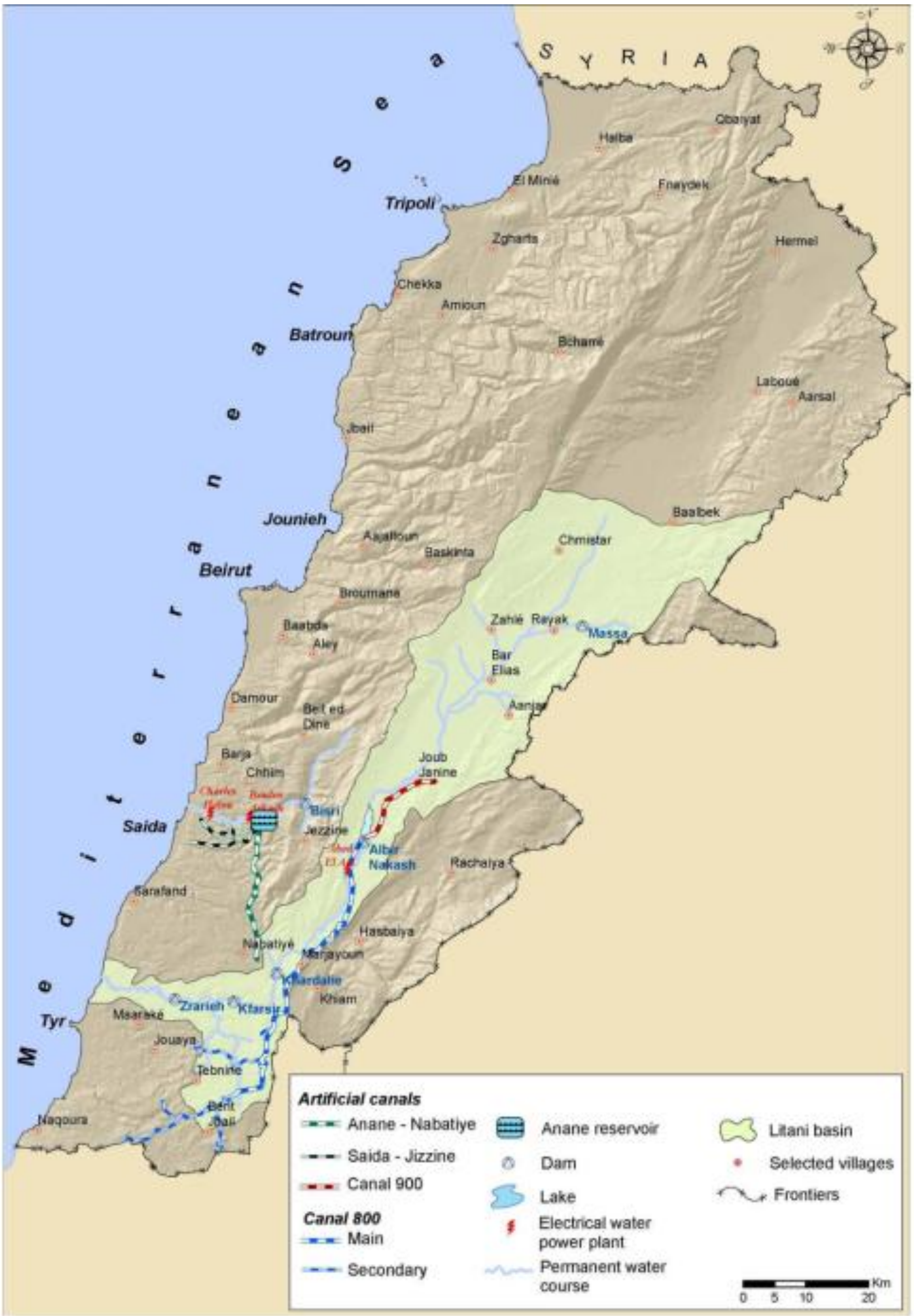
Source: LRA website: <www.litani.gov.lb>; USAID website: <www.usaid.gov/Lebanon/>.

21. In this report, ULB is defined as the area upstream of Qaraoun Dam and includes the Qaraoun Lake. Moreover, the UNDP In this report, the terms “Litani” and “Litani Basin” refer to the entire river and basin, from the source to the sea. Moreover, the 2011 MOE/UNDP/ElArd has extended the catchment area of the upper Litani Basin to the north by 103 km^2 to include the town of Baalbeck and its neighborhood as the treated effluents of the Laat WWTP are released in the upper Litani catchment, and the Yammouneh Spring that was diverted to feed the Litani Spring.

22. The average annual discharge rate of the Litani River is 764 MCM per year of which 75% is discharged in winter. This discharge is shared between 542 MCM upstream and 221 MCM downstream of the Qaraoun Dam. The total runoff of surface waters of the river is 946 MCM (30% of the total flow of all national rivers), of which 70 MCM are considered from the side catchment areas in the west mountains. The total available capacity of the groundwater in the basin was estimated at 125 MCM per year. This water volume is stored in five aquifers of which three are located in the Bekaa Valley and the remaining along the south coastal plains.[24] There are very few studies that were carried out in the Lower Litani Basin which covers an area of 500 km^2 in view of its low development and its topography of mountains and narrow and constricted valleys. In fact the rivers drops within 60 km from an altitude of 800 m to its outlet in the sea level.

[24] Comair, F. 2012. L’efficience d’utilisation de l’eau et approche économique, Plan Bleu. Sophia Antipolis.

Figure 3.1 The Litani River Basin



Source: LRA (2007).

23. The major existing and planned infrastructure on the Litani River includes the following (Figure 3.1):

i. The **Qaraoun Dam** on the Litani River is a 1,090 m long and 61-metre-high concrete-faced rockfill dam. It is the largest dam in Lebanon. The dam is retaining the Qaraoun artificial lake of a surface water area of 12.3 km^2 and a nominal capacity of 220 MCM per year. Of this nominal capacity 160 MCM can be used for irrigation (40-60 MCM) and hydropower (100-120 MCM) and a volume of 60 MCM as a storage for the dry season. In addition, the groundwater reserves are estimated at 104 MCM.

ii. The **Mount Lebanon tunnels, conveyors, canals and small lakes** allow the transfer of water from the Qaraoun Dam (under the Mount Lebanon Chain) to produce electricity through three hydropower plants (total capacity 190 MW): a tunnel of 6.5 km long and an elevation of 199 m with an installed capacity of 2x17 MW in Markaba; 17 km, 400 m and 3x36 MW in Awali with water being stored in the Anane Basin (160,000 m^3) before being released to generate hydropower; and 6.8 km, 196 m and 2x24 MW in Joun with water being stored in the Joun Reservoir (300,000 m^3) before being released to generate hydropower. The water allocations for electricity takes precedence over other allocations and can reach up to a range of 300 to 420 MCM to produce about 500-600 million kW/hour per year.

iii. The **Canal 900** (900 m altitude) withdraws water from the Qaraoun Dam through 3 pumping stations that raise water to 950 m level reservoirs and transfers it back by gravity and against topography to irrigate areas up to 21,500 ha in the upper Litani Basin. To date, the canal 900 extends for 18 km and is projected to reach 35 km once the South Bekaa Irrigation project is fully implemented. This canal will receive remaining water needs from wells and springs. However, this potential irrigated land seems over optimistic and more a conservative assessment suggests a total of 14,000 ha to be irrigated with 2,000 ha being actually irrigated and 12,000 ha being planned in the future. Water allocations are estimated at 8 MCM.

iv. The **Canal 800**, whose phase I is under construction and will be operational by 2017, will provide domestic and industrial water and irrigate 14,600 ha in 76 villages in South Lebanon.[25] The canal stretches from Qelia in West Bekaa to Braachit in the south at a length of 51 km and will withdraw 20 MCM of water per year for domestic and industrial use and 86 MCM of water per year for agricultural purposes from the Qaraoun lake.

v. The **Qasmiyeh-Ras el Ain main conveyor** on the LLR, where portion of the river flows west, stretches parallel to the river bed at a length of 8.2 km to reach a partition facility at the area of Djazireh. This section of the canal contains several tunnels at a length of 2.2 km. The end of the main canal is equipped by a divider at Djezireh allowing to divide the water to two separate canals: the Saida Branch (or Qasmiyeh North) with a length of 28.9 km, It comprises 3 tunnels and several siphons and the Tyr Branch (or Qasmiyeh South) with a length of about 9.4 km. Annual water pumped are estimated at 10 MCM.

vi. The water transferred through the **Mount Lebanon tunnels, conveyors and small lakes** is released, after being used to generate hydropower, in the Awali River where a coastal south-north Beirut conveyor is planned and will allow to augment Greater Beirut water sources.

vii. **Two dams are planned on the LLB: Khardale** (126 MCM of storage capacity of which 87 MCM from the LLB and 28 MCM from wells; 80 MCM are allocated towards irrigating 11,900 ha), which will include **Qasmiyeh-Ras el Ain** main conveyor phase II (33 MCM of

[25] USAID. 2003. Water Quality Assessment of the Upper Litani River Basin and Lake Qaraoun. Beirut.

which 18 MCM from the Khardale and the rest from wells and springs and 4,100 ha) and Kfarsyr (12 MCM of storage capacity) that will supply the Tyre coastal area to irrigate 2,000 ha and Saida to provide potable water from Ain ez-Zarqa (11 MCM).

viii. The **Canal 600 is shelved (and is subject to be cancelled in the future) for the time being and is planned to run from the Anane Lake before the Awali** hydropower plant **to Zahrani and then Nabatiyeh** as water will irrigate 1,200 ha. Water allocations are estimated at 42 MCM of which 13 MCM for irrigation will be supplied from the Qaraoun reservoir and 29 MCM from Ain ez-Zarka (LLR) with 18 MCM for potable water and 11 MCM for irrigation.

24. As most of the population and their socio-economic activities are situated in the ULB, the majority of the reports and documentations has been devoted to this sub-basin which covers an area of 1,468 km^2 (67% of the basin area) and include 99 towns and villages distributed among the four districts of Baalbeck, Zahleh, West Bekaa and Rachaya.[26] The population range in the ULB is approximately 1.04 million people in 2010 (1.06 in 2012) of which 77% are rural and 23% are urban with a total number of the households in the range of 107,110.[27] The Litani region has a prevalence of poverty ranking third after Tripoli-Akkar and Sour regions respectively: 25% of the population is considered poor or very poor,[28] and unemployment is higher than 60%. The main activities in the basin are services, trade, agriculture and industry. Agriculture contributes to 20% of incomes.

25. The rainfall ranges from 200 mm in the North Bekaa to 800 mm and the humidity from 35-75% in the Bekaa plain. The Litani River is also prone to floods due principally to the natural riverbed characteristic, lack of riverbed maintenance and as well as illegal constructions and dumping of municipal and hazardous waste as well as release of debris from stone cutting. Also there is seasonal flooding from minor channels due to lack of drainage, poor maintenance, and lack of drainage ditches from farmlands. The winter of 2003 provided a large amount of heavy precipitation resulting from the 400 mm rain falling over an 11 day period during February 2003, and after several years of near drought conditions. This resulted in heavy flooding in the Bekaa from the Litani River and other areas and generated several billion Lebanese pounds of damages. As a result, 80% of the cultivated areas were destroyed, and the west Bekaa was transformed into pocket of islands to be reached by boat. Under the Litani River Basin Management Support[29] financed by USAID, a Litani River Flood Management Model for the Litani River Authority was prepared in order to establish a topographic survey which will provide indication on the flow of the river under various structure and the establishment of a river model for the prevention and management of floods. The flood prevention and mitigation efforts suffer from a lack of effectiveness although there is a unit for emergency preparedness that is under implementation to coordinate all emergency matters and housed at the Prime Minister's Office. However, the unit lacks a clear mandate that makes it effective and adequate means.

26. With regards to distinctive ecosystems, the ULB is home to 4 protected areas: Kfar Zabad wetland is designated a Protection of Sceneries and Natural Sites *Hima* (protected area) by the MOA and a designated Important Bird Area (Birdlife International, 2008) located at 850 m altitude on the east side of the Bekaa Valley within Anjar and Kfar Zabad and spreading on an area of 60 ha characterized with a

[26] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.
[27] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.
[28] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut
[29] USAID/IRG and Dar El Handassah Nazih Taleb and Partners. 2010. Litani River Flood Field Survey Report. Beirut.

mixture of marchland, constant springs, riparian woodland and pine woodlands; the Yammouneh area (notably known for its juniper trees) is a MOE reserve whereas its lake was declared a Natural Sites and Monuments by a 1942 Decree; the Qaraoun Lake's LRA self-proclaimed protected area (12.3 km^2) and some parts of riverbank areas falling below the level of 860 m (about 220 ha) that is owned by LRA; and the Aammiq wetland (253 ha) that is the largest remaining freshwater wetland in Lebanon, a remnant of much more extensive marshes and lakes that once existed in the Bekaa Valley, and which is a designated Important Bird Area in the Middle East (Birdlife International, 1994), is included in the Directory of Wetlands in the Middle East (IUCN, 1995), is declared a Ramsar site (1999), and is designated with Al Shouf Cedar reserve uphill as a "Biosphere reserve" (UNESCO, 2005).[30]

3.2 Pollution in the Upper Litani Basin

27. The major sources of pollution of the Upper Litani Basin are:

- Municipal Waste water
- Industrial Waste Water
- Municipal and Industrial waste
- Agriculture run-offs

Municipal Waste Water

28. An estimated amount of 45.4 MCM of untreated wastewater is discharged into the ULB with a BOD load of 16,600 tons/year. It is expected that the wastewater volume will increase to 72.9 MCM/year.[31] About 71% of the household (76,350) are connected to a sewer, while the remaining 29% (30,674) discharge in the private cesspools where non-maintained septic tanks and open discharges contribute to the fecal contamination of the ULB.

[30] MOE website: <www.moe.gov.lb>; and EU SPI Water. 2007. The Litani River.
[31] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.

Table 3.1: State of Municipal Wastewater Treatment and Discharge in the Upper Litani Basin

Wastewater Balance	Installed Capacity	Operating Capacity	
ULB Existing, Ongoing and Planned WWTP	**m^3/day**	**m^3/day**	**% of installed capacity or discharge**
Completed			
Baalbeck (Laat)	12,500	1,250	10%
Aitanit, Forzol and Ablah	8,000	4,320	54%
Yammouneh	1,000	500	50%
Sub-total	21,500	6,070	**28.2%**
Under Construction			
Zahleh	18,000		
Saghbine	7,500		
Jib Janine	10,500		
Sub-total	36,000		
Planned			
Tamnine	24,534		
El Marg	120,000		
Maaraboun	383		
Sub-total	144,917		
UBL Total Existing, Ongoing and Planned Capacity	**202,417**		**3.0%**
ULB Discharge			
ULB 2010 Total Municipal Discharge	**157,697**		**3.8%**
ULB Industrial effluents	10,233		
Total liquid discharge	**167,930**		**3.6%**

Source: MOE/UNDP/ElArd (2011); USAID Evaluation Report (2012); and CDR Progress Report (2013).

29. Five wastewater treatment plants (WWTP) have been constructed with a total installed capacity of 21,500 m^3/day in the ULB. With the exception of the Baalbeck (located at Laat) medium scale WWTP, which was financed by the World Bank with an installed capacity of 12,500 m^3/day and is working at 10% of its capacity, 4 small scale WWTPs serving villages and communities were financed by USAID, i.e., Ablah, Forzol and Aitanit (collectively 8,000 m^3/day working at 54% of their capacities),[32] and the Government of Lebanon, i.e., Yammouneh with a 1,000 m^3/day working at 50% of its capacity. Two other WWTPs are under construction namely for Zahleh (18,000 m^3/day), Saghbine/Bab Maraa (7,500 m^3/day) and Jib Jenine (10,500 m^3/day) whereas two are under preparation, Timnine el Tahta (12,500 m^3/day) and El Marg (120,000 m^3/day). **Only 3.8% of ULB total municipal waste effluents are treated in 2012** (Table 3.1) as the wastewater sector is still constrained by a low network density, network clogging, poor WWTP management and unfinished WWTPs. The situation becomes aggravated during the summer months in which untreated wastewater concentration increases in view of the dishing flow of the surface water discharge in the river transforming the river into "an open sky sewer."[33] Untreated wastewater is being used in irrigation[34] in many areas in the basin. Untreated wastewater is a major cause of diseases as it was estimated that 7.5 cases annually per 10,000 population suffer from

[32] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut.
[33] Kaskas, A., Awida, K., 2000. ''Litani River and Lake Qaraoun Environmental Masterplan.'' Aqua Abu Dhabi 2000 Wastewater Management for a Better Environment, Abu Dhabi.
[34] USAID/IRG. 2012, Litani River Basin Management Support-Water Quality Survey. Beirut.

dysentery, typhoid and hepatitis A in the Bekaa which is twice the national average. These are reported cases by the public sector but the number of real cases could be even higher in terms of under-reporting and cases treated by the private sector that are not consolidated in public sector statistics.[35]

30. As for the LLB, 3 WWTPs are under construction in Yohmor, Zaoutar and Kafrsir (collectively 35,000 m^3/day) along the Litani River and others WWTPs are planned on its tributaries.[36] Also, a number of small scale WWTPs were constructed on some of the tributaries of the Litani in the late 1990s but none of them is currently working.

Industrial Pollution

31. The total amount of industrial water was estimated at 4 MCM in 2011 and generated from about 294 industrial medium and small scale establishments of which half are situated in the industrial zones of Zahleh and Taanayel (Table 3.1). The type of industries include agro-business (dairy, olive oil, wine, livestock, poultry, fruit and vegetable processing) as well as manufacturing of plastics, synthetic rubber, detergents and cosmetics, non-metallic mineral products such as paper mills manufacturing dyeing and tanning as well as manufacturing of batteries. Untreated industrial wastewater include organic pollutants which are mostly biodegradable, such as oil, fats, hydrocarbons, phenols and detergents and inorganic pollutants which are mostly non-biodegradable, containing inorganic slats and chemicals (such as chlorine, ammonia, phosphates and nitrates). Their untreated wastewater which are either discharged into the sewer network or directly into the river. There is little incentive for the industries to pre-treat their wastewater either before its release in the waterways or before reaching the treatment plant.

Municipal and Industrial Solid Waste

32. **The Municipal and Industrial Solid Waste** is also major source of pollution. Industrial, municipal and stone cutting waste are mixed and thrown either in the river or scattered in the basin or in the banks of the river. The ULB generates a total of 680 t/day disposed mostly in 60 dumps sites[37] and in which the leachate containing heavy metals and organic chemicals could either percolate the soil and the groundwater and be discharged in the river. Zahleh is the only city that has one operational sanitary landfill, which was financed by both the World Bank and USAID, and could dispose of 200 t/day from its 12 neighboring municipalities. Moreover, medical wastes are being collected in parts of the Bekaa area and treated at the Zahleh landfill site (autoclave) managed by the NGO Arcenciel[38] although other areas are not yet properly covered by the medical waste collection and treatment system such as Baalbeck. Another landfill is under construction in Baalbeck and has encountered implementation delays. The main dump sites exerting pressure on the Litani River are: Temnine El Tahta, Saadnayel, Qabb Elias, Barr Elias, Hawch El Harimi, El Khiyara, Ghazze and Jeb Jennine.[39] Moreover, There is a large number of quarries and stone processing industries in the catchment's area which is affecting water quality. The most obvious impact from the quarry and stone cutting industry is the effluent of large quantities of

[35] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut.
[36] CDR Progress Report 2012: <www.cdr.gov.lb>.
[37] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.
[38] Arcenciel website: <www.arcenciel.org>.
[39] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.

stone sediments that is affecting the fauna and the flora. In some places the river has been totally clogged from lime from these industries.[40]

Agriculture run-off

33. **Agricultural run-off** is also an important source of pollution due to primarily of the overuse of fertilizers and pesticides. Fertilizer applications were estimated to be 1.5 to 3 times the needed doses and pesticides applications are twice the required doses.[41] Most of the agricultural practices are not neither regulated nor monitored. And the famers do not receive technical support as to the proper use of the pesticides and fertilizers. Agricultural runoffs do not only pollute the surface water but percolate also the ground water, reducing agricultural productivity and causing the formation of algae in the river bed and in Canal 900.

3.3 Water Quality Assessment of the Upper Litani Basin

34. The ULB is under great environmental stress with degraded water quality that varies from good to bad to very bad in several places along the river. The highest contamination is in the mid upper Basin of Barr Elias which included the largest population and the major industries. The results of the Surface, Lake Qaraoun and Underground Water Quality Profiles is summarized in Table 3.2 and Figure 3.2.

35. The water quality has deteriorated since 2005 and showed the same levels of fecal coliforms in surface, lake and underground water as tested by USAID in 2010 although the tested levels should be considered with caution due to the relatively significant discrepancy between the two considered years. At any rate, these fecal coliforms, whose levels could be acceptable in water bodies, become however problematic for treatment as they increase the cost per m^3 treated and most importantly become dangerous when water is directly used through domestic wells or distributed by trucks for domestic use after intake from water bodies. Further analysis shows BOD and dissolved oxygen could be as low as 3.6 kg/day and as high as 2,000 kg/day.[42] Total petroleum hydrocarbons compounds as well as heavy metals such as barium, chromium, vanadium and zinc were also found in the Litany river before the Ghazayel river. The river is also polluted with high concentrations of ammonia and nitrites from waste eater and industrial discharges as well with high concentration of **phosphates** and **sulfates** due to agricultural pollution. A recent study based on 5 year monitoring of the ULB also confirms the anthropogenic impacts from nitrates and phosphates on the surface, subsurface and even underlying aquifer water conditions, which makes this water unsuitable for human consumption. Furthermore, even higher concentrations has led to severe eutrophication of the Litani River, as well as the Qaraoun reservoir, entailing the use of copper sulfate on a continual basis by the LRA to keep algae and weeds in check. The concentration of the remaining parameters such as chloride, sulfate, pH, EC, and DO remain within permissible standards set for human consumption, irrigation and river quality indicators.[43]

36. The Qaraoun lake is also polluted with fecal coliforms and traces of metals. However, water quality for aquatic life is in a better state than it was in the upper streams though it contains a high level of ammonia. Moreover, cyanobacterial blooms have been reported despite the high levels of

[40] EU SPI Water. 2007. The Litani River.
[41] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut.
[42] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.
[43] Saadeh, Mark, Lucy Semerjian and Nabil Amacha. 2012. Physicochemical Evaluation of the Upper Litani River Watershed, Lebanon. The Scientific World Journal. Volume 2012, Article ID 462467, 8 pages doi:10.1100/2012/462467.

ammonia.[44] Nevertheless, sedimentation and biodegradation are phenomenon taking place in the reservoir, leading to improvement in the Lake water quality.[45]

Table 3.2: ULB Comparison of Surface Water, Lake and Underground Quality Profiles in 2005 and 2010

Indicator	Unit	USAID BAMAS 2005			USAID LRBMP 2010			Drinking Water Standards		
		Min	Mean	Max	Min	Mean	Max	National	USEPA	WHO
Surface Water										
TDS[1]	Mg/l	88	291	706	187	502	1,979	<500	<500	<600
pH[2]	pH units	7	7	8	7	8	9	6.5-8.5	6.5-8.5	6.5-8.5
BOD[3]	Mg/l	2	48	624	3	547	2,530	NA	NA	NA
Nitrates[4]	Mg/l as N	3	13	62	0.1	1	5	<10	<10	<11
Phosphates	Mg/l	0	12	197	0.0	9	72	NA	NA	5
Fecal Coliform[5]	CFU/100 ml	0	223,487	1,500,000	1	72	400	0	0	0
Cadmium[6]	Mg/l	NA	NA	NA	0.00	0.01	0.08		<0.005	<0.003
Manganese[6]	Mg/l	NA	NA	NA	0.01	0.07	0.3		<0.05	<0.4
Qaraoun Lake										
TDS[1]	Mg/l	120	160	196	221	232	256	<500	<500	<600
pH[2]	pH units	6.5	7	7.5	8.2	8.3	8.3	6.5-8.5	6.5-8.5	6.5-8.5
BOD[3]	Mg/l	<2	2.6	4.0	2.0	2.7	3.3	NA	NA	NA
Nitrates[4]	Mg/l as N	62	16	21	0.8	0.9	1.2	<10	<10	<11
Phosphates	Mg/l	0.01	0.13	0.35	0.0	0.09	0.24	NA	NA	5
Fecal Coliform[5]	CFU/100 ml	0	17	450	0	160	400	0	0	0
Cadmium[6]	Mg/l	NA	NA	NA	0.0007	0.010	0.021		<0.005	<0.003
Underground water										
TDS[1]	Mg/l	NA	NA	NA	170	385	863	<500	<500	<600
pH[2]	pH units	6.5	6.9	7.2	7.0	7.7	8.7	6.5-8.5	6.5-8.5	6.5-8.5
Nitrates[4]	Mg/l as N	3	48	171	0.2	6.7	41.0	<10	<10	<11
Phosphates	Mg/l	0	0.3	12	0.1	1.2	6.4	NA	NA	5
Fecal Coliform[5]	CFU/100 ml	0	42.8	400	0	39.2	400	0	0	0
Manganese[6]	Mg/l	NA	NA	NA	0.03	0.07	0.54		<0.05	<0.4

Note: NA Not applicable. Cells highlighted in red exceed MOE, USEPA or WHO standards.

Definition of indicators:

1.TDS: measures mineral content; reflects on the type of water source and exposure to pollution. Increased levels in surface water represent mostly increased exposure to sewage, industrial wastewater effluents, leachate of municipal solid waste dump sites and agriculture run off.

2. pH: measures alkalinity or acidity; agricultural runoff and sewage shift the pH towards alkalinity.

3. BOD: measures oxygen needed by aerobic microorganisms to treat organic pollution; high BOD reveals pollution from sewage and inefficient wastewater treatment, agribusiness effluents and excessive application of organic fertilizers.

4. Nitrates: measures presence of nitrates which causes algae growth and impacts aquatic life. Sources of nitrates are mostly nonpoint-source runoff from heavily fertilized croplands. High nitrate presence is improper for domestic use.

5. Fecal Coliform: measures sewage discharge. Decreasing levels found by the survey (as compared to BAMAS) are due to reducing conditions not supporting development of fecal organisms, not decreased discharge of sewage.

6. Cadmium and Manganese: trace metal indicators that measure exposure to agriculture runoff (increased use of pesticides and fertilizers).

Source: adapted from USAID/IRG: Litani River Basin Management Plan; Volume 1, Water Quality Survey (2011); Guidelines for Drinking-Water Quality, Fourth Edition (2011); and WHO Drinking Water Guidelines (2011).

[44] Slim et al. 2012. Effets des Facteurs Environnementaux sur la Qualité de L'eau et la Prolifération Toxique des Cyanobactéries du Lac Karaoun (Liban). Larhyss Journal, ISSN 1112-3680, n°10, Mars 2012, pp. 29-43.

[45] EU SPI Water. 2007. The Litani River.

37. Water transferred through the Mount Lebanon tunnels, conveyors, canals and small lakes get supplemented and mixed with fresh water sources from Mount Lebanon's coastal range. Hence, the water dilution reduces certain parameters exceeding drinking water standards found in the Qaraoun Lake but some will found their way to the Lake sediments (see below). Indeed, a series of tests performed on the Joun reservoir (last reservoir before releasing the water in the Joun turbines) in terms of heavy metal, pesticides and organic proved that they are below drinking water guidelines whereas microbial, nitrite, turbidity, and color parameters will need to be addressed during treatment but are well within the limits of treatability.[46]

38. The quality of the groundwater shows acceptable levels of total dissolved solids of 385mg/l in accordance with the Lebanese standards but high levels of concentrations of fecal and total coliforms as well as nitrates, chloride and sulfates.[47]

39. With regards to the fauna, cat fish was living in the Litani River bed before the construction of Qaraoun Dam. After the construction of the dam, this type of fish disappeared and LRA replaced it by trout and carpe. Starting from 2000, the effect of eutrophication problem started to become obvious on trout that disappeared from the Qaraoun Lake where only the carpe still live. Bio-indicators derived from fish during the 2000 MOE study revealed low levels of metals (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Zn) accumulated in the food chain.[48] By contrast, the USAID BAMAS study revealed heavy metals in all fish samples with levels exceeding the US Food and Drug Administration (FDA) standards for cadmium (70 mg/kg against 3 mg/kg for the FDA).

40. Analysis of the sediments in the river beds shows the presence of TPH, heavy metals as well as concentration of cadmium which is a trace elements found in pesticides. The highest frequency of metal concentrations exceeding international acceptable standards include: across the catchment's sediments Cadmium (Cd), Lead (Pb), Arsenic (As), Zinc (Zn) Vanadium (V), Chromium (Cr) and Copper (Cu); and within the Qaraoun Lake sediments Arsenic (As), Cadmium (Cd), Mercury (Hg), Nickel (Ni) and Vanadium (V).[49,50]

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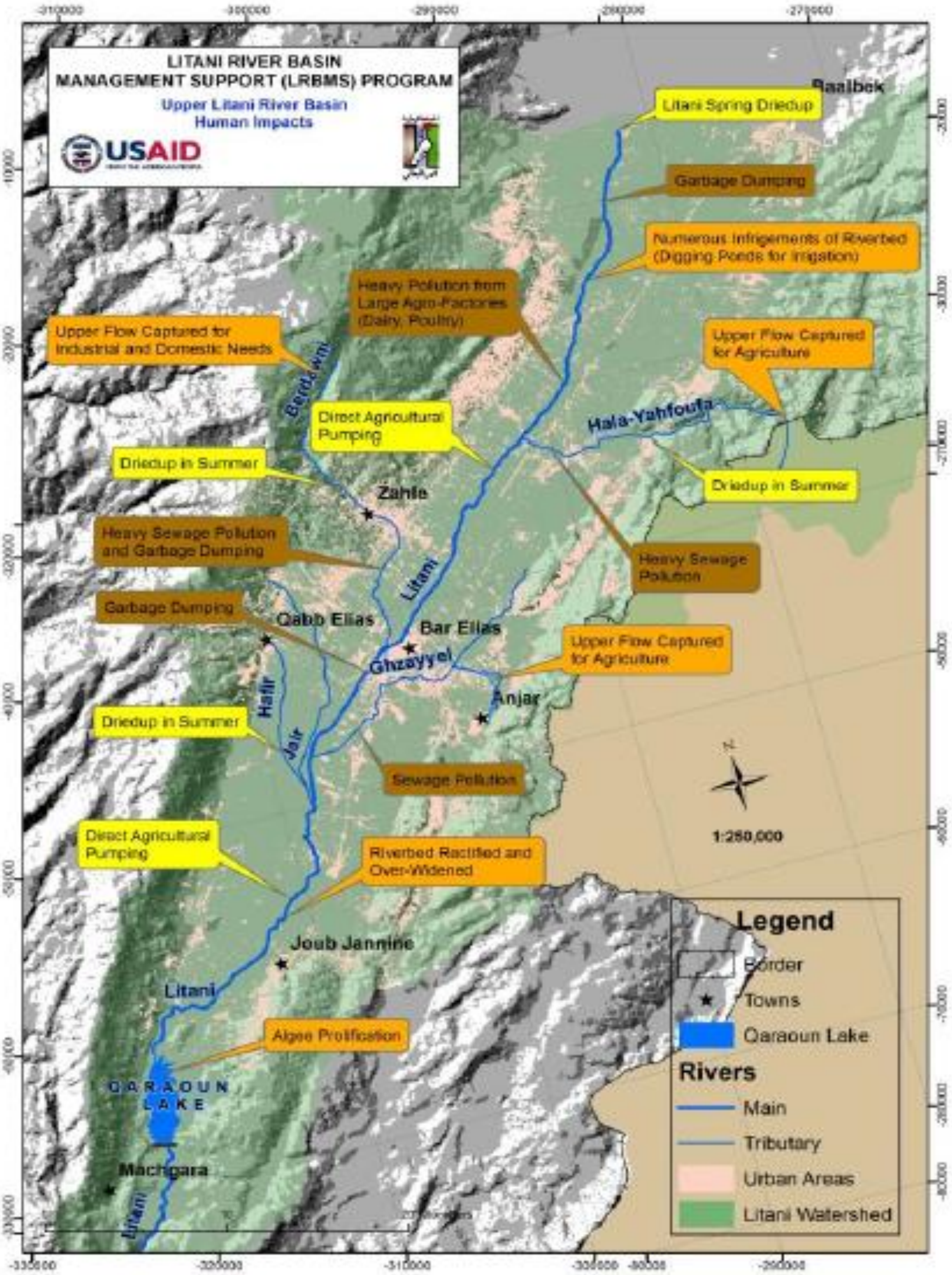
[46] Bartram, Jamie and Joseph LoBuglio. 2011. Greater Beirut Water Supply Project: Independent Technical Review of Source Water Quality. Final Report commissioned by the World Bank Sustainable Development Department Middle East and North Africa Region and produced by the Water Institute at University of North Caroline, Chappell Hill.
[47] USAID/IRG. 2011. Litani River Basin Management Plan; Volume 1, water quality survey. Beirut.
[48] EU SPI Water. 2007. The Litani River.
[49] MOE/UNDP/ElArd. 2011. Business Plan for Combating Pollution of the Qaraoun Lake. Beirut.
[50] EU SPI Water. 2007. The Litani River.

Figure 3.2 The Litany River Basin



Source: USAID/IRG, Water Quality Assessment of the Upper Litani River Basin and Lake Qaraoun (2003).

3.4 Water Quality Assessment of the Lower Litani Basin

41. There is few reliable information on the Lower Litani Basin. In general, the water quality is good when compared to the Upper Litani Basin and despite Fecal Coliform exceeding drinking water standards --as in some cases, direct water intake is distributed by trucks to households--, the water can

be good enough for drinking subject to water treatment.[51] Water quality levels are good with only nitrate showing cumulative increases downstream relative to increasing fertilizer application as confirmed by Table 3.3 that illustrates the results collected in 7 locations along the LLB in 2006.[52]

Table 3.3: ULL Surface Water Quality Profiles in 2006

Indicator	Unit	Mean	Standard Deviation	Drinking Water Standards		
				National	USEPA	WHO
Nitrate	mgL^{-1}	10.19	6.3	<10	<10	<11
Nitrite	mgL^{-1}	0.01	0.04		<1	<1
Phosphate	mgL^{-1}	0.11	0.19	NA	NA	5
Fecal Coliform	c/ml	100	208	0	0	0
Total Coliform	c/ml	304	368	0	0	0
Ammonium	mgL^{-1}	0.01	0.01	NA	NA	NA

Note: NA Not applicable. Cells highlighted in red exceed MOE, USEPA or WHO standards.

Source: IDRC (2007).

42. Water salinity for irrigation along the southern coast has been reported as the Litani surface water is complemented with underground water where salt intrusion is a growing concern.

3.5 The Institutional Framework

43. There are several government agencies involved to varying degrees in water resource management in the Litani with overlapping functions. The main agencies are:

1. At the national level
   - The Ministry of the Energy and Water (MOEW)
   - The Ministry of the Environment (MOE)
   - The Council for Reconstruction and Development (CDR)
2. At the Regional Level
   - The Litani River Authority (LRA)
   - The Water Authority (WA)
3. At the local levels
   - The local water committees
   - The municipalities

<u>At the National Level</u>

44. The Ministry of Energy and Water (MOEW).The MOEW has the following mandate to :

a) Protect develop, and assume jurisdiction of water resources;

b) Develop policies and strategies in water resources;

[51] USAID/IRG. 2012. Litani River Basin Management Plan; Volume 1, current situation. Beirut.
[52] IDRC (2007).

c) Determine water supply and demand as well as conservation of water resources;

d) Design, implement and operate large hydraulic facilities; and

e) Administratively supervise the WAs and the LRA.

45. MOEW has two general directorates: the Directorate General of Hydraulic and Electric Resources (DGHER) which is responsible for research, studies and implementation of large-scale projects and the Directorate General for Operations which is responsible for overseeing the public establishment, for administration and financial aspects as well as administratively supervising as the Water Authorities and the local autonomous water boards and local committees.

46. **The Ministry of the Environment (MOE)** is the environmental regulatory arm of the country. Its major roles and functions is to formulate laws, regulations, standards and guidelines; prepare environment policies and strategies, monitor, control and enforce water, air, and soil quality; providing the necessary environmental conditions for issuing permits and licenses for construction of industrial establishment and zones, quarries and various kinds of animal farms, and implement environmental projects related to biodiversity and natural resources, climate change, ozone depleting substances and hazardous chemicals. The MOE was asked to take the lead by the Council of Ministers, for the preparation of a comprehensive report on the combating pollution of the Qaraoun Lake which it completed with UNDP support.

47. **The Council for Development and Reconstruction** is the planning and implementing arm of the central Government. Its major functions are: (a) the preparation of the investment plans for the country; (b) as the design, planning and implementation of programs and projects for reconstruction and development; (c) the mobilization of external financing from development partners. CDR has the responsibility for selecting, in cooperation with line ministries, the institutions for the implementation of programs and projects. In the Litani Basin, the CDR was the implementing agency for the Baalbeck WWTP.

At the Regional Level

48. **The Litani River Authority (LRA)** was established in 1954 to develop the necessary domestic, irrigation and hydropower schemes for the Litani, develop a national interconnected power grid, and build electrical power stations and distribution networks in all Lebanese territory. The LRA was subsequently given the technical and the financial power for operating and exploiting all Litani River Basin related projects. In 1962 the LRA responsibilities were expanded to include a water development plan for all the Litani/Awali basins and the area between the international Beirut-Damascus road and the southern Lebanese border. Moreover, the decree 14522/1970 still defines the amount of manageable water from the Litani System and its allocation for irrigation and domestic use in the southern Bekaa and on the “Western Foothills” (Box 3.2). The LRA conducts and publishes monthly water quality surveys and monitors and prevent pollution and is assisted until September 2013 by the Litani River Basin Management Support Program financed by USAID for an improvement and a more efficient and sustainable river basin management at the Litani River Basin. Despite the establishment of the regional water establishments as per the water Law 221, LRA has still maintained its responsibility to develop and manage the irrigation water and associated works in the Southern Bekaa and South Lebanon.

49. **The Bekaa Water Establishment** (BKWE) is one of the four regional water establishment mandated by Law No. 221 of May 2000. The establishment is located in Zahleh is governed by a Board consisting of six members and a president appointed by the Council of Ministers The responsibility of

the establishment is inter-alia to set setting the water fees for potable, irrigation and industrial uses which are approved by MOEW, monitor the quality of the potable and irrigation water, and carry out studies, and the necessary exploitation, operation and maintenance of the potable water, wastewater and irrigation projects (except the except the irrigation water in the Southern Bekaa and the South which is the LRA responsibility). The BKWE is supposed to take over the management of irrigation, potable water and sewerage schemes, but due to the technical, administrative and financial constraints, it is currently not able to undertake these tasks bestowed upon them by the law. Although the BKWE is meant to be have legal autonomy to select the most appropriate level of service delivery, it cannot yet operate on a commercial basis.

Box 3.2: Water Allocation in the Litani System according to Decree 14522/1970

Article 1

The term "western foothills" in this decree means the Lebanese territories between Beirut River, the Mediterranean and the south borders at an altitude of 800 m above sea level.

The term "South Bekaa" refers to the area from the Bekaa plain from the Albert Naccache Dam in the south to the road of Beirut-Damascus in the north and the section in the north of this road between the course of the Litani River and the irrigation channel at an altitude of 900 m till Rayak.

Article 2

The total amount of water which can be used in an average water year in the regions covered in this decree is determined at 510 MCM. This amount can be distributed during the period as of mid-April until the end of October every year as shown in table 1 attached to this decree.

Article 3

This total volume of water of 520 MCM shall be allocated over the regions as follows: South Bekaa 140 MCM; Western Foothills 320 MCM; Potable water and water for industrial purposes 50 MCM.

The irrigation water currently used in these regions is included in this amount.

Article 4

Pending the construction of Khardale Dam, storing water therein, and using it for irrigation purposes, the above quantities shall be reduced to a total of 430 MCM allocated as follows: South Bekaa 120 MCM; Western Foothills 270 MCM; Potable water and water for industrial purposes 40 MCM.

Article 5

In case new water resources are available, the government of Lebanon will distribute them to the western foothills, taking into consideration technical rules and future water needs based on the distribution guidelines by virtue of this decree.

Article 6

Water quantities mentioned in article 2 of this decree shall not be deemed a vested right vis-à-vis the State. These quantities can be decreased in drought years depending on water availability. The State is also entitled to decrease the quantities allocated for irrigation as per figures stated in Article 4 by 25% and, if necessary, add this 25% to the 50 MCM allocated for potable water, household, and industrial purposes without any compensation to beneficiaries of irrigation water.

In view of the foregoing, the State is entitled to identify the areas that can be cultivated using permanent irrigation water, while the remaining areas shall be cultivated on a seasonal basis.

The State, temporarily, may distribute unneeded potable water and water allocated for household and industrial purposes to irrigation.

Shortage of water in drought years and due to meeting the needs for potable water and water for household and industrial purposes shall be distributed over all regions pro rata to allocated quantities.

Article 7

In line with water distribution scheme and new irrigation projects developed for different regions, priority shall be given to fertile soil most fit for irrigated agriculture.

Source: Official Gazette, May 1970.

At the Local Level[53]

50. **The Municipalities** which are under the tutelage of the Ministry of the Interior and Municipalities (MOIM), are responsible for preparing general plans for water, sanitation and solid waste projects, as well as operations and maintenance of municipal waste collection and for general matters concerning protection of the environment and pollution control. Some municipalities still assume processing (segregation, composting and recycling) disposal of waste and the management of WWTP although the former is meant to be assumed by the Central Government under the 2010 MOE/CDR strategy, and the latter is meant to be assumed by Water Establishments as pertained in Law No. 221.

51. **The Local Committees** were established by ministerial decree from the MOEW, under the tutelage of the Regional Water Establishments. Their responsibilities are the operation, maintenance, rehabilitation and renovation of the water and sewerage networks and equipment. In the Bekaa, they are 58 local committees, of which 14 are for potable water, 41 for irrigation, and 3 for irrigation and potable water.

3.6 General Conclusions

The above diagnosis and analysis of the Litani Basin showed the following four conclusions

a) Water pollution is the major issue in the Litani and is responsible for the degradation of natural resources and is affecting public health.

b) Several governmental, autonomous and semi-autonomous agencies are involved in the water sector. Their responsibilities overlap and it is difficult to distinguish a clear responsibility system liking the appropriate ministerial decrees to their corresponding agencies.

c) Institutions and agencies each works on programs and technical reports in the Litani Basin in well- defined areas; however, coordination and exchange of information and experience on the basin are low and horizontal reinforcement among these institutions should be considered. Moreover, there is an urgent need to address the missing link that exists between the excellent applied research that was done on the Litani Basin over the years and the mainstreaming and application of the results.

d) Qualitative and quantitative assessments of impacts on natural resources are generally understood from a technical point of view, however, the economic assessments of these

[53] World Bank. 2003. Lebanon Policy Note on Irrigation Sector Sustainability. Washington, D.C.

impacts are almost nonexistent. Moreover, despite the changes in land use patterns, demographic trends, economic drivers, environmental pressures and climate vulnerability that occurred since the LRA was set up, water is a vital natural resource that is not valued and costed according to well established general principles and therefore is not allocated efficiently (Section 5 and Figure 5.2).

52. In view of the lack of economic assessment of water degradation and water remediation that this present study has been developed. The economic assessment of water degradation will enable an approximate quantification in form of orders of magnitude of the economic costs associated with environmental degradation. This assessment will enable the decision makers the national and regional levels to develop sectoral priorities based in the cost and benefits of investments and the impact of the environmental externalities on these investments.

4. Taking Stock of Cost of Environmental Degradation in Lebanon

53. Many studies on CAWRD at the national, regional and sectoral levels or the benefits accruing thanks to pollution reduction were conducted in Lebanon over the past twelve years. Also, the Cost of Coastal Zone Environmental Degradation with a 2005 base year[54] and the Cost of Hostilities with a 2006 base year[55] were performed to get a better understanding on the degradation in the northern coastal zone and the cost associated with the 2006 War with Israel but are not reflected below. The results of the national, partial and sectoral valuations, which cover various base years, are shown in Figure 4.1.

54. METAP Project/World Bank, Economic Research Forum in Egypt, the European Commission and USAID estimated national, partial or sectoral cost assessment of environmental degradation, each using different methodologies. The results are as follows:

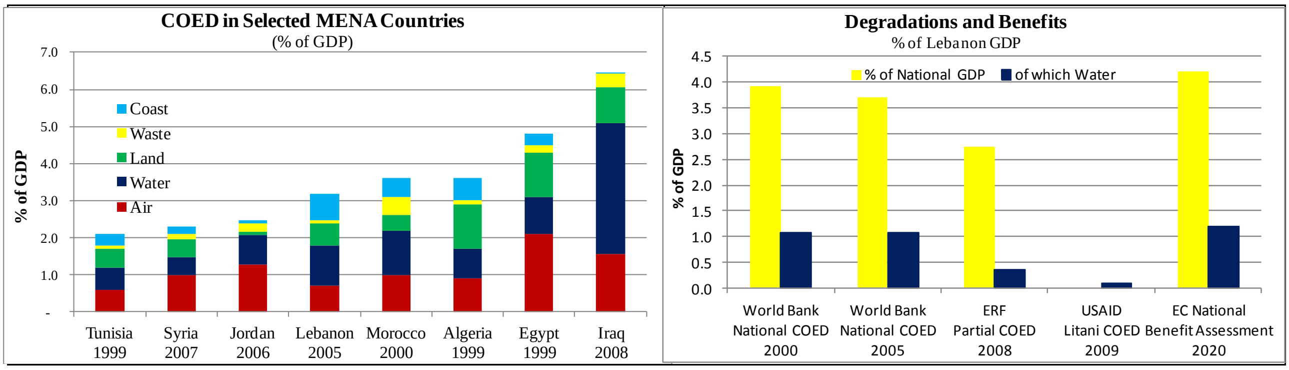
- In 2004, the **METAP/World Bank** calculated the national cost assessment of environmental degradation using data from 2000 covering six categories: air, water, waste, soil and biodiversity; coastal and cultural heritage, and global environment. These costs have been estimated US$ 655 million in 2000 per year, or 3.9% of GDP including global environment. The CAWRD due to water was estimated at 1.07% of GDP or US$ 175 million in 2000. In comparison with other countries in the region, these costs rank relatively high in terms of percentage of GDP among the seven countries of the Region Mashreq and Maghreb countries where the cost of the damage was assessed. However, these costs are significant and indicate that the greatest damage would be in two areas: (i) public health, especially in regard to water-borne diseases related to poor sanitation in the rural areas, respiratory diseases related to air pollution and the impact of the lack of disposal and treatment of waste and (ii) the productivity of natural resources, including the loss of agricultural productivity due to soil degradation, and impact on property values due to lack of disposal and treatment of waste.[56]
- In 2011, the **World Bank** produced a rapid update of the national cost of environmental degradation in the Country Environmental Analysis which almost resulted in the same damages: US$ 800 million in 2005 per year equivalent to 3.7% of GDP including global environment. The CAWRD due to water was estimated at US$ 233 million equivalent to 1.08% of GDP in 2005.[57]
- In 2011, the **Economic Research Forum** has re-estimated a partial cost of damage covering three categories: air, water (waterborne diseases) and agricultural land degradation. The costs were estimated at about US$ 801 million equivalent to 2.74% of total GDP in 2011, the impact on the water was around 0.37 % of GDP or US$ 108 million for waterborne diseases in 2008. Although this estimate was calculated 10 years after the World Bank, this assessment is not of

[54] Ministry of Environment website: <www.moe.gov.lb/getattachment/cc55ae33-fb34-4c08-a3c8-cc9202ce0dec/Integrated-Coastal-Zone-Management-in-Lebanon.aspx>.
[55] World Bank website: <www.worldbank.org>.
[56] Sarraf et al. 2004. Cost Assessment of Environmental Degradation, World Bank Environmental Economics Series. Paper number 97. Washington, D.C.
[57] World Bank CEA (2011). Op. cit.

the same order of magnitude as that estimated by the World Bank studies with a baseline of 2000 and 2005 respectively.[58]

- In 2011, the **European Commission** estimated the increased environmental benefits at the national level covering 5 categories: air, water, nature, waste, and global environment. The benefits were estimated at 4% of GDP including global environment of € 2 billion in 2020 in 2008 prices if pollution were to be reduced by ± 50% in 2020 compared to 2008. The proportion of water in these benefits has been estimated at 1.2% of GDP in 2020 equivalent to € 570 million including water resources degradation and water-related diseases. In other words, in the case where pollution could not be reduced by 50 % in 2020, the cost of degradation considered could reach at least the equivalent of 2.4% of GDP in 2020.[59]
- In 2012, **USAID** attempted to determine the total economic value (TEV) of the Litani River basin (Figure 5.2) and produced a rough estimate ranging between US$ 58 to more than 98 million (a surprising US$ 2.5 billion upper bound is also stated).[60] This assessment used substantial approximation based on the World Bank/METAP cost assessment of environmental degradation which estimated the burden of water pollution to be 1.1% of GDP for the year 2000. The study deduced that since the Litani River Basin covers about 20% of Lebanon's geographical area and includes 10% of its population, the cost assessment of water degradation was estimated in 2009 to be US$ 20-40 million per year or US$ 50-100 per capita per year. However, the study did not used the methodology developed by the World Bank to calculate the cost assessment of water degradation using water quality and quantity data as presented in this report but rather used the WHO method based on improved water supply and sanitation scenarios.

Figure 4.1: Costs of environmental degradation and environmental benefits in MENA and Lebanon



Note: Lebanon figures in the second quadrant include degradation associated with the global environment whereas they are not included in the first quadrant.

Source : World Bank (2004); World Bank (2011); ERF (2011); EC ENPI (2011); USAID (2012); and Authors.

55. The study of the CAWRD of water resources of the Litani Basin takes into account these preliminary estimates, but will focus effectively on the damage caused by water pollution and degradation of natural resources.

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[58] ERF (2011).
[59] Doumani and Mucharrafiyeh. 2011. EU Benefit Assessment, Lebanon Report. Brussels. <www.environment-benefits.eu>.
[60] USAID/IRG. 2012. LRBMSP: An Economic Assessment of Water Use and Water Pollution in the Litani River Basin. Beirut.

5. Methodology, Calibration and Limitations of the Valuation, and Categories Considered in the Analysis

56. The CAWRD were valued by using available data source that cannot be entirely reliable. In addition, gaps in the data required to make several assumptions. Nevertheless, the CAWRD is meant to help policymakers make informed and efficient choices to maintain the integrity of the environment and promote conservation based on a common denominator: monetizing the environmental damage and remedial interventions. These results, which should be considered as preliminary order of magnitudes, could nevertheless help highlight the trade-offs between economic development and growth, well being, and the preservation of the commons. Moreover, these results, which should guide further analyses, provide policymakers with a preliminary tool for integrating environment into economic development decisions and comparing damage costs as a percentage of GDP within categories and across countries.

57. Moreover, it is difficult to accurately define the environmental degradation that is strictly natural and the one that is strictly anthropogenic. In some cases, there is overlap between the two causes of degradation that could lead to mutual reinforcement such as natural soil salinity and water that is exacerbated by human practices by adding fertilizers.

5.1 Methodology

58. The economic valuation of environmental projects are proven methods that are summarized in the Handbook of the World Bank on the Cost Assessment of Environmental Degradation,[61] the European Commission's Manual on the Benefit Assessment[62] and other reference sources such as The Economics of Ecosystems and Biodiversity (TEEB), also funded by the European Commission in cooperation with the German Government.[63]

59. The main methods for estimating impacts are grouped around three pillars with specific techniques under each pillar (Figure 5.1):

- Change in production.
    - Value of changes in productivity such as reduced agricultural productivity due to salinity and / or loss of nutrients in the soil;
    - Approach the opportunity cost of such shortfall of not re-selling the recycled waste;
    - Approach replacement cost when for example the cost of construction of a dam to be replaced by a dam that was silted.
- Change in condition with the dose-response function to establish between pollutant (inhalation, ingestion, absorption or exposure) and disease.

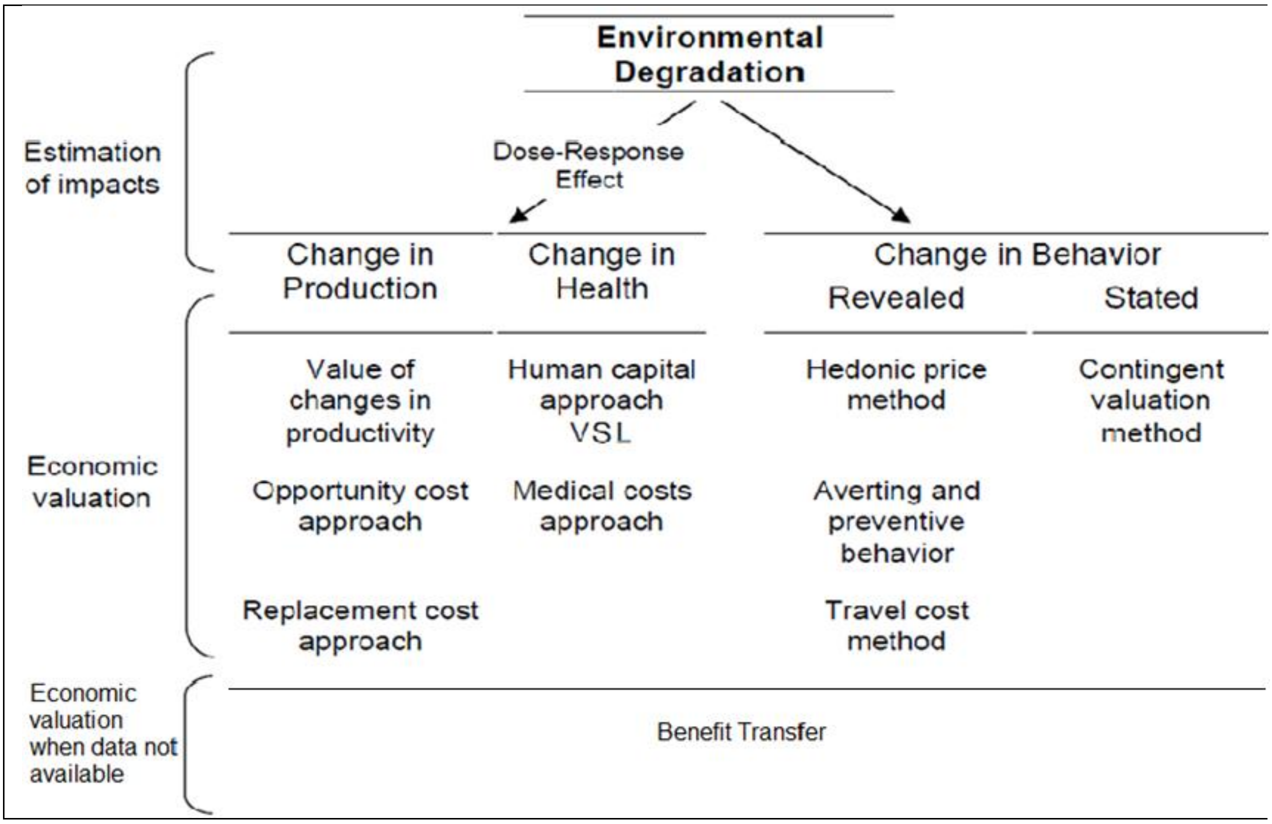
[61] Website of the World Bank : <www.worlddbank.org>.
[62] Website of the EU ENPI BA : <www.environment-benefits.eu>.
[63] Website of TEEB: <www.teebtest.org>.

- The value associated with mortality through two methods: the future shortfall due to premature death, and the willingness to pay to reduce the risk of premature death. Only the latter method is used in this study.
- The approach to medical costs such as the costs when a child under 5 years is taken to the hospital to be cured of diarrhea.

- Changing behavior with two sub-techniques: revealed preferences, and stated preferences.
  - Revealed preferences by deriving the costs associated with behavior: e.g., hedonic method where for instance the lower value of land around a landfill is derived; trying to derive travel costs to visit a specific place like Lake Titicaca; and preventive behavior as when a household buys a filter for drinking water.
  - Stated preference where a contingent valuation is used to derive willingness to pay through a survey for example, improve the quality of water resources.

60. In cases where data are not available, a benefit transfer can be based on studies made in other countries by adjusting the results for the differential income, education, preferably, etc. The original results that are used for the benefit transfer are based on one of the economic valuation methods under the three pillars as illustrated in Figure 5.1.

Figure 5.1 : Estimation of Impacts and Associated Economic Valuation Techniques

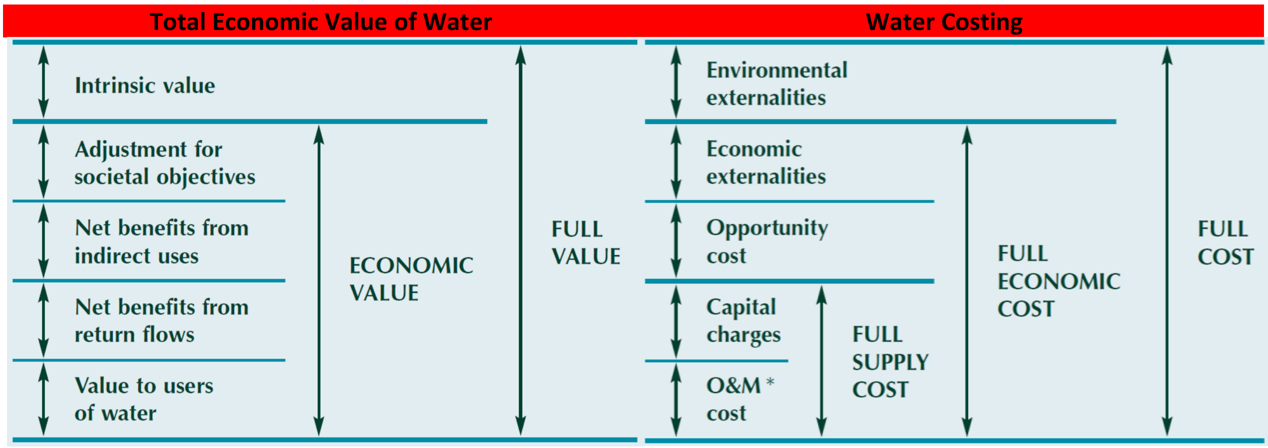


Source : Adapted from Bolt et al. (2005).

61. Usually, valuing and costing water are not performed according to well established general principals and these principles are a bit more elaborated than the economic valuation techniques illustrated in Figure 5.1 and will sometimes be used in the analysis. The full value of water consists of its use value – or economic value – and the intrinsic value. The economic value which depends on the user

and the way it is used, include: value to (direct) users of water, net benefits from water that is lost through evapotranspiration, which is not taken into consideration in the CAWRD or other sinks (e.g., return flows), and the contribution of water towards the attainment of social objectives. The full cost of providing water includes the full economic cost and the environmental externalities associated with public health and ecosystem maintenance. The full economic cost consists of: the full supply cost due to resource management, operating and maintenance expenditures and capital charges, the opportunity costs from alternative water uses, and the economic externalities arising from changes in economic activities of indirectly affected sectors.[64]

Figure 5.2: Water Valuing and Costing Guiding Principles



*Note: * O&M stands for operations and maintenance.*

Source: Integrated Water Resources Management 2000. Global Water Partnership. Technical Advisory Committee Background Paper number 4.

62. The base year 2012 was chosen to estimate the CAWRD. The valuation of benefits (reduced CAWRD over a year) was used to derive the cost of remediation that are calculated for selected priority sub-categories. After determining the alternative remediation cost, the most suitable cost is selected and used in a cost/benefit analysis (CBA) to determine the profitability of the project. The cost/benefit analysis allows to present the decision-maker/investor with the most efficient choice. Three indicators are taken into account in analyzing the CBA to determine the profitability of the project:

- The net present value (NPV) is the difference between benefits and total discounted costs;
- The internal rate of return (IRR) is the discount rate that resets the NPV or the interest rate that makes the NPV of all cash flows equal to zero, and
- The present value B/C ratio, which is the ratio of the present value of benefits over the present value of costs over the life of the project must be equal or greater than 1.

5.2 Calibration and Limitations of the Valuation

63. In addition to resource constraints and binding time, the techniques used have their own methodological limitations. In the process of fact finding it became clear that availability, accessibility

[64] Integrated Water Resources Management 2000. Global Water Partnership. Technical Advisory Committee Background Paper number 4.

and topicality of information relevant for the assignment posed problems. Information has been very scattered, not up-to-date and sometimes inconsistent. Inconsistencies have been experienced with similar types of information from different sources. Approaching local authorities helped generate response, feedback and clarifications in terms of facts and figures.

64. The results allow for a margin of error through sensitivity ranges (lower bound, upper bound) that were taken into account. In addition, marginal analysis has been attempted in some cases to assess the benefits (reducing the CAWRD) and investment costs.

65. Most valuation techniques used have inherent limitations in terms of bias, hypothetical premise, uncertainty especially when it comes to non-tradable goods. Moreover, the results are of course sensitive to the context. The use of benefits transfer could therefore exacerbate the results and uncertainties. Therefore, some results are described in the text and should be subject to further analysis when investments will be considered.

5.3 Categories Considered in the Analysis

66. Five main categories were selected for the watershed assessment: air (Baalbeck and Zahleh), water, waste, biodiversity, and the continuum natural disasters and climate change. Sub-categories were also retained to meet the diverse impacts affecting the watershed and are shown in Table 5.1. Thus, air pollution has been selected for Baalbeck and Zahleh, and when there are issues of greenhouse gas (GHG) emissions including methane emissions from landfills. Effects on coastal areas have been covered to the extent of pollution of the marine environment (preference on improving the quality of water resources) in this study. In addition, certain investments considered for a sub-category might as well have a positive impact on other categories, for example, better landfill management (urban and rural waste) could have a positive impact on sub-category such as the quality water resources and/or biodiversity.

67. Thus, the CAWRD covers all sub-categories while the cost of remediation only covers four sub-categories. The selection criteria for calculating the cost of the remediation was based on sub-categories experiencing degradation.

68. Categories, sub-categories, impacts and methods to assess the CAWRD and remediation are developed in Table 5.1. The general description of the methods and specific sub-categories can be found in Annexes II to IV.

Table 5.1: Categories, sub-categories, impacts and methods used for the valuation of degradation and remediation of the Litani Basin

Category	Sub-category	Impact	CAWRD: Method used	Cost of Remediation: Possible intervention
Water	**Water-borne diseases:** improved drinking water supply and sanitation and change in behavior with regards to hygiene	Illness associated with drinking water supply quality and quantity as well as sanitation and poor hygiene (see Annex II for water-borne disease)	HCA/VSL and COI	Coverage rate of improved drinking water supply and sanitation, and hygiene awareness campaign
	Quality and treatment: drinking water in urban and rural areas	Consumer preference (tap water vs. bottled water); filter use or chlorine addition; boiling water; etc.	CR and CB (additional cost of treatment)	Desalination for dilution with potable water and upstream investments ; water treatment improvement and improvement of potable water and tariff/charge adjustments
	Quality of services: drinking water in urban and rural areas, and irrigation	Costs of alternative sources of water (bottle, tank, wells, etc.); technical losses (financial losses are not considered as services are provided but tariff/charges are not collected) while considering the opportunity cost and economic externalities (subsidies) ; lost time hauling water	CR and CO	Improved delivery, service effectiveness; and tariff/charge adjustments
	Quality of the resource (anthropogenic): effluents and seepage (see Solid waste)	Surface water quality affecting : water use (domestic, agricultural, fisheries, industrial et mining) ; basin ecosystem and (eutrophication, etc.) coastal zones; territories ; and eco-tourism	CV (restoration of water quality)	Wastewater investments, reduction of industrial effluents) and reduction of pesticide and nitrate use (See Solid waste); and tariff/charge adjustments
		Underground water quality affecting : water use (domestic, agricultural and industrial); basin ecosystem and coastal zones; territories ; and eco-tourism	CV and RC (restoration of water quality)	Artificial recharge for dilution ; substitution wells or water desalination/transport
	Salinity (anthropogenic and natural): surface and underground water, marine environment and soil	Salinity of soils, effects on health **(see Quality and treatment)**, reduction of agricultural and fishery productivity and effects on ecosystems	CP (agricultural productivity)	Fertilizer increase (short term measures) and land use planning (long term measures to reduce salinity)
	Quantity (anthropogenic and natural):surface water flow reduction and underground water drawdown	Surface : treated and untreated water use that could cause contamination of the food chain; and in extreme cases, substitution effects through desalination	CP (agricultural productivity and additional cost of pumping/substitution)	Opportunity cost of treated and reused water; and of desalination and water transportation; and tariff/charge adjustments
		Underground : deeper pumping, substitution wells or desalination (rapid drawdown or fossil water) to overcome domestic needs and/or agricultural productivity	CP (agricultural productivity and additional cost of pumping/substitution)	Opportunity cost of pumped/substitution water; and tariff/charge adjustments
	Erosion and Storage: soil	Soil nutritional losses and sedimentation of dams, hill lakes, river	CP et RC (dredging;	Costs : Land use planning to prevent and reduce

Category	Sub-category	Impact	CAWRD: Method used	Cost of Remediation: Possible intervention
	management is affected by erosion and exacerbated by climate change	beds and coastal zones exacerbated upstream by poor land use management due notably to deforestation, wind and water erosion, etc.	increase the dam height; or construction of new dams/hill lakes)	erosion
	Hydropower: affected by a longer drought cycle or lack of optimization of storage capacity	Reduction of production due to droughts or lack of storage capacity and substitution with fossil fueled plants (GHG emissions)	RC, CC (substitution by fossil-fuel powered plants)	Costs : increase water storage and/or substitution by renewable energy powered plants
Solid Waste	**Solid waste chain including sludge:** urban, rural, agro-industrial and agricultural	Ill wellness; health; sight, odor, noise, air, soil and water resource (leachate) pollution; and impact on land/house/apartment costs	CP, CR, RC, HA and CB	Costs : from collection, transfer stations, segregation, composting and recycling; sanitary landfill; and tariff/charge adjustments
	Medical and hazardous waste chain	Ill wellness; health; sight, odor, noise, air, soil and water resource (toxic leachate and radioactive contamination) pollution; and impact on land/house/apartment costs	Not covered	Not covered
Air	**Ambient air pollution** (anthropogenic): transfers and dilution of pollutants in soils and water bodies include the marine environment	Dose-response function of annual concentrations of pollutants to derive cardio-pulmonary disease; particulates washed off into water bodies; agricultural productivity reduction and infrastructure and building decaying, etc.	HCA/VSL and COI	Reduction/elimination fuel subsidies; Reduction of emission from fixed sources (industries, energy, construction, landfill, quarries, etc.) and non-fixed (traffic management, scraping old vehicles, substitution effect thanks to public transportations, etc.)
Biodiversity	**Various encroachments**	Loss of ecosystem and medicinal plants	CV meta-analysis; CR	Upstream investments (see above)
Natural Disaster and Global Environment	**Floods, droughts, forest fires, extreme events, etc.**	Exacerbation of the intensity and frequency with an impact on: health (mortality, injuries, drowning, communicable diseases); goods; services ; infrastructures; productivity; resources (water release with reduction of stored resources and impact on the ecosystem); etc.	HCA/VSL and COI RA, CP, CR and RC	Preparedness State and effectiveness of response
	GHG Emissions	5 variables for climate change and effects on the use of soils, water, evapotranspiration, agriculture, migration, sea level rise, etc. In this particular case, only carbon sequestration (forest fire) and avoided GHG emissions (dump) are considered while that attributable to the use of fertilizer is not.	CP, CR, RC and CB	Modular adaptation, mitigation and resilient ongoing or planned investments

Note: CB: change in behavior; COI: cost of illness; CO : Opportunity cost ; CP: change in production; CR: cost of remediation; DR : dose-response ; HA: hedonic approach; CV: Contingent valuation; HCA: human capital approach; RA: risk analysis; RC: replacement cost; VSL: Value of Statistical Life ; and CC : Carbon credits. Source: Authors.

6. Cost Assessment of Water Resources Degradation of the Upper Litani Basin

6.1 Cost Assessment of Aggregate Results

69. The ULB socioeconomic dataset used in the analysis is derived from the 2011 MOE/UNDP/ElArd 7 zone study where the 2010 population was adjusted to 2012 by using the 2 year population growth of 1.91%.[65] The ULB 4 Casa areas and 7 zones are illustrated in Table 6.1 and Figure 6.1.

Table 6.1 : Socioeconomic Dataset for the Upper Litani Basin 7 Zones, 2012

Input	Unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Total
Land area	km^2	286	406	117	132	149	231	248	1,571
Agricultural Land	km^2	166	243	48	62	92	143	121	876
Water body	%/area	0.0%	0.0%	0.1%	0.0%	11.2%	0.2%	3.1%	14.5%
Total Population	#	131,415	210,346	307,346	106,294	83,568	109,555	110,218	1,058,742
Urban Population	#	0	133,000	102,449	0	0	0	0	235,449
Rural Population	#	131,415	77,346	204,897	106,294	83,568	109,555	110,218	823,294
Resident Pop.	#	81,280	137,461	253,253	81,581	59,517	98,753	59,418	771,264
Avg. HH size	#	4.53	5.0	4.71	5.12	4.35	5.21	4.4	4.76
Improved Water	% pop	81%	63%	55%	100%	78%	100%	89%	74%
Bottled Water	% pop	30%	33%	58%	61%	NA	18%	NA	35%
WW Improved	% pop	31%	21%	44%	39%	33%	52%	19%	35%
Waste	t/day	59.1	138.4	208.2	70.7	49.5	81.5	70.2	677.6
Landfill active	#	0	0	1	0	0	0	0	1
Dumpsite active	#	8	9	1	7	2	9	16	52
Dumpsite total	#	11	11	4	11	6	11	17	71
Quarries	#	12	16	19	31	7	7	11	103

Source : Adapted from MOE/UNDP/ElArd (2011).

70. The total population exceeds one million or about 1/4 of the Lebanese population while only 23% is urban (Baalbeck and Zahleh) and where the resident population represents 73% of the total population, which suggests that 27% of the population comes during summertime and holidays. Improved water and sanitation are 74% and 35% respectively. One sanitary landfill and 52 dumpsites are active and 19 dumpsites are not. Moreover, the ULB is home to 103 quarry sites.

71. The results of the CAWRD of the ULB are shown in Table 6.2 and Figure 6.1. It should be noted that the total cost are compared both to national GDP (LP 64,740 billion in 2012)

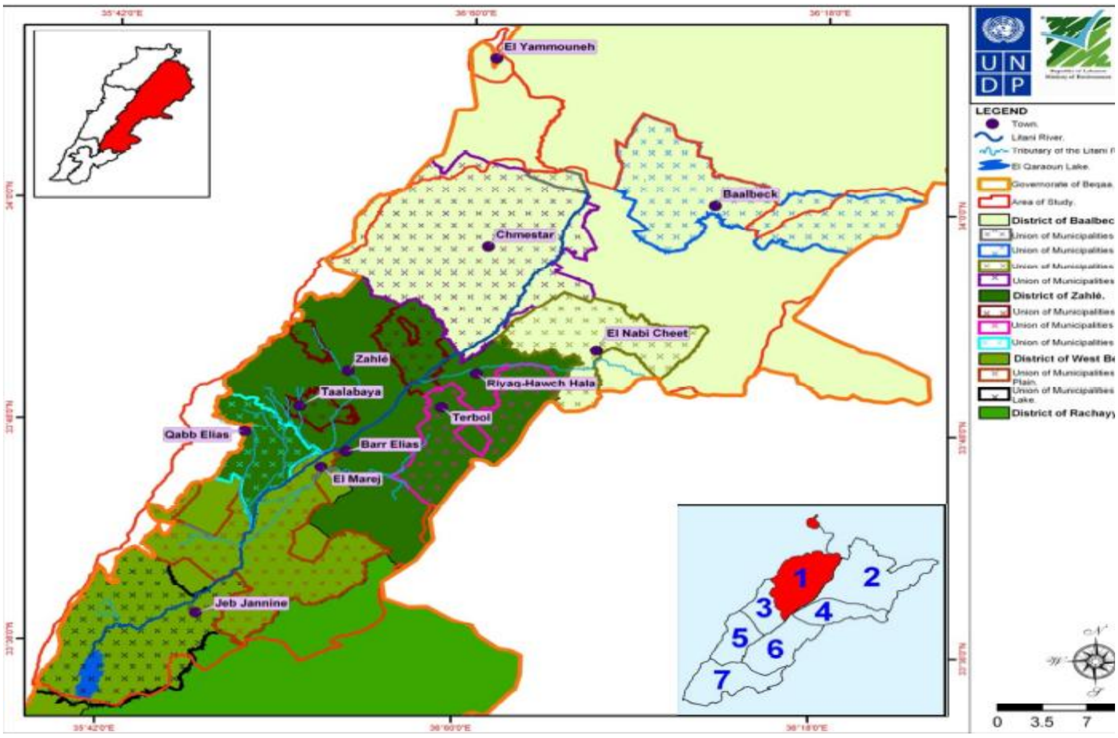
[65] WDI (2013); and CAS website: <www.cas.gov.lb>.

and the ULB GDP (LP 15,549 billion in 2012), which was extrapolated by using the GDP per capita for the ULB (LP 14,630,879 per capita in 2012) and multiplying by the number of inhabitants: 1.06 million. The disaggregated results are available in Annex VI.

72. The CAWRD of the ULB reaches LP 339 billion (US$ 225 million) in 2012 with a variation between LP 280 and 401 billion equivalent on average to 2.2% of GDP in the ULB and 0.6% of GDP current national of Lebanon in 2012. Degradation cost associated to human health reached LP 102 billion in 2012 or 30% of the CAWRD of the ULB with LP 74 billion for waterborne diseases and LP 28 billion for respiratory diseases in the region of Zahleh and Baalbeck (Table 6.2 and Figure 6.2). Air pollution was covered as it affects water resources in terms of reducing agricultural productivity and particulate wash off into water resources during the rainy season.

73. Broken down by category, the water degradation is the most significant in the ULB with a relative value with 77% of the total in 2012. Waste ranks second with 11% followed by air pollution with 9%, then by natural disasters and the global environment including flood disruption and forest loss that occurred in the region of the basin in 2012 with 3% and finally biodiversity coming last with 0.1%.

Figure 6.1: The 4 Casa (Districts) and 7 Zones of the Upper Litani Basin



Source: MOE/UNDP/ElArd (2011).

74. The CAWRD of the ULB reaches LP 342 billion (US$ 227 million) in 2012 with a variation between LP 283 and 404 billion equivalent on average to 2.2% of GDP in the ULB and 0.5% of GDP current national of Lebanon in 2012. Degradation cost associated to human health reached LP 102 billion in 2012 or 30.6% of the CAWRD of the ULB with LP 74 billion for waterborne diseases and LP 28 billion for respiratory diseases in the region of Zahleh and Baalbeck (Table 6.2 and Figure 6.2). Air pollution was covered as it affects water resources in terms of reducing agricultural productivity (smog requiring additional fertilizers that could

indirectly increase run-off) and particulate wash off into water resources during the rainy season.

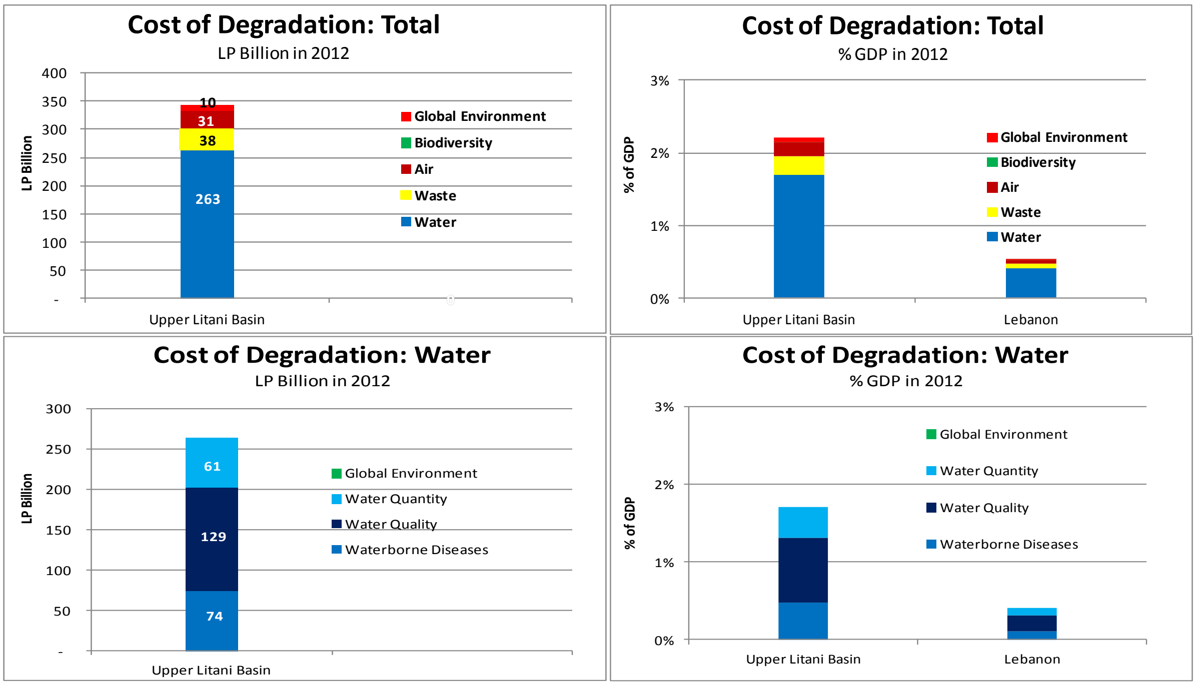
Table 6.2 : CAWRD of the Upper Litani Basin, 2012, in LP billion

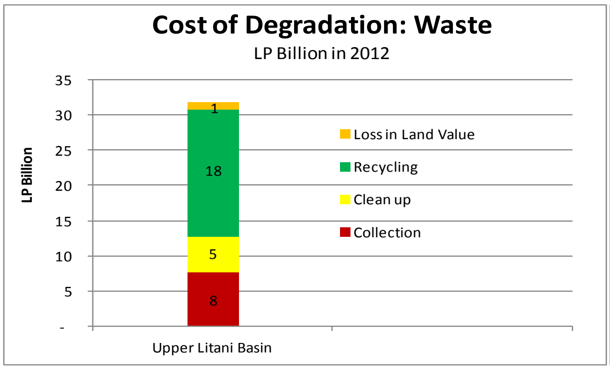
Category	Upper Litani Basin	%	Lower bound	Upper bound
Water	263.5	77%	218.8	312.2
Solid Waste	37.8	11%	29.5	44.3
Air (Baalbeck and Zahleh)	31.3	9%	26.6	36.0
Biodiversity	0.3	0%	0.2	0.3
Natural Disaster and Global Environment	9.8	3%	8.0	11.6
Total	342.6	100%	283.0	404.3
% GDP Upper Litani Basin	**2.2%**			
% GDP Lebanon	**0.5%**			

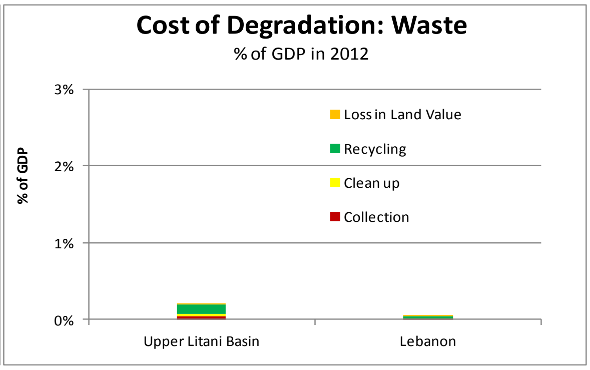
Source : Authors.

75. Broken down by the water subcategory (LP 264 billion in 2012), water quality represents almost half the degradation costs of the ULB (LP 129 billion and 49%), followed by water-borne diseases (LP 74 billion and 28%) and finally water quantity (LP 61 billion and 23%). This category has a small impact on the global environment but costs were not calculated.

Figure 6.2: CAWRD of the Upper Litani Basin, 2012 and in LP billion







Source : Authors.

6.2 Water Category and Sub-categories

76. The Water subcategories are ranked by the importance of the degradation:

a. Water Quality which includes:

- Water quality (also includes quantity to secure domestic needs) of potable water
- Water quality of water resources
- Water quality due to salinity

b. Water Borne Diseases

c. Water Quantity which includes:

- Water supply network and irrigation efficiency losses
- Drawdown of the Water Table
- Water Storage

d. Erosion

6.2.1 Quality: Potable Water Treatment

77. The water and sanitation sector provides poor services to both dwellers and the business community, and is increasing the distortionary effects that translate into competitiveness losses and dweller additional time and expenses. Moreover, water supply is inadequate in terms of both quantity and quality and the prevalence of connected households that tend to purchase water from alternate sources reached 77% with the average weighted household expenditures on the combined water sources reaching LP 904,800 per year according to a survey commissioned by the MOEW in 2004.[66] Lebanon average yearly water tariff for 1 m^3/day per household was by then LP 201,250 net of VAT, which is more than 4 times less what each connected household was incurring on water

[66] Ministère de l'Energie et de l'Eau. 2004. *Les Libanais et l'Eau Potable*. En collaboration avec le financement du Service de Coopération et d'Action Culturelle de l'Ambassade de France au Liban. ICEA, Corail Association et IPSOS. Beyrouth.

tariff. This ratio was only 3 nationally according to a similar survey conducted by the World Bank in 2008.[67]

78. Hence, irrespective whether households have access to the network or not, they have to supplement it with other sources such as bottled/containers, wells, trucks, springs, etc. So most households supplement their initial source of water with 2 to 4 water supply sources.[68] According to the 2011 MOE/UNDP/ElArd social statistics, only 35% of the population used bottled water although 2 of the 7 ULB zones studies did not have information on the prevalence of bottled water but most household zones relied on private wells (Table 6.1).

Table 6.3: Poor Potable Water Quality and Insufficient Water Quantity in the ULB, 2012, in LP billion

Area	Population	Number of Households	Yearly Tariff per household for supplying 1 m^3/day	Incremental Household Expenditures Incurred to securing water quality and quantity	Total
	#	#	LP/Household/year	LP/Household/year	LP billion
Rural	823,294	172,961	188,000	383,471	66.3
Urban	235,449	49,464	188,000	383,471	19.0
Total	**1,058,742**	**222,425**	**188,000**	**383,471**	**85.3**
Lower bound					*72.5*
Upper bound					*98.1*

Source: Word Bank SIA (2010) ; and MOE/UNDP/ElArd (2011).

79. The cost of damage was derived from the incremental use of alternative sources to complement or substitute (when water quality is perceived to be below standards) the initial water sources. Based on the 2009 World Bank survey, each household is paying on average, being connected or not to the network, triple the current tariff on average. This incremental figure is nevertheless only twice the Bekaa WE current tariff (LP 188,000 including a gauging fee, the VAT and a LP 1,000 stamp charged within the geographical coverage of the Bekaa WE) in ULB according to the 2009 World Bank survey to supply the needed quantity for domestic use and the adequate quality for drinking water: LP 383,471 in 2012 prices. Moreover, it is important to note that people and namely the poor without network coverage tend to spend a higher share of their disposable income (in cash or kind in terms of time and effort fetching water) to secure their household water needs: 3.7% (bottom quintile) to 2.8% (top quintile).[69] Hence, the doubling of the tariff is used as incremental expenditures across the board. The cost of the damage amounts to LP 85 billion in 2012 with a bracket ranging between LP 73 and 98 billion (Table 6.3).

[67] World Bank. 2009. Lebanon Social Impact Assessment for the Water and Electricity Sectors. Washington, D.C.
[68] Ministère de l'Energie et de l'Eau. 2004. Op. cit.
[69] World Bank. 2009. Lebanon Social Impact Assessment for the Water and Electricity Sectors. Washington, D.C.

6.2.2 Quality: Water Resources

80. Given the multiplicity of sources of pollution and the number of pollutants along the ULB, a method based on the stated preferences was selected for the valuation. In addition, certain investments to reduce pollution are underway (see section 3) but the estimation of all investments to reduce pollution as defensive spending for the restoration and maintenance functions of ecosystem services are far beyond the scope of this study. Baker et al. (2007) recently conducted a survey to estimate the economic value given by the English and Welsh households to improve the water quality both in terms of watersheds and coastal areas in the context of the implementation of the EC water Directive (see Annex II). A benefit transfer is thus considered to derive the CAWRD of the ULB. After the benefit transfer, the willingness to pay amounts to LP 186,992 per capita per year for a 100% improvement after 9 years. Hence, the cost of the damage amounts to LP 43.3 billion in 2012 in the ULB with a bracket ranging between LP 39 and 48 billion (Table 6.4).

Table 6.4: Water Resource Quality in the ULB, 2012, in LP Billion

Area	Population	Household	Willingness to Pay LP/Household/Year			WTP to Improve Water Resources LP Billion		
	#	#	*Lower Bound*	*Middle Bound*	*Upper Bound*	Total	*Lower Bound*	*Upper Bound*
Rural	823,294	172,961	173,420	186,992	215,644	**32.3**	*30.0*	*37.3*
Urban	235,449	49,464	173,420	194,532	215,644	**9.6**	*8.6*	*10.7*
Total	1,058,742	222,425	173,420	194,532	215,644	**43.3**	*38.6*	*48.0*

Source: Baker et al. (2007); Annexes II and III; and Authors.

6.2.3 Quality: Salinity

81. The main crops of the central Bekaa valley, which covers an area of 57,000 ha, are potatoes, vegetables, grapevine, olives, stone fruits and grains. Wheat and some legumes are cultivated in winter and are rainfed. However, potato, which is a staple and a cash crop, is a crop cultivated twice in winter and summer that is planted on about 2,000 ha in the ULB.

82. Various studies showed that salinization of soils is anthropogenic in the ULB but is more acute in water-stressed Hermel north of UBL. Hence, the mismanagement of fertilizer and water application results in salt build up in the soil and groundwater systems. For instance, potatoes could use less water and less fertilizers should modern cropping techniques are used.[70] The average salinity of 2.5 deciSiemens per meter (dS/m) is commonly used in the region of the Bekaa but overall soil salinity is usually positively correlated with that of the irrigation water can therefore produce lower or higher average in parts of the ULB. Salinity levels and reductions in productivity were developed by Kotuby-Amacher et al. (2003) and Evans (2006) for potato crops and are based on the electrical conductivity of saturated soil (ECs) expressed in dS/m. However, other factors could affect

[70] Darwish, T., T. Atallah, S. Hajhasan, and A. Chranek. 2003 Lebanon: Management of nitrogen by fertigation of potato. Nutrient Cycling in Agroecosystems, 67: 1-11, 2003.

the tolerance of crops (variety, climate, level of precipitation, etc.), and therefore the thresholds are merely suggestive. The reduced productivity due to salinity affecting agricultural production affects a number of crops but only potatoes will be considered as it is one of the major crops affected by salinity unlike wheat that is more tolerant to saline soil and water (Table 6.5). However, the additional use of fertilizer should offset the loss of productivity while creating a vicious cycle (see above), but it is not possible to determine the cost of preventive behavior in this particular case. Therefore, despite the use of fertilizer, a third of productivity loss is assumed to be lost due to the degradation associated with soil salinity and the 2/3 of losses are recouped with the use of fertilizers. Hence, the cost of the damage amounts to LP 0.012 billion with a bracket ranging between LP 0.010 and 0.014 billion (Table 6.5).

Table 6.5: Agricultural Productivity Losses due to Salinity in the ULB, 2012, in LP Billion

Potato: 2 Crop per season	ULB Area planted	ULB Production	Salinity Threshold CEs	Yield reduction CEs		Wholesale Price	Productivity losses at -10%			
							Total	1/3 Losses not compensated with Fertilizers	Lower Bound	Upper Bound
	Ha	Ton	dS/m	-10% with dS/m at :	Ton	LP/ton	LP Billion			
Total	**2,000**	**800**	1.7	2.5	80	450,000	0.04	**0.012**	*0.010*	*0.014*

Source: Kotuby-Amacher et al. (2003) ; and Evans (2006); Recensement Agricole, MOA (2010); and USAID LRBMS (2010).

6.2.4 Waterborne Diseases Associated to Water and Sanitation Services

83. Lebanon's 2012 National Water Sector Strategy reports a potable network coverage of 74% (62% for the Bekaa) and wastewater network coverage of 60% for Lebanon in 2010. By contrast, Lebanon connection rates for water are 80% based on a survey conducted by the World Bank[71] which are almost similar to the data gathered by MOE/UNDP/ElArd (2011) study for the ULB with 74% access to improved drinking water. Moreover, urban areas has a 100% improved water access (although some private wells are included in this figure) but only 76% of improved sanitation. In rural areas, the results are well below the national average with only 52% of the population that has access to improved water and 27% of the population that has access to improved sanitation (Table 6.6).

[71] World Bank. 2009. Social Impact Assessment for the Water and Electricity Sectors, Lebanon. Washington, D.C.

Table 6.6: Water Access and Sanitation Typology, % of considered population, 2012

Access Typology	Year	Access rate		
		Urban	Rural	Total
National Statistics				
Improved Water Sources	**2011**	**100%**	**100%**	**100%**
Unimproved Water Sources	**2011**	**0%**	**0%**	**0%**
Improved Sanitation	**2005**	**100%**	**87%**	**98%**
Unimproved Sanitation	**2005**	**0%**	**13%**	**2%**
Upper Litani Basin Considered				
Improved Water Sources	**2010**	**100%**	**67%**	**74%**
Unimproved Water Sources	**2010**	**0%**	**33%**	**26%**
Improved Sanitation	**2010**	**76%**	**27%**	**35%**
Unimproved Sanitation	**2010**	**24%**	**73%**	**65%**

Source : adapted from MOE/UNDP/ElArd (2011); and World Development Indicators (2013).

84. The septic tanks were considered as unimproved in this particular case (50% connected to the network, 42% using septic tanks and 8% relying on primitive means to dispose sewage on average in the Bekaa). As there is no service to remove the sludge (although it is the responsibility of the Municipality which collects an unrealistically low *Arsifa wa Majarir* fee, which is a percentage of the already deflated appraised value of properties, to collect the waste and remove the sludge from septic tanks), these are subject to overflow and pollute the soil and water resources. Hence, the improved and unimproved water and sanitation access figures in Table 6.6 were used in the analysis (Box 6.1).

Box 6.1: UNICEF Definition of Improved Water Supply and Sanitation

UNICEF defines Improved Water Supply and Sanitation as follows: improved drinking water sources include water points, by construction or active intervention, are protected against outside contamination, particularly faeces, i.e., running water at home (household connection to a network, supply of water in the house of the household, or on his plot in his yard) and public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs and rainwater; and improved sanitation facilities are sanitary facilities that can prevent the user and their immediate surroundings to come into contact with excreta (flush to a piped sewer system/septic tank/pit latrine, ventilated improved pit latrine, toilet with lid, composting toilet).

Source: UNICEF website: <www.unicef.org>.

85. The prevalence of diarrhea and mortality due to diarrhea in the Litani Basin in urban and rural areas due to poor water quality, water quantity and hygiene were derived from national statistics with 0.3 cases of deaths on 13 newborns per 1,000 inhabitants in 2012. The prevalence of diarrhea was 2.3 cases per child under 5 years and 0.45 cases per population equal to or more than 5 years. The CAWRD amounts to LP 74 billion in 2012 with a bracket ranging between LP 60 and 92 billion (Table 6.7 and Annex III).

Table 6.7: Access to Unimproved Water and Sanitation in the ULB, 2012, in LB billion

Population rural	2012	Coefficient for diarrhea	Mortality due to diarrhea	Cases of diarrhea	Value per case VSL	Cost of Ill health
		#	#	Million	LP	LP Billion
Total population (million)	1.1					
Crude birth rate (Number of newborn per 1,000 inhabitants)	13.0	0.30	24		1,798,740,834	44.0
Population < 5 years (million)	0.06	2.30		0.1	88,923	12.0
Population ≥ 5 years (million)	1.0	0.45		0.5	40,419	18.2
Total						**73.8**
Lower bound						*59.7*
Upper bound						*92.0*

Source: adapted from Bassi et al. (2011); World Development Indicators (2013); WHO Burden of Disease for High Middle Income Countries (2013); Annex II; and Authors.

6.2.5 Quantity: the Water Supply Network and Irrigation Efficiency Losses

86. For water supplies: The *American Water Works Association*[72] suggests a benchmark of 10% for acceptable water service providers losses. A range of more than 10% to 25% is considered intermediate, and should be given special attention to reduce the losses to less than 10%. Water losses above 25% are considered chronic and require immediate attention. Lebanon average municipal water losses is estimated at 40%[73] as no reliable water losses estimates are currently available for the individual regional Water Establishments (WE). Yet, the 2012 National Water Sector Strategy reports a non-revenue water of 50% for the Bekaa WE. Thus, these losses could be seen as a cost borne by taxpayers with no return on investment while, from an environmental point of view, these losses are usually recharging the aquifers. However, these positive externalities are not taken into account in the analysis.

87. The Bekaa WE provided municipal water to 75,000 customers in 2008.[74] According to 2011 MOE/UNDP/ElArd study, about 165,000 household have access to improved water but it seems that more than half are not supplied by the Bekaa WE and are supplied by private wells. Hence, using a very conservative stance, only 60,000 customers are assumed to be covered by the Bekaa WE in the ULB region. Should the technical losses were to be reduced by 30%, efficiency losses in terms of residual production and financial losses would amount to 20%. The bulk water produced and consumed is available in the 2010 World Bank Public Expenditures of Water and are illustrated in Table 6.8. The tariff and incremental household expenditures are used (see above) but the latter is used as the opportunity cost of water where municipal water is subsidized in Lebanon as operations and maintenance costs are barely covered by tariffs in the Bekaa.

[72] Website of AWWA: <www.awwa.org>.
[73] World Bank. 2010. Lebanon PER of the Water Sector. Washington, D.C.
[74] Ibid.

Table 6.8: Water Distribution Technical Losses in the ULB, 2012, in LP Billion

WE Services		Water Production	Water Distribution	Losses brought from 50% to 20%	Cost based on Tariff	Cost based on Incremental Household expenditures	Total	Lower Bound	Upper Bound
		MCM/year	MCM/year	MCM/year	LP/m^3	LP/m^3	LP Billion	LP Billion	LP Billion
Bekaa WE		30.0	15.0						
UBL	Tariff	24.0	14.4	7.2	515		**3.7**	*3.0*	*4.5*
	Increm. Cost	**24.0**	**14.4**	7.2		1,051	**7.6**	*6.1*	*9.1*

Source: World Bank PER Water Sector (2010); and Authors.

88. The value associated with the non-revenue domestic water based on real cost of water paid by household as a defensive measure to augment domestic water supply and ensure the quality of drinking water amounts to LP 7.6 billion for the ULB population in 2012 with a bracket ranging between LP 6.1 and 9.1 billion (Table 6.8).

89. For irrigation water a benchmark of 10% for acceptable losses is also suggested where losses are not only associated with leaks in the system but also irrigation techniques, cropping patterns, surfacing soil, drainage systems, etc. The irrigation losses are also estimated at 40% according to Plan Bleu.[75] However, water wastage is not included in this figure and it is still difficult to pinpoint the water wastage although some reports make the case that this a priority issue to increase efficiency,[76] especially with the penetration of drip irrigation in the Bekaa. Should technical losses were to be reduced by half, efficiency losses in terms of residual production and financial losses would amount to 20%. Water allocated for irrigation from the Qaraoun Dam ranges between 40 and 60 MCM annually whereas 60 MCM are kept for summertime.

90. In this particular case, the losses will only cover Canal 900 that provides between 8 to 10 MCM annually (8.81 MCM in 2011 and 9 MCM considered in the analysis), the irrigated parcels adjacent to the Dam (6.1 MCM and 6 considered) and 2/3 of the Bekaa WE (53 MCM) and private small and medium (140 MCM) irrigation schemes used in the Bekaa and southern part of the ULB according to the 2012 National Water Sector Strategy in 2010. A conservative figure of 143.8 MCM (2/3) is used for the analysis. Not considered in the analysis are LRA water transfers from the Qaraoun (220 MCM total static of which 160 MCM is dynamic with 10 MCM for Canal 900, 20 MCM for the Qasmiyeh for irrigation and 130 MCM for hydropower) through the LLB to the southern coastal agricultural corridor and to produce electricity are not considered (Section 3).

[75] Comair, F. 2011. L'efficience d'utilisation de l'eau et approche économique, Etude nationale, Liban. Plan Bleu. Sophia Antipolis.
[76] Darwish, T., T. Atallah, S. Hajhasan, and A. Chranek. 2003 Lebanon: Management of nitrogen by fertigation of potato. Nutrient Cycling in Agroecosystems, 67: 1-11, 2003.

Table 6.9: Irrigation Technical Losses in the ULB, 2012, in LP Billion

ULB		Volume allocated to Irrigation in the Bekaa	Volume allocated to Irrigation in ULB (2/3)	Losses brought from 40% to 20%	Charges	Operations & Maintenance Cost	CAWRD	Lower Bound	Upper Bound
		MCM	MCM	MCM	LP/m^3	LP/m^3	LP Billion	LP Billion	LP Billion
LRA Canal 800 & Dam area allocation in ULB		15	15	3.0	603		1.8	*1.5*	*2.2*
		15	15	3.0		1,420	4.3	*3.4*	*5.1*
WE & Private Small & Medium Scale irrigation		193	129	25.7	603		15.5	*12.4*	*18.6*
		193	129	25.7		1,420	36.5	*29.2*	*43.9*
Grand total	Charges	218	144	28.8			17.3	*13.9*	*20.8*
	O&M	218	**144**	**28.8**			**40.8**	*32.7*	*49.0*

Source: See Table 6.10; Plan Bleu (2011); LRA Annual Report (2011); National Water Sector Strategy (2012); and Authors.

91. The LRA average irrigation charges amounts to LP 603 per m^3 whereas the operations and maintenance costs are twice as much.[77] This figure is used for RE and private operations and maintenance costs although these are considered to be less efficient than LRA's. Hence, a LP 1,420 per m^3 in 2012 prices is used for valuing the losses. The CAWRD reaches up to LP 41 billion in 2012 for the irrigation productive losses in the ULB with a bracket ranging between LP 33 and 49 billion (Table 6.9).

6.2.6 Quantity: Drawdown of the Water Table

92. The rapid development of illegal wells during the Civil War was accompanied by significant withdrawals and poorly compliance and controls regarding groundwater resources. Due to groundwater drawdown, source spring waters to the Upper Litani function briefly over the winter months when water tables are raised sufficiently. However, the rate of pumping exceeds the natural recharge rate where an average drawdown in water table was reported as 20-25 m and 5-10 m in the Cenomanian and Jurassic aquifer, respectively in the area of the Litani River watershed in the last 15 years, or a conservative average of 0.75 m per year.[78] Moreover, a recent study on the Casa of Zahleh shows also a drawdown trend in wintertime of a 0.74 meter on average between February 1, 2011 and February 1, 2012. This drawdown is more accentuated during summertime which makes the 0.74 m very conservative as some wells are overexploited and other dry out in July. The results of 6 sampled wells are illustrated in Table 6.10.

[77] World Bank. 2010. Lebanon PER of the Water Sector. Washington, D.C.
[78] Shaaban, A. 2011. Analyzing Climatic and Hydrologic Trends in Lebanon. Journal of Environmental Science and Engineering, 5 (2011) 483-492.

Table 6.10: Drawdown in the Casa of Zahleh, 2011-2012

Day	Domestic and Agricultural Well	Unused Well	Karstic Well for Domestic Use	Domestic Well	Industrial Well	Agricultural Well	Average
	m	m	m	m	m	m	m
February 1, 2011	33.0	49.7	20.4	42.2	46.4	64.8	
February 1, 2012	32.3	49.2	21.1	40.2	45.8	63.2	
Drawdown differenc	-0.6	-0.5	0.8	-2.0	-0.6	-1.6	-0.74

Source: Kehdy (2013).

93. Hence, for groundwater resources, the amount of water is affected by a lowering of the water table and deep resources of 0.75 m per year, which requires additional pumping. The amount retained is 2/3 of groundwater extraction volume from the Bekaa WE and the private sector for the ULB area (see above). Thus, the change of production is considered to derive the additional cost of pumping equivalent to the CAWRD. The damage cost amounts to LP 0.5 billion in 2012 with a variation of LP 0.4 to 0.7 billion (Table 6.11).

Table 6.11: Additional Cost of Pumping in the ULB, 2012, in LP Billion

Pumping Cost	Unit	Bekaa Underground Water	ULB Underground Water (2/3)
Bekaa WE Groundwater Extraction	Million of m^3	140	128.7
Private Groundwater Extraction	Million of m^3	53	35.3
Total Extraction	Million of m^3		93.3
Average Consumption of diesel	liter/meter of depth/m^3		0.004
Annual drawdown	meter		-0.75
Market price	LP/liter of diesel		1,418
Total	LP Billion/year		**0.5**
Lower bound	LP Billion/year		*0.4*
Upper bound	LP Billion/year		*0.7*

Source: Shaaban et al. (2011); National Water Sector Strategy (2012); and Kehdy (2013).

94. For surface resources, the non-replacement of lost capacity due to siltation dams can lead to the reduction of water availability for users (see Storage below). The preliminary siltation results reported by the 2013 USAID LRBMP are insignificant and amounts to 3 MCM over the lifetime of the Qaraoun Lake. The cost of dredging was not considered given the quality of sediment that could have a negative impact in areas where they would be discharged. Hence, the yearly average siltation is equivalent to the forgone major consumer of water from the impact of siltation which is valued by the forgone change in agricultural production. Considering a consumption of 5,000 m^3/ha for intensive irrigation, a loss would be the difference between the value of agricultural production between intensive and non-intensive irrigation. All other factors remaining constant, a shortfall of LP 1,892,258/ha for all

crops was retained. The CAWRD thus amounted to LP 0.023 billion in 2012 in the ULB with a bracket ranging between LP 0.019 and 0.026 billion (Table 6.12).

Table 6.12: Agricultural Losses due to Qaraoun Lake Sedimentation, 2012, in LP Billion

Dam	Qaraoun Volume	Sedimentation 1963-2013 Volume	Sedimentation in 2012	Allocation for Intensive Agriculture	Agriculture value-added to Intensive Irrigation	Total
	Million of m^3	Million of m^3	m^3	m^3/ha	LP/ha	LP Billion
Total	220	3	60,000	5,000	1,892,258	**0.02**
Lower bound						0.02
Upper bound						0.03

Source: World Development Indicators (2013); USAID LRBMP (2013); and Authors.

6.2.7 Quantity: Storage

95. To avoid infrastructure damages, the LRA has to release excess water during winter time due to a lack of optimized storage. Hence, the same 2011 volume drained off is considered for 2012 and amounts to 17 MCM. The forgone opportunity of this water is valued and includes two forgone layers of benefits: agricultural production that could be used after being used for hydroelectricity generation where the positive effects it has on Electricité du Liban (EDL) and the global environment are also considered. If technically feasible, the Qaraoun Dam wall could be elevated based on these results to be able to store the excess volume or underscore the justification for the building of new dams such as the ones planned on the Khardale and on the Bisri albeit both dams together with the Qaraoun Dam have been suggested to be built almost 60 years ago by the USDI Point-4 in 1954. The forgone agriculture production methods is the same used above in Table 6.12 whereas the forgone hydroelectricity is based on the LRA production efficiency and actual LRA sale prices to EDL and the real EDL production cost that is highly inefficient and putting a growing strain on the government deficit.

96. Thus, the forgone opportunities from draining off the Lake Qaraoun in the ULB amounts to: LP 1.8 billion to which is added the avoided GHG emissions valued at LP 0.23 and are accounted for under Global environment below; and the agriculture production of LP 6.5 billion. Hence the total forgone benefits amounts to LP 8.25 billion in 2012 to which the avoided GHG valued at LP 0.23 billion should be added with a bracket ranging between LP 6.9 and 9.5 billion (Tables 6.13 and 6.14).

Table 6.13: Forgone Opportunities due to the Qaraoun Lake Draining Off during Wintertime, 2012, in LP Billion

Second Layer of Forgone Benefits	Volume Drained off from the Lake	Allocation for Intensive Agriculture	Agriculture value-added to Intensive Irrigation	Total
	Million of m^3	m^3/ha	LP/ha	LP Billion
Agricultural production	17	5,000	1,892,258	6.5
Lower bound				5.5
Upper bound				7.5

Source: World Bank PER Electricity (2008); LRA Annual Report (2011); and Authors.

Table 6.14: Forgone Opportunities due to the Qaraoun Lake Draining Off during Wintertime, 2012, in LP Billion

First Layer Forgone Benefits	Volume Drained off from the Lake	Weighted Hydro production efficiency	Forgone Production	LRA Sale Price to EDL	EDL average production cost	LRA Gains	EDL net Deficit reduction	Total	Carbon Emission Saved
	Million of m^3	kW/h/m^3	mW/h	LP/kW/h	LP/kW/h	LP Billion	LP Billion	LP Billion	LP Billion
Hydroelectricity	17	0.72	12.4	41	127	0.51	1.24	1.75	0.23
Lower bound	17	0.58	10.0	41	127	0.41	1.00	1.41	0.20
Upper bound	17	0.86	14.6	41	127	0.60	1.46	2.06	0.25

Note: hydroelectric power generates 4 g of CO_2 per kW/h whereas Lebanon's alternative fuel-based electric power generates at least 891 g of CO_2 per kW/h. Carbon Emission Saved are not included in Total. EDL net deficit reduction include EDL LP 14 profit when buying LRA's kW/h at LP 44 and selling it at LP 55 on average.

Source: Website Green It <www.greenit.fr>; World Bank PER Electricity (2008); and LRA Annual Report (2011).

6.2.8 Erosion

97. The erosion in the ULB is due to a convergence of natural and human-made factors. Reduced flow energy of running water due to the flatness of the Bekaa plain and gentle sloping terrain with a gradient not exceeding 25m/km, with 18m/km as average,[79] which enhances the sedimentation processes along the primary river course. High river bank

[79] EU SPI Water. 2007. The Litani River.

erosion rates are caused by the increasing intensity of precipitation events that result in flooding such as the 2003 disastrous flood. The dominance of thick alluvial deposits in the Bekaa plain reduces the infiltration capacity of the top soil as well as increases the irregularity of overflow of rainwater towards the river.[80] The texture shows that about 50% of soil covering the region are made of clay and the rest is composed of loamy soil, sandy clay loam or sandy clay making less permeable soil.[81] Hence, the upstream river beds of the Litani confluents are indeed being encountering sedimentation due to anthropogenic factors (human activity along the banks, agricultural patterns, stone cutting, settlements, et.) and the precipitation events. Nevertheless, the recent telemetry results from the Qaraoun Lake invalidates the notion of assumed high sedimentation of the Qaraoun Lake.

98. In addition to the above mentioned factors, agricultural water mismanagement leads to nutrient losses which exacerbates the cycle of soil degradation, erosion, runoff and leaching of fertilizers and pesticides. Remote sensing studies have been shy of pinpointing the loss of soil per ha. A professional judgment based a number of exchanges helped to determine a conservative soil loss in the upstream of the Litani of 1 ton per ha on average for 10% of the cultivated area.

Table 6.15: Agricultural Land Nutritive Losses due to Erosion, 2012, in LP Billion

Area	Cultivated Area	Affected Area			Annual Erosion	Fertilizer Cost	CAWRD		
		10% : Middle Bound	5% : Lower Bound	15% : Upper Bound			Total	Lower Bound	Upper Bound
	Ha	Ha	Ha	Ha	Ton/ha	LP/ton	LP Billion		
ULB	57,000	5,700	2,850	8,550	1	677,092	3.9	1.9	5.8

Source: Arif et Doumani (2012).

99. The replacement cost for the calculation of the CAWRD of agricultural productivity due to soil erosion is to compensate for the loss of nutritional value of the soil with fertilizers. An amount of LP 677,092 per ha is based on the market price of fertilizers. Thus, the cost of the damage amounted to LP 3.9 billion in 2012 with a bracket ranging between LP 1.9 and 5.8 billion (Table 6.15).

6.3 Solid Waste Category

100. Waste management in the ULB remains problematic especially in rural areas. However, not the entire chain of waste has a direct impact on water resources but rather the landfill of Zahleh where some leachate runoff was measured, the active dumps and the abandoned dumps that are sometimes on the banks of the Litani. Moreover, only the CAWRD of the chain of domestic waste is considered in the analysis although some industrial waste and sometimes medical wastes are mixed with municipal waste. Yet, although the collection rate seems to reach 95% in ULB, it is the rest of the waste chain that raises some

[80] MOE/UNDP/ElArd. 2011. Op. cit.

[81] Kehdy, Nagy. 2013. La Gestion Intégrée Quantitative de la Ressource en Eau Souterraine, Cas du Kaza de Zahlé. Thèse de Doctorat. Université St. Joseph. Beyrouth.

concern except for Zahleh's landfill whose volume will not be considered in the analysis as some sorting and composting is already ongoing. Moreover, Zahleh processes 130 ton/day and charges a LP 19,604 per ton gate fee to other municipalities to process their waste at the landfill. A 100 ton/day sorting and composting facility is being constructed in Baalbeck with an € 1.4 million EU grant. Moreover, the Italian Embassy is rehabilitating the Kayyal dump and building a new one for Baalbeck thanks to an € 1.8 million grant. Moreover, a rehabilitation of the major dumps with a high pollution risk index was performed in 2010 by MOE/UNDP/ElArd where the rehabilitation and closure of 8 dumps in the ULB were estimated at LP 7 billion.

101. The CAWRD in ULB include: 5% uncollected waste; the cost of rehabilitation of collected waste generated that is disposed into dumps in 2012 (except for the waste processed at the Zahleh landfill); the shortfall in recycling in 2012 (except for Zahleh); the valuation of land depreciation near active and abandoned dumps; the forgone future electricity that could have been generated in cells (discounted at 5% for the 2012 waste); and the methane emissions that could be avoided (discounted at 5% for the 2012 waste). The description of the methodology and calculations are developed in Annex IV. The CAWRD caused by waste amounts to LP 38 billion in 2012 with a variation of LP 30 to 44 billion (Table 6.16) to which should be added the GHG emissions that are reported under Global Environment.

Table 6.16: Solid Waste in the ULB, 2012, in LP Billion

Results	Collection	Cleaning dumps for generated solid waste	Foregone Revenues from Recycling	Land Value Depreciation due to dump vicinity	Forgone Electric Generation discounted at 5%	Total	GHG emissions discounted at 5%
Total	**7.6**	**5.1**	**18.2**	**1.0**	**6.0**	**37.8**	**1.4**
Lower bound	*6.1*	*4.1*	*12.7*	*0.8*	*5.1*	*29.5*	*1.3*
Upper bound	*9.2*	*6.1*	*21.8*	*1.2*	*6.1*	*44.3*	*1.5*

Note : GHG emissions are accounted for under Global Environment.

Source: Annex IV.

6.4 Air Pollution Category

102. Air pollution is an important media that cannot only affect health but also agricultural productivity and particulates could be washed into the soil and water bodies during the rainy season. Unfortunately, the lack of emission loads prevented the quantification of all the damages. Yet, only health, agricultural productivity and infrastructure decaying effects were valued. The damage associated with air pollution in Zahleh and Baalbeck was calculated for PM_{10} based on the lower bracket [30-59] of 30 $\mu g/m^3$

average emissions in both cities as suggested by the World Bank for cities with more than 100,000 inhabitants in Lebanon in 1999 and also retained for WHO cross regional analysis on urban areas in 2004.[82] $PM_{2.5}$ are being equivalent to half PM_{10} (15 μg/m^3 as an annual average and usually about half of PM_{10}). The air pollution in the 2 major cities is mainly generated by the Baalbeck diesel-fueled power plant (2x70 MW), the district and industrial generators to compensate for the shortfall of EDL production and distribution, the industrial activity in the Zahleh area, the motorized vehicles, the burning of waste in dumps and few annual sandstorms emanating from the Sahara and the Arabic Peninsula. Usually, particulates are washed off into soil and water bodies especially during the rainy season and pollution (smog as often reported and noticed from the upper slopes of eastern Mount Lebanon overlooking the Bekaa valley) is known to reduce the agricultural productivity.[83]

Table 6.17: Air Pollution in Zahleh and Baalbeck, 2012, in LP Billion

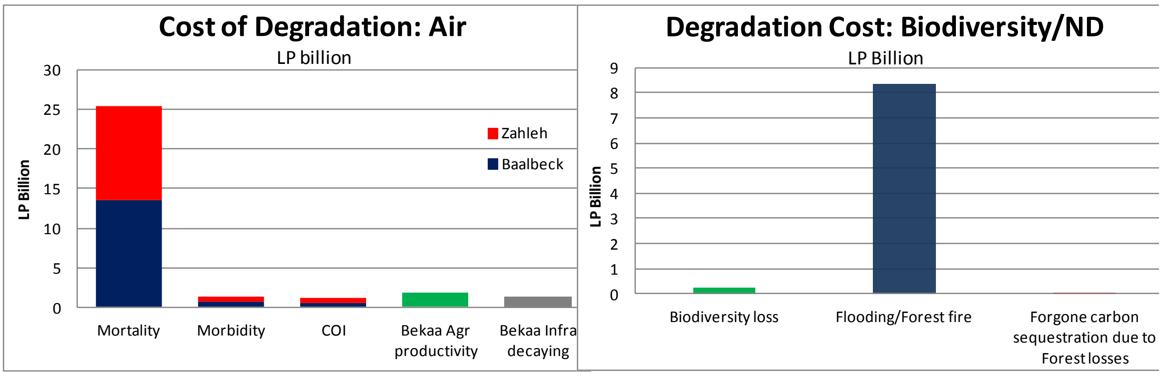
Results	Unit	Zahleh	Baalbeck	Total	Lower bound	Upper bound
Burden of Disease	DALY lost	**172**	**206**	**378**		
Burden of Disease	LP Billion	**12.8**	**15.2**	**28.1**	*25.3*	*30.1*
-of which Cost of Illness	*LP Billion*	*0.5*	*0.7*	*1.2*	*1.0*	*1.3*
Agricultural productivity	LP Billion			**1.9**	*1.7*	*2.1*
Infrastructure decaying	LP Billion			**1.3**	*1.1*	*1.4*
CAWRD	LP Billion			**31.3**	*28.1*	*34.4*

Source: Annex V.

103. At any rate, the degradation cost associated with the health burden was calculated to bring the multimedia issue to the fore. The total burden of disease amounts to 378 DALYs lost (a DALY stands for a *year lost of healthy life*) equivalent to LP 28.1 billion in 2012 with a variation from LP 25.3 to 30.1 billion (Table 6.18 and see Annexes II and V). Air pollution also agricultural productivity and infrastructure and facades hence accelerating their decaying and contaminates soils and water bodies when particulates are no longer airborne. A preliminary valuation is based on EcoSense[84] and amount to LP 1.9 billion in terms of reduction in agricultural productivity and LP 1.3 billion in terms of decaying. The CAWRD amounts to LP 31.3 billion with a variation from LP 28.1 to 34.4 billion (Table 6.17). Hence, all these effects call for new quantitative research especially with regards to multimedia issues in ULB in general and agricultural productivity in particular.

[82] The World Bank, Development Economics Research Group Estimates website: <www.worldbank.org>; and WHO website: <www.who.int>.
[83] EU website: <http://edgar.jrc.ec.europe.eu>.
[84] EcoSence website : <http://scenarios.ew.eea.europa.eu/fol079729/online-model-inventory/ecosense>.

Figure 6.3: Air Pollution, Biodiversity and Natural Disaster of the Upper Litani Basin , 2012, in LP Billion



Source: Annex V.

6.5 Biodiversity Category

104. The role of wetlands as use values (e.g., in agriculture, fisheries in the Qaraoun, flood mitigation, groundwater recharge) and non-use (as habitats for species of fauna) have been validated in several studies in Lebanon. The loss of biodiversity is more reflected by the reduction of the fauna and flora wealth as the wetlands and protected areas are increasingly under pressure the years from human activity despite the efforts deployed by the government and NGOs as well as international institutions to preserve them (Section 3). The interesting synthesis of the IDRC (2007) study on the Litani Ecosystem is reported in Box 6.2. Moreover, the construction of dams has indeed increased the area of water surface but has changed the natural flow regime of the Litani. The previous drainage of certain areas of the Bekaa, urbanization along the river and agricultural expansion are all putting more pressure on the Litani ecosystem services. Moreover, floods and especially the one that occurred in 2003 have had a direct impact on the morphology of the river bed that resulted in biodiversity losses.

Box 6.2: Litani Ecosystem Assessment

The Upper Litani is divided into two sectors as follows:

- **The Upper Bekaa Valley**. This section of the Litani River has the worst water quality. The water here is hazardous to human health. The river is fed by source springs close to the natural divide of the Litani and the Orontes. Groundwater ponds are used in the headwater region for the year round supply of water for irrigation, municipal and domestic use. This results in a drawdown of the water table and a drying out of the upper reaches of the Litani River. Most of the irrigation water is lost by evaporation and evapotranspiration and no evidence was seen of irrigation water return flow to the river. Groundwater after use for domestic and municipal purposes is largely collected by sewage systems and the untreated wastewater is returned to the river. From Location 28 downstream until the Beirut-Damascus highway, year round flow is observed increasing downstream due to the numerous wastewater out-falls along the river course.

- **The Lower Bekaa Valley.** Downstream of the Beirut-Damascus highway, the river receives the tributary waters of the Ghzayel, the Berdaouni and Chtoura Rivers. Each of these tributaries is fed year round by Karstic springs in the mountains on each side of the Bekaa Valley. High flow is therefore maintained year round. The high tributary loading of water to the Lower Bekaa results in dilution of most elements including the most important of all - bacterial concentrations. Despite this dilution, water quality remains extremely poor until the Qaraaoun Reservoir. Reduction in pollution in the Upper Bekaa would obviously improve the Lower Bekaa. However, the presence of towns and villages throughout the Valley will continue to result in extremely bad water quality unless all sources are subjected to remedial measures.

Fertilizers. The evaluation of Nitrate in the Litani indicates over-fertilization of agricultural soils as the major cause of very high nitrate concentrations throughout the Litani. Control of fertilizer application is needed (see below).

Solid Waste. Enrichment of the river waters with Nitrite indicates leaching of solid waste with exposure to rising water levels during higher flow conditions. Nitrite in itself may not be of immediate concern. However, it serves as a tracer indicating the probability that many other organic and inorganic materials are being leached from the solid wastes deposited throughout the basin.

The Qaraoun Reservoir. This reservoir has a dramatic effect on water quality from input to output to the generating station. There are clear reductions in bacterial concentrations and in nutrients. Seasonal levels of nutrients clearly reflect the limnology of the reservoir and indeed it can be postulated that phosphorus is the limiting nutrient to phytoplankton growth in the reservoir. An evaluation of nutrient cycling in the sluggish, inflowing waters of the Litani River indicate the nitrogen may be the limiting nutrient in the river system.

Diversion of Litani River water to the Awali Valley. The physical transfer of water by tunnel through the mountain range to the Awali River shows little change in water quality and only Phosphate and Ammonia show a statistically significant decline in concentration.

Impact of Litani Waters on the Awali River. The Litani River water discharge to the Awali has a significant impact. Bacterial levels are reduced whereas both nitrate and nitrite concentrations are increased. Phosphate both increases and declines relative to the concentration of the Litani diversionary water as compared to the Awali River phosphorus levels upstream of the point of discharge.

Lower Litani River. Most of the annual flow of the Lower Litani is derived from the many springs occurring along its course through the mountains. Discharge from the Upper Litani from the Qaraaoun Reservoir occurs only during periods when the water supply in the Reservoir exceeds that required for power generation. In general the water quality is good when compared to the Upper Litani. However, bacterial infection exceeds the guidelines for most human uses but is within the guideline for use as a supply of water for drinking water treatment. Nutrient water quality levels are good with only Nitrate showing cumulative increases downstream relative to increasing fertilizer application and the oxidation of ammonia and nitrite found in the discharged domestic wastewater to nitrate.

Source: IDRC (2007).

105. It is very difficult to assess the actual loss of biodiversity of the Litani. Yet, the replacement cost was adopted to value the CAWRD. It is important to note that this approach is affected by significant limitations. On the one hand, the use of actual costs may underestimate the damage costs because they can rarely compensate for all services previously provided by the original ecosystem, especially in regard to the effect of releases from dams on the biodiversity. TEEB has estimated the cost of replacement of a wetland on the basis of a comprehensive meta-analysis. The cost amounted to LP 74.3 million per ha.

The average loss of the Litani wetlands mainly in Kfar Zabad was estimated at 3.5 ha. Thus, the CAWRD, which is very conservative, amounts to LP 0.26 billion in 2012 with a lower bound of LP 0.21 and an upper bound of LP 0.31 billion (Figure 6.3).

6.6 Natural Disaster and Global Environment

6.6.1 Natural Disaster

106. The Litani is subject every few years to catastrophic events that cause casualties, significant damages, destruction of agricultural plantations, mobility disruption, forgone revenues, environmental impact as well as indirect costs. The most severe flooding occurred in 2003 with more than 400 km^2 of flooded areas and billions of Lebanese Pounds in damages and forgone revenues. The flood occurred after approximately 10 consecutive days of heavy rainfall in combination with snowmelt and where 36 mm of rainfall were recorded during one day. The USAID LRBMP commissioned a report to perform to assess the magnitude of flood damages and modeling that will help recalibrate riverbed width and depth. Moreover, the EU funded Improvement of Irrigation Water Management project has already performed some adjustments that were necessary (introduced gallion techniques, where rocks are maintained by wire nets, to reduce erosion in flood prone areas) but still not sufficient.

107. The evidence provided by the climate projections indicates potential increased frequency in time and space that will increase flood flows that affect the Litani. However, the year 2012 did not witness a flood per se but a disruption of 1 day of economic activity (measured by the gross national income per capita per day) for 20% of the population was assumed due to lack of reliable sources. In addition, deforestation already due to urban expansion and land clearing for agriculture and urban use is exacerbated by fires. In 2012, no forest fire was reported in ULB unlike 2010 where a forest fire devastated 5 ha of forests on the eastern flank of the Mount Lebanon.[85] However, ULB forest fire risk is very low compared to Mount Lebanon and Akkar. Hence, the same area of 5 ha was considered in 2012 to have been lost (encroachment and/or forest losses-fires). Therefore, the degradation cost associated with forest loss is equivalent to LP 0.011 billion in 2012 with a bracket ranging between LP 0.009 and 0.013 billion. Thus, the CAWRD associated with natural disasters include 1 day of disruption from torrential rains and amounts to LP 8.4 billion with a lower bound of LP 6.7 and an upper bound of LP 10 billion (Figure 3). Carbon sequestration lost due to forest losses is reported under Global Environment.

6.6.2 Global Environment

108. The imbalance between the proportion of use of surface water compared to the share of groundwater at the expense of the first is likely to intensify in the future. This imbalance will further be exacerbated by the effects of climate change. Indeed, in addition to the expected increase in temperature leads to an increase in transpiration and evapotranspiration, a reduction in rainfall is expected to decrease. This could lead to both lower recharge and increased use of groundwater by farmers to offset the growth in the

[85] Association for Forest Development and Conservation website: <www.afdc.org>.

rainfall deficit and the increase in evapotranspiration. Moreover, the reduction in snow cap acting as a water reservoir to feed the hydrological cycle during the spring season and high temperatures resulting in more rain fall than snow in Lebanon's high altitudes will exacerbate the picture in the future.

109. GHG emissions were considered in the context of the global environment and was covered in forgone hydroelectric production, solid waste's avoided methane emissions and loss of carbon sequestration after forest fires and amounted to LP 1.7 billion in 2012 with a variation ranging between LP 1.5 and 1.8 billion.

6.7 Conclusions

110. The estimated cost of the degradation of water resources has confirmed what the previous studies have indicated in qualitative terms that: (a) the Upper Litani Basin is heavily polluted; (b) the quality of the water in the Basin is poor and that the services and utilities are not performing efficiently. This study has estimated in monetary terms the degradation due to poor water quality and quantity as well as the effect of this degradation on public health and the quality of the services as follows:

- Poor water service in terms of quality and quantity (23% of the total CAWRD) and waterborne diseases (20%) represent together more than half the CAWRD in the ULB. The 2 sub-categories are followed by significant efficiency losses in the drinking water and irrigation networks (13%). The lack of storage optimization is also penalizing the ULB in terms of forgone agricultural production and electricity generation. It is interesting to note that the CAWRD is 50% of the total water resources degradation for Lebanon given that the area of this basin is only one fifth of the Lebanon.
- Lack of waste treatment and proper landfilling is disfiguring the ULB where the riverbed is filled with waste, trash and, in certain areas, stone debris that exacerbate the already poor quality of water resources that are subject to municipal, industrial and agricultural pressures.
- Sedimentation, the drawdown of the water table, soil/water salinity and natural disasters are prevalent to a lesser extent but should nevertheless be addressed. The increasing prevalence of evapotranspiration was neither quantified nor valued but deserves additional research as agricultural practice and cropping pattern evidence shows that there is no irrigation water return flow to the Litani River but probable infiltration to the ground water.
- Air pollution is affecting both Zahleh and Baalbeck and could affect the growing suburbs of these 2 towns as well as agricultural productivity and infrastructure decaying although air pollution impact on water resources (cross media) from particulate wash off during the rainy season was not quantified and valued.

111. Based on these findings, a number of priorities emerged but only 3 are considered for the remediation analysis in the short and medium term:

- Improving water services in terms of quality and quantity, reducing the losses of drinking water and irrigation supply systems, and rebuilding the trust between the utility and dwellers;

- Increasing improved access to water and sanitation and provide hygiene practices where needed;
- Tackling all 4 sources of pollution, which covers the 2 above-mentioned priorities, by speeding up the implementation of projects addressing municipal and industrial effluents, solid waste management and agriculture runoff.

7. Remediation Cost of the Upper Litani Basin

7.1 Remediation Cost Aggregate Results

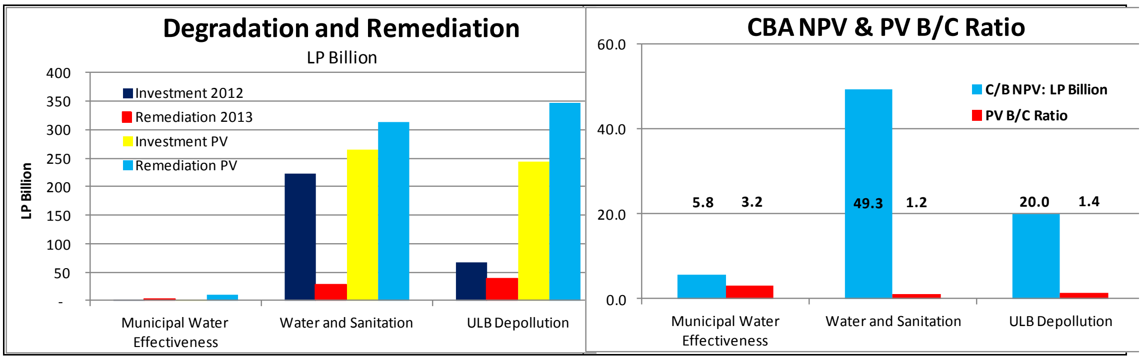
112. Based on priorities identified in the previous section, three priority remediation interventions were considered and valued in ULB: improvement efficiency of municipal water; improved drinking water and sanitation that improve health; and Qaraoun Depollution based on Government/Development Partner ongoing project and suggested MOE/UNDP/ElArd additional investments needed to bring water resources parameters within acceptable international and national standards.

Table 7.1: Cost/Benefit Analysis of Upper Litani Basin Selected Interventions, 2012, in LP Billion

CBA Indicators	Viability Criteria(10% Discount rate and 20 year investment)	Scenario A1 Municipal Water leakage 5% of Household Incremental Spending	Scenario B3 Improved Water and Sanitation	Scenario C2 Stand-alone additional investments that assumes that ongoing and planned investments were implemented and are efficiently operated
NPV (LP Billion)	>0	5.8	49.3	20.0
IRR (±%)	≥10%	39%	13%	12%
PV Benefit/Cost Ratio	>1	3.2	1.2	1.4
Project Viability		Yes	Yes	Yes

Source: Authors.

Figure 7.1: Priority Remediation Cost of the Upper Litani Basin, 2012, in LP Billion



Source: Authors.

113. The most relevant scenarios were selected and are shown in Table 7.1 and Figure 7.1. Two scenarios were considered for improvement efficiency of municipal water where: (A1) costs were based on 5% incremental cost incurred by households; and (A2) cost were based on optimal incremental cost incurred by households that is the switch off point that would justify the investment. For water and sanitation, three scenarios are suggested: (B1) improved drinking water supply exists but the connection to the sewer system does not

exist, (B2) improved drinking water and sewer connection access do not exists, and B3 where B1 and B2 are both considered collectively. Two scenarios were considered for the ULB depollution to reach water resource quality standards where: Scenario C1 being the combined cost of ongoing, planned and additional investments as reported by the Government/Development Partners and MOE/UNDP/ElArd; and Scenario C2 being Stand alone additional investments as suggested by MOE/UNDP/ElArd. In other words, the full benefits of Scenario C2 cannot materialize without the full implementation and operationalization of the Government/Development Partner ongoing and planned investments. The results are a very preliminary estimate that need to be refined should the Government decide to move ahead with this ambitious project. Alternatively, a cost/benefit analysis should be performed for each ongoing and planned intervention by the Government/Development Partners and MOE/UNDP/ElArd to prioritize and sequence investments based on their efficiency.

Table 7.2 : Cost of Remediation of the Litani, 2012 and LP billion

Litani	Investment 2012	Remediation 2013	NPV of Investment	NPV of Remediation
	LP Billion	LP Billion	LP Billion	LP Billion
Municipal Water Effectiveness	3	1	3	10
Water and Sanitation	223	28	265	314
ULB Depollution	68	38	243	347
Total	**294**	**68**	**511**	**671**

Source: Authors.

114. The analysis of the remediation cost is based on the net present value (NPV) of the investment over 20 years with a 10% discount rate, the internal rate of return (IRR) PV of the B/C ratio helped identify the most efficient investments (See Annex VI for calculations details):

- For domectic water leakage, the BCA shows a positive NPV of LP 5.8 billion, an IRR of 39% and the PV B/C ratio of 3.2.
- For improved water and sanitation, the BCA shows a positive NPV of LP 49.3 billion, an IRR of over 10% and the PV B/C ratio greater than 1.
- For the Depollution of the ULB, the BCA shows a positive NPV of LP 20 billion, an IRR of 12% and the PV B/C ratio of 1.4. However, when the combined ongoing, planned and additional investments are considered under Scenario 2, the project is no longer viable and require a series of BCA to prioritize the most efficient investments.

115. Usually, when alternatives are not or barely viable, a multi-criteria analysis could be considered by decision makers where weights are assigned to CBAs, creation of employment, poverty reduction, etc.

7.2 Water Supply Service Improvement

116. Municipal water service efficiency is a serious problem facing the Bekaa WE with an estimated 7.2 MCM that could be reduced (see Section 6 and Table 6.8). A valuation of the

reduction of technical losses will be attempted in the ULB. There is little empirical evidence available on the actual unit cost of physical leakage reduction interventions. A 2006 study[86] reviews a number of leakage reduction performance-based service contracts in the State of Selangar (Malaysia), Bangkok (Thailand), Sao Paolo (Brazil) and Dublin (Ireland). The actual unit cost of physical leakage reduction per m^3 ranges between US$ 215 and 750. A narrower range will be adopted for the ULB as peri-urban and rural area leakages should be less costly to fix. A range between US$ 215 and 500 per m^3 is adopted equivalent to a range of LP 234 and 543 per m^3 when adjusted to 2012 prices.

117. Two scenarios were considered: (i) the remediation costs are confronted to 5% of the incremental cost incurred by household to supply additional water (quality and quantity) and the incremental cost incurred are assumed constant over the 20 year investment; and (ii) the remediation costs are confronted to the optimal incremental cost needed to cover the investment and could be considered as the switch off point above which the investment is no longer viable.

Table 7.3: Cost/Benefit Analysis of Municipal Water Leakage Reduction, 2012, LP Billion

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 1 5% of Household Incremental Spending over 20 years	Scenario 2 Household Optimal Incremental Spending over 20 years
NPV (LP Billion)	>0	5.8	0.1
IRR (±%)	≥10%	39%	10%
PV Benefit/Cost Ratio	>1	3.2	1.1
Project Viability		Yes	Yes

Note : Benefits start accruing in year 2.

Source : Authors.

118. The results of the 2 scenarios are as follows (Table 7.3):

- Scenario 1 is viable with a positive NPV of LP 5.8 billion, an IRR of 39% and the PV B/C ratio of 3.2.
- Scenario 2, which is considered the switch off point beyond which the investment is no longer viable, is profitable with a positive NPV of LP 0.1 billion, an IRR of over 10% and the PV B/C ratio of more than 1.

119. In retrospect, the 2 scenarios are profitable but the most salient point is that the cost of investment to reduce the 7.2 MCM leakage represents only 1.5% of the actual annual incremental cost already paid by households to supplement water for their domestic use.

[86] Kingdom, Bill, Roland Liemberger and Philippe Marin (2006). "The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries – How the Private Sector Can Help: A Look at Performance-Based Service Contracting. PPIAF.

7.3 Improved Water and Sanitation

120. Many projects are underway to improve drinking water and sanitation in the ULB. The achievable reductions morbidity and mortality due to diarrhea after improving water supply, sanitation and hygiene (Box 6.1) measures are based on the latest meta-analyses that are shown in Table 7.3. Three scenarios were considered: (i) improved drinking water supply exists but the connection to the sewer system does not exist, (ii) improved drinking water and sewer connection access do not exists, and (iii) scenarios (i) and (ii) are both considered. On average, reductions would be 50% for scenario (i) and 60% for scenario (ii) and this is taking into account the state of hygiene in households.[87]

Table 7.4: Diarrheal morbidity and mortality reduction with improved services

Groups	Current water supply and sanitation Coverage in ULB	Improved Water and Sanitation Definition	Benchmark Expected average reduction in diarrheal disease and mortality	
			Already good hygiene	Substantial scope for hygiene improvement
Piped water supply and sewage connection	**35%**	Improvement in reliability and quality of piped water (so as to ensure plentiful and safe water supply) for those of this population currently having water reliability and quality problems	15%	45%
Piped water supply but no sewage connection	**40%**	a) Improvement in reliability and quality of piped water (so as to ensure plentiful and safe water supply) for those of this population currently having water reliability and quality problems. b) Sewage connection for all of this population.	**35%**	**65%**
Not piped water supply but sewage connection	0%	Reliable and safe piped water supply to premises for all of this population	25%	55%
Not piped water supply and no sewage connection	**25%**	Reliable and safe piped water supply and sewage connection for all of this population	**45%**	**75%**
Total	**100%**		**28%**	**60%**

Source: adapted from Bassi et al. (2011); MOE/UNDP/ElArd (2011); Table 6.1; and Authors.

[87] Bassi et al. (2011).

121. Investment costs associated with the improvement of water supply, sanitation and hygiene measures are shown in Table 7.4 with wide variations. Average reductions of 50% for sanitation and 60% for water and sanitation have been adopted to derive gains amounting LP 214 billion in 2013 (Table 7.5) should investments were to be immediately implemented in the basin. Intervention would increase the rate of sanitation coverage to 100% between 2013 and 2031. Similarly, intervention would increase the coverage of water and sanitation to 100% between 2013 and 2031.

122. The results of the 3 scenarios are as follows (Table 7.6):

- Scenario 1 ensures an improved sanitation to 319,229 inhabitants in the ULB between 2013 and 2031 and is viable with a positive NPV of LP 53 billion, an IRR of over 10% and the PV B/C ratio of more than 1.
- Scenario 2 ensures improved safe drinking water and sanitation to 504,385 inhabitants in the ULB between 2013 and 2031 and is not viable with a negative NPV of LP 3.8 billion.
- Scenario 3, which includes scenarios 1 and 2, the investment is viable with a positive NPV of LP 49.3 billion, an IRR of over 10% and a PV B/C ratio over 1 (Table 7.5). In other words, Scenario 3 provides gains in terms of health benefits only. For instance, being connected to the sewer network improve the health state without improving the environment unless these effluents are treated before being discharged in water bodies.

Table 7.5: Cost and Benefits for Improved Water and Sanitation, 2012-31

Water and Sanitation	Investment per capita		Initial investment in 2013	Investment & O&M PV at 10% over 20 years	Initial Benefit in 2013	Benefit PV at 10% over 20 years
	Lower Bound LP/capita	Upper Bound LP/capita	LP Billion	LP Billion	LP Billion	LP Billion
Water	*180,960*	*226,200*				
Sanitation	*120,640*	*150,800*				
Hygiene Awareness	*7,540*	*13,572*				
Scenario 1 Sanitation and Awareness			47	55	10	119
Scenario 2 Water, Sanitation and Awareness			176	209	19	226
Scenario 3 = Scenarios 1 and 2			223	265	29	314

Note: Benefit flows accrue on second year. Operations and Maintenance are set at 3% of capital cost with an annual increase of 3%. Awareness is added to the first year with annual media reminders.

Source: site web de WASH: <www.sanitationupdates.wordpress.com/2012/10/16/wash-by-numbers-the-latest-on-cost-benchmarks-economic-returns-and-handwashing/>; and Authors.

Table 7.6: Cost/Benefit Analysis of Improved Water and Sanitation on Health, 2012

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 1 Sanitation and Hygiene Awareness over 20 years	Scenario 2 Water, Sanitation and Hygiene Awareness over 20 years	Scenario 3 Scenarios 1 and 2 over 20 years
NPV (LP Billion)	>0	53.0	-3.8	49.3
IRR (±%)	≥10%	23%	10%	13%
PV Benefit/Cost Ratio	>1	2.2	1.1	1.2
Project Viability		**Yes**	**No**	**Yes**

Source : Authors.

7.4 Depollution of the Upper Litani Basin

123. A preliminary analysis on the depollution of the ULB was performed to determine whether the Qaraoun Depollution project could be justified. An economic analysis would require additional data, work and testing for sensitivity to derive the social cost and determine whether the project is viable. Nevertheless, a number of assumptions had to be made to derive this first order of magnitude of this investment.

124. Two Scenarios are considered: Scenario 1 being the combined cost of ongoing, planned and additional investments as reported by the Government/Development Partners and MOE/UNDP/ElArd; and Scenario 2 being Stand alone additional investments as suggested by MOE/UNDP/ElArd. In other words, the full benefits of Scenario 2 cannot materialize without the full implementation and operationalization of the Government/Development Partner ongoing and planned investments.

Table 7.7: Ongoing, Planned and Additional Remediation Cost of the Upper Litani Basin, 2012, in LP Billion

ULB Depollution Categories	Reported Government and Development Partners Ongoing and Planned Investments	Suggested MOE/UNDP/ElArd Additional Investments to reach ULB water quality standards	Total Investment
	LP Billion	LP Billion	LP Billion
Solid waste	17.5	16.4	33.9
Municipal liquid waste	270.5	160.0	430.5
Industrial liquid waste	-	23.8	23.8
Agriculture runoff	21.0	4.0	25.0
Total	308.9	204.3	513.3

Note: Only 1/3 of the agricultural runoff financed by the Government was considered as they are national projects. O&M are not included in the figures but included in the analysis below.

Source : MOE/UNDP/ElArd (2011); and Authors.

Table 7.8: Remediation Cost of the Upper Litani Basin, 2012, in LP Billion

Proposed remediation	Investment 2012	Remediation 2016	Investment PV 2012-31	Remediation PV 2016-31
	LP Billion	LP Billion	LP Billion	LP Billion
Scenario 1: Combined cost of ongoing, planned and additional investments (Government/Development Partners and MOE/UNDP/ElArd)	171x3 years	29	611	920
Scenario 2: Stand alone additional investments (MOE/UNDP/ElArd)	68x3 years	38	243	347

Note: Investment amounts are equally distributed over 3 years. Operations and Maintenance are set at 5% of capital cost with an annual increase of 3%.

Source : Authors.

125. The costs were derived from the 2011 MOE/UNDP/ElArd report where the ongoing Government/Development Partners investment for municipal liquid waste, industrial effluents, solid waste and agricultural runoff are considered and the investments suggested by the report to bridge the gap of existing and planned investment to bring back the ULB water resource parameters within international and national standards. The investment amounts are illustrated in Table 7.7. with the a number of caveats such as: the existing infrastructure (waste processing and landfilling; WWTP, sewers, etc.) is not accounted for; investments that are ongoing and not mentioned in 2011 MOE/UNDP/ElArd report are not considered such for instance the World Bank Lebanon Environmental Pollution Abatement

Project under preparation and that will help reduce industrial pollution on a demand basis;[88] some discrepancies exist between the figures provided by CDR and the figures provided by the 2012 MOEW National Sanitation Strategy on the priority WWTPs and their capacity; financial rather economic costs are used in the analysis; the reduction of runoff was not properly costed in the MOE/UNDP/ElArd Qaraoun Depollution Study; etc. The aggregated ongoing, planned and additional investments amount to LP 513 billion with LP 309 billion already ongoing and planned by the Government/Development Partners and LP 204 billion as additional investments that will allow the ULB water resources parameters to be in line with international/national standards.

126. Regarding cost, total investments were assumed to be disbursed over 3 years in equal tranches. Operations and maintenance were removed from the original MOE/UNDP/ElArd figures and added over 17 years. Regarding the benefits, 20 years is used for all the remedial analysis for consistency although it is considered a short period with regards to environment investments where benefits could accrue over a longer period of time. For scenario 1, three layers of benefits were used as the others CAWRD sub-categories were more related to water competitiveness and efficiency. Hence, the revealed prevalence based on the Baker et al. (2007) study that is adapted for Lebanon amounts to improve water resources over 9 years, and was annualized over 17 years and used as a benefit starting Year 4. The waste damages, which are only associated with collection, clean up, recycling and depreciation of land, were used as benefits starting to accrue in Year 4 (Table 7.8). The improved sanitation benefit accruing over 20 years as calculated in Section 7.3 was used as a third layer although improved water is not included. For scenario 2, the latter benefit was not considered.

127. The results of the 2 scenarios are as follows (Table 7.9):

- Scenario 1's combined ongoing, planned and additional investments to bring ULB water parameters to acceptable standards is not viable with a negative NPV of LP 26 billion, an IRR of 9% and the PV B/C ratio of 1.2. Hence, a series of BCAs are needed to see the most efficient interventions among both the ongoing, planned and additional investments.
- Scenario 2's stand-alone additional investment as calculated by 2011 MOE/UNDP/ElArd is viable with a positive LP 20 billion, an IRR of 12% and the PV B/C ratio of 1.4. The positive result assumes that Government/Development Partner ongoing and planned investments were implemented and are efficiently operated.

128. In a nutshell, the municipal water leak and illegal taping reduction are pressing issues from a societal point of view as the most salient point is that the cost of investment to reduce the 7.2 MCM leakage represents only 1.5% of the actual annual incremental cost already paid by households to supplement water for their domestic use. Improved water and sanitation interventions is viable when all households without coverage are targeted. When

[88] World Bank website: <www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/10/03/000333037_20131003144027/Rendered/PDF/E43020v20LEPAP000PUBLIC00Box379839B.pdf>.

considering the additional Qaraoun Depollution Project as a stand-alone project, the preliminary results suggest that the investment is viable provided that the Government/Development Partner ongoing and planned investments were fully implemented and efficiently operated. Finally, the Government/Development Partners ongoing and planned investments to which is added the additional Qaraoun Depollution Project of the ULB is not viable and requires an in-depth economic analysis to prioritize the most efficient interventions. All these results are built on the assumptions that all investment projects will be run efficiently in the future to bring ULB water parameters to acceptable standards and help most ecosystem services to regain their strength.

Table 7.9: Cost/Benefit Analysis of the Upper Litani Basin, 2012

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 1 Combined cost of ongoing, planned and additional investments Water Resources Parameters will reach Acceptable Standards from Accruing Benefits if Investments are Efficiently Managed	Scenario 2 Stand-alone additional investments that assumes that ongoing and planned investments were implemented and are efficiently operated
NPV (LP Billion)	>0	-26	20
IRR (±%)	≥10%	9%	12%
PV Benefit/Cost Ratio	>1	1.2	1.4
Project Viability		**No**	**Yes**

Source : Authors.

8. Conclusions and Recommandations

129. The diagnosis and analysis developed in the previous sections helped reach the following conclusions:

- **The environment neglect of the Litani Basin is becoming a burden on the Lebanese Economy**. The cost assessment of water resources degradation was estimated at 264 billion LBP or US$ 227 million/year corresponding to the 0.5% of the GDP of Lebanon in 2012. The cost of water degradation corresponds to approximately half of the 2005 cost the water resources degradation in Lebanon for a basin occupying only 21% of the Lebanese surface area and about 25% of its population.
- **The environmental health bill due to the burden of waterborne diseases is also high** and was estimated at LP 74 billion/year (US$ 49 million) or 0.7% of the ULB GDP**.** Major sources of waterborne diseases are due to: untreated wastewater which is 96% of the total wastewater generated as only 4% is being treated; poor quality of potable water from private wells as more than 50% of the ULB population rely on wells; and poor hygiene practices that still need to be assessed, especially among the poor.
- **Physical losses and other non-revenue water are excessive and was estimated at 50% for domestic water and 30% for irrigation.** These losses of totalling 151.2 MCM/year and estimated at LBP 48.4 billion/year (US$ 32.0 million) could be seen as a cost borne by citizens with no return on investment. The high rate of leakage in the water network contributes to heavy losses and to the low reliability of water supply. These losses are due mainly of lack of investments in the networks and more importantly due to a lack of regular operation and maintenance costs. Both induce a poor services delivery at high household cost.
- **Water resources allocation does not reflect the reality of the socioeconomic conditions in the Litani Basin.** The decree 14522/1970 issued for more than 40 years ago still defines the amount of manageable water from the Litani System and its allocation for irrigation and domestic use in the southern Bekaa. Priority of water allocation is for hydropower (without which many cities and villages will be in the dark) and for domestic use. There is no approved water resources master plan for the Litani which should take into account the demand and supply management based on economic principles, the future long term needs of this basin taking into consideration population growth, climate change impacts as well as the necessary environmental flow for protecting the biodiversity resources in the basin.
- **Too little attention was given to the Lower Litani Basin and its development opportunities were not fully explored**. The majority of studies, research and monitoring were focused in the ULB because of its socioeconomic importance. The water resources in the LLB are not contaminated with the same level of pollution found in the ULB, however with the future operation of the canal 800, the water quality may be adversely affected as the canal will withdraw 20 MCM of water per year for domestic and industrial use and 86 MCM of water per year for agricultural

purposes from the Qaraoun Lake which is already polluted. As the construction of the canal is in its first stage which will be completed in 2017, further investigation on the water quality of the canal 800 and the impacts of pollution transfer should be undertaken by the MOEW and the MOE so as to prevent further deterioration of the water quality as it is occurring in canal 900.

- **The fragmented responsibilities between the MOEW, MOE, LRA, and the WEs are contributing to poor environmental performance** in terms of monitoring and enforcement and have prevented the efficient development and management of the water and wastewater services. Major sector studies and notes prepared by Development Partners such as the World Bank, USAID and AfD have stressed the importance of speeding up the process of a transparent governance in the water and the wastewater sectors as required in the NWSS. The World Bank[89] has recommended strengthening the capacity of the WEs and provide them the operational and financial autonomy with accountability. USAID[90] has recommended that the best institutional arrangement for the Litani is that the Litani River Authority becomes the Litani Basin Authority with full-fledged responsibility and accountability of all the water activities in the Basin. No formal decision was yet reached by the Government.

130. On the basis of these challenges, five axes of intervention are recommended:

a) Support the River Basin Agency Concept to be implemented by the Litani River Authority (LRA). The underlying issues of the Litani Basin and its socio-political impacts are so complex that the present status quo of the present fragmented responsibilities will not ensure the environmental sustainability of this important basin. There is an urgent need to establish an integrated river basin management at LRA in which water management should be made at the basin level for water allocation, monitoring, compliance and enforcement and closer interactions with water users and operators. MOEW strategic role in developing water policies, regulating the regional water establishment and planning and financing large hydraulic infrastructures will certainly be maintained.

b) Focusing first on "the low hanging fruits" for reduction of the water losses and for non-revenue water in the water and irrigation networks as well as practices. The cost of remediation showed for instance that the reduction of 7.2 MCM/year leakage represents only 1.5% of the actual annual incremental cost already paid by households to supplement water for their domestic use. In this regard, it will be important to implement the first elements of the NWSS Infrastructure initiative investment # 1.4 related to water supply transmission and distribution. This intervention is both economically feasible and will contribute to job creation. This will require:

i. Preparation of an inventory and an action plan with costs for the rehabilitation of the water, wastewater, and irrigation networks and the

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[89] World Bank. 2012. Lebanon Country Water Sector Strategy (2012-2016). Washington, D.C.
[90] USAID/IRG. 2013. Litani River Basin Management Support: Achievements and Possible Follow up.

establishment of outcome-based technical and financial targets for reducing losses in these systems.

ii. Implementation of the action plans using the local manpower for replacing existing old transmission and distribution of potable water and irrigation systems.

iii. Establishment and maintenance a leak detection system and irrigation techniques, cropping patterns, surfacing soil, drainage systems, etc. as well as establishing specific indicators of management and performance for the water and irrigation systems to be contracted out to professional engineering firms.

Improving the programming, investment efficiency and the maximization of environmental benefits in the wastewater sector. At present the investments programmed by the Government and the Development Partners in the wastewater sector will not cover the entire population of the Litani Basin. The remaining population will not have access to any improved sanitation let alone that their effluents will not be treated before being discharged or percolate in the water bodies. Furthermore for the population which has access to improved sanitation and for which municipal wastewater is being treated in WWTPs, the major constraint lies in the weak coverage, low installed capacity and lack of O&M and qualified staff to operate the plants. The proposed intervention will be:

iii. To improve first the sanitation in rural and urban poor areas to cover about 688,000 inhabitants by 2032 that could not have access to improved sanitation, through the adoption of low cost technologies and subsidized capital and operation and maintenance costs.

iv. To increase also the coverage and the treatment capacities of the existing wastewater treatment plants which are either not functional or not operating at their initial installed capacity. These measures will have to be undertaken within an effective reprogramming and sequencing of investments which take into account the capital and the operation and maintenance costs as well as the operation of these plants by qualified utilities firms.

c) Reducing environmental threats due to the 4 pollution pressures in the ULB. The preliminary results of the ongoing and planned Government and Development Partners investments to which is added the additional investments suggested by the MOE/UNDP/ElArd Qaraoun Depollution project so that water resources parameters will reach acceptable standards is not economically viable. In order to proceed with the suggested investments, the following recommendations are proposed:

iv. To conduct additional pre-feasibility and economic studies to prioritize investments based on efficiency out of a long list of interventions proposed in this program regarding municipal wastewater discharge, industrial effluents, solid waste leachate and agricultural runoff.

v. To adopt, based on results of these pre-feasibility and economic studies, a structured and sequenced approach to pollution control by investing in: (a) building, densification and calibration of the sewer network and connect it to the operating and planned WWTPs and set up check and balances to monitor the efficient management of the system; (b) the in situ treatment of industrial effluents; (c) closing/rehabilitating open dumps near by the Litani River and its tributaries with high pollution risks as identified in the 2011 MOE/UNDP/ElArd study and establishing municipal treatment facilities in major cities using the model established in Zahleh and its neighbouring municipalities; and federate under the Ministry of Agriculture tutelage all the efforts to optimize the utilization of fertilizers, fungicides and pesticides in ULB.

vi. To reinforce the monitoring and enforcement and compliance system by ensuring that polluting enterprises would comply with auto-control and self-monitoring as required by the Framework of the Environment Protection Law 444 and the environmental compliance certification system (Decree 8471-2012) and by outsourcing regular inspections to certified laboratories or universities to enable the MOE to take the necessary legal actions against polluters in conjunction with both the MOEW and Ministry of Industry.

d) Strengthening the knowledge on the development of water resources in the Lower Litani Basin (LLB) and future transfers by:

vii. Institutionalizing the water quality and quantity monitoring system which was developed under the LRBMS.

viii. Conducting a strategic regional environmental assessment of the LLB to evaluate the environmental consequences and impacts of transferring the polluted water from the ULB to the LLB, canal 800 that is under construction for mainly irrigation purposes in Southern Lebanon, and Beirut through the planned conveyor.

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Annex I Identification Mission and Validation Workshop

1. Identification Mission List of People Met

Table A1.1: SWIM Mission List of Institutions: April 4-11, 2013

Meeting	Institution	Name	Address
Tuesday April 2	Mission Preparation		
Wednesday April 3	Mission Preparation		
Thursday April 4	Mission Preparation		
Friday April 5			
9:00-13:30	Litani River Authority USAID/LRMBS	Eric Viala, Chief of Party Bassam Jaber, Consultant Fadi Karam, Agricultural Specialist	Bechara el Khoury
13:30-14:30 Lunch break			
14:30-15:30	Ministry of Environment	Manal Moussalem, Advisor to the Minister	Riad El Solh
16:00-18:00	St Joseph University	Jocelyne Gerard, Head of Geography Dept. Naji Kahdy, Doctoral Student	Damascus Road
Saturday April 6			
10:00-12:00	Consultant (USAID)	Bassam Jaber, Former MOEW DG	Bechara el Khoury
Monday April 8			
9:00-10:30	Litani River Authority	Nabil Amacha, Head of Water Monitoring and Environmental Studies	Bechara el Khoury
11:00-13:00	American University of Beirut	May Jurdy, Professor Environmental Health	Bliss Street
13:00-14:00 Lunch break			
14:00-15:00	CDR	Sami Feghali, Head of Land Use Planning Assem Fidaoui, Sector Manager, Water/WW	Grand Serail
15:30-16:30	ESCWA	Carol Chouchani, Chief, Water Resources Section	Riad El Solh
16:15-18:00	Environmental Fund for Lebanon/GIZ-GFA	Angela Akl, Project Manager	Grand Serail
Tuesday April 9			
9:00-11:30	Ministry of Energy and Water	Fadi Comair, DG Mona Fakih, Director (SWIM Focal Point)	Cornice el Nahr
12:00-14:30	Litani River Authority	Selim Catafago, President Adel Houmani, DG Elias Chaoui, Head of Gauging Stations	Bechara el Khoury
15:00-17:00	MOE/UNDP/ELARD Qaraoun Study	Ricardo Khoury, Deputy President Hanadi Moucharrafieh, Team Leader	Sin el Fil
Wednesday April 10			
8:00-18:00	Field Visit to the Litani with Bassam Jaber		
	Ferzol Municipality	Ibrahim Nasrala, Mayor	Ferzol

Meeting	Institution	Name	Address
		tnasrala@lau.edu.lb	
	Baalbeck Municipality	Omar Solah, Deputy Mayor	Baalbeck
	Qaraoun Municipality	Yahia Daher, Mayor	Qaraoun
	Jib Janine Municipality	Khaled Said Charanik, Mayor and President of the Municipality Federation	Jib Janine
Thursday April 11			
8:30-10:00	Ministry of Environment	Bassam Sabbagh, Head of Urban Environment Pollution Control Department	Riad El Solh
10:30-13:00	Friends of Ibrahim Abdel Al	Nasser Nasrallah, President Iman Abdel Al, Treasurer	Bechara el Khoury
13:00-14:00 Lunch break			
14:00-15:30	European Union Delegation	Maciej Madalinsky, Head of SD Section Cyril Dewaleyne, Program Manager	Saifi
16:00-18:00	USAID WISE	Salah Saliba (Former GIZ), Technical Advisor Fadi Nakad, Construction Management Specialist	Sodeco

2. Workshop Background, Objectives

2.1 Introduction

The Sustainable Water Integrated Management – Support Mechanism (SWIM-SM) is a regional technical support project funded by the European Commission (EC) and that includes the following Partners Countries (PCs): Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria[91] and Tunisia. The project aims to promote actively the extensive dissemination of sustainable water management policies and practices in the region given the context of increasing water scarcity, combined pressure on water resources from a wide range of users and desertification processes, in connection with climate change.

The specific objectives of the SWIM-SM are to: (i) raise the decision-makers and stakeholders' awareness in the Partner Countries on existing and upcoming threats on water resources, on the necessity to switch to more viable water consumption models as well as on possible solutions to face the challenges; (ii) to support the Partner Countries in designing and implementing sustainable water management policies at the national and local levels, in liaison with on-going relevant international initiatives; and (iii) contribute to institutional strengthening, to the development of the necessary planning and management skills and to the transfer of know-how. SWIM-SM has now included among its four pillars, the economic valuation of water resources at the basin level.

SWIM-SM has included in its work package # 1, a regional activity on the cost assessment of water degradation (CAWRD) at the basin level. The overall objective is to assist national and local decision-makers in identifying concrete actions to improve watershed management in

[91] The situation in spring 2012 is that cooperation with Syria is temporarily suspended until further notice from the EU.

selected Partner Countries through the potential for financing projects that will derive environmental benefits and reduce externalities. To achieve the overall objective, there is a need to improve the investment opportunities of the government at the sub-national or basin level in order to effectively curb water degradation.

Although water issues and their impact on the economy have been assessed at the national level, the situation is different at the watershed because no assessment of costs associated with degradation has yet been undertaken. However, it is at the basin level, that decisions must be made regarding the management and protection of water resources and in close collaboration with local authorities. The Cost Assessment of Water Resources Degradation (CWRD) would allow local institutions to have the necessary tools to interact on the basis of monetary terms with the central government, national ministries, especially with the Ministries of Finance, the different types of costs of degradation and the policies needed to reduce these costs.

Lebanon through its national Focal Point, has requested assistance from SWIM-SM to estimate the degradation cost of water resources in the Litani watershed. The main objective is to value the cost of water resource degradation in the Litani watershed to assist decision-makers at national and local levels to identify and prioritize specific actions to improve the management of this basin through potential funding of projects related to environmental benefits and the reduction of externalities.

The draft report was completed by the SWIM-SM consultants and is the subject of the consultation meeting for which an agenda is attached below. However, most participants coming from the Beqaa did not make it due to bad weather. An additional succinct session was organized to the Mayors in the Beqaa one week later (see below).

2.2 Objectives and expected results

The Objective of the Consultation was to:

a) Present the study on the cost of water resources degradation of the Upper Litani Basin

b) Discuss the content of this report and receive comments from the participants

c) Propose concrete actions to ensure ownership of the MOEW of the recommendation to improve the water resources management of the ULB.

The Anticipated Results were:

a) Exchanges of point of views concerning the study.

b) The added value of this study to mainstream environment into the management of water resources.

c) The proposed actions for the use of this study in the decision making process for improving the water resources management of the ULB.

3. Workshop Methodology

In order to achieve the workshop's objectives, the workshop was designed to be highly dynamic and interactive. Power point presentations were made to illustrate the results of the CAWRD report with Questions and Answers sessions after each of the 5 presentations.

4. Overview of the Workshop Agenda

The workshop was held over one day (December 12, 2013) as per the detailed Agenda in Section 7 of this report. The agenda consisted of:

a) Opening Remarks, and introduction to the workshop's background and objectives;

b) Presentations of the country's assessment in three parts: (a) main findings of the country and Litani's water assessment and institutional set up; (b) the cost of degradation and remediation of water resources (c) presentation of the conclusions and recommendations.

c) Closing remarks.

The draft report was sent only to a small number of participants. As a result, some participants complained that they did not receive the report beforehand. All participants were provided with electronic copies of all presentations and the draft report. A deadline to receiving the comments was set on December 20, 2013.

5. Main Outcomes of the Discussions

Comair opening speech (see attached the speech under point 9.):

- Importance of a micro-credit system for farmers
- Potential of non-conventional water resources
- Need to establish a Commission – possibly under MENBO (Mediterranean Network of Basin Organisations) - for monitoring the cost of degradation in future years
- Lebanese Ministry has contributed to the process towards drafting the UfM Strategy for Water in the Mediterranean

1st ppt (SA)

Comments:

H.E. Adel Cortas (formers Minister of Agriculture + Member of the NGO "Water Friends"): welcomes the initiative but also stresses on the lack of data and the importance of having a M&E system

SA: the problem with data and M&E of data is common to other countries in the world and if a system is not put in place this will cost very much. Our intention is to talk money with the Ministries.

2nd ppt (SA)

H.E. Adel Cortas: asks about comments received by LRA to the study and also mentions a loan by the WB to support all municipalities on the Litani to solve the problems of the river.

SA: there are many funding institutions/organizations working on the Litani (USAID, Italian Cooperation, WB, etc.) and on Qaraoun for its depollution (WB) + there is another planned project from the WB "Lebanon Pollution Abatement".

Mr. Bassam Jaber (ex DG of Exploitation at MEW and member of the NGO "Water Friends"): the MoE and LRA are the coordinating body of a programme voted by the Council of

Ministers and transmitted to the Parliament for the depollution of the Litani. It included originally the upper LRB but finally all the river will be considered.

Mr. Mustapha Fawaz: in order to protect areas from floods there is a need for an acceptable land-use plan, in the meanwhile other projects are extended to residential areas and not legalized yet.

H.E. Adel Cortas: asks about the role of Water Users Associations as they were not mentioned among the actors who should be involved in implementing programmes towards the remediation of the river. Acutaully the WUAs are mentioned in the report as important stakeholders.

SA: points out that there is still no legal framework in Lebanon for WUAs, in addition there is a lack of enforcement of laws

3rd or 4th ppt (FD): for one of the ppts there were no questions, for the other there were few comments.

H.E. Adel Cortas: we have to be careful about figures we give to policy/decision makers

Fadi Karam: concern about opportunity costs if it was taking into consideration in the analysis.

H.E. Adel Cortas: why cropping patterns were not considered in the assessment? Did it consider saving irrigation techniques (sprinkler/drip irrigation etc.). We understand that there are a lot of interventions that could be considered but the consultants considered the most important ones.

6. Conclusions and Recommendations

A set of conclusions and recommendations were presented by the consultants that were followed by Mr. Comair's closing speech where, in his capacity as the Honorary President of MENBO, Mr. Comair will help disseminate the results of these studies among members and other actors in the Mediterranean, including River Basin Organisations who are the most appropriate to tackle IWRM in an effective way. The participants suggested to share the results of the studies with Decision makers, Parliamentarians and Mayors because most of the people coming from the Beqaa did not attend the workshop because of the bad weather. A workshop organized by USAID (Eric Viala and Bassam Jaber) to the Mayors of the ULB on December 19, 2013 was attended by Mr. Fadi Doumani who presented the results of the Litani CAWRD.

A number of adjustments were suggested by various ministries and entities. Most comments were addressed in the final version of the report. With regards to current opportunities for improving integrated water management, an SEA on water resources is being conducted in Lebanon.

7. Workshop Evaluation findings and recommendations

At the end of the workshop, the participants filled an evaluation form to express their opinion and feelings about the efficiency, effectiveness and soundness of both the organization and delivery of the training. The forms were thereafter analysed to extract lessons and recommendations for future activities. Below is a summary of the evaluation findings and the main feedback from the participants. Out of 23 participants who attended the workshop, 11 filled in the evaluation form despite repeated reminders during the workshop to fill in the evaluation at the end of the workshop (48%).

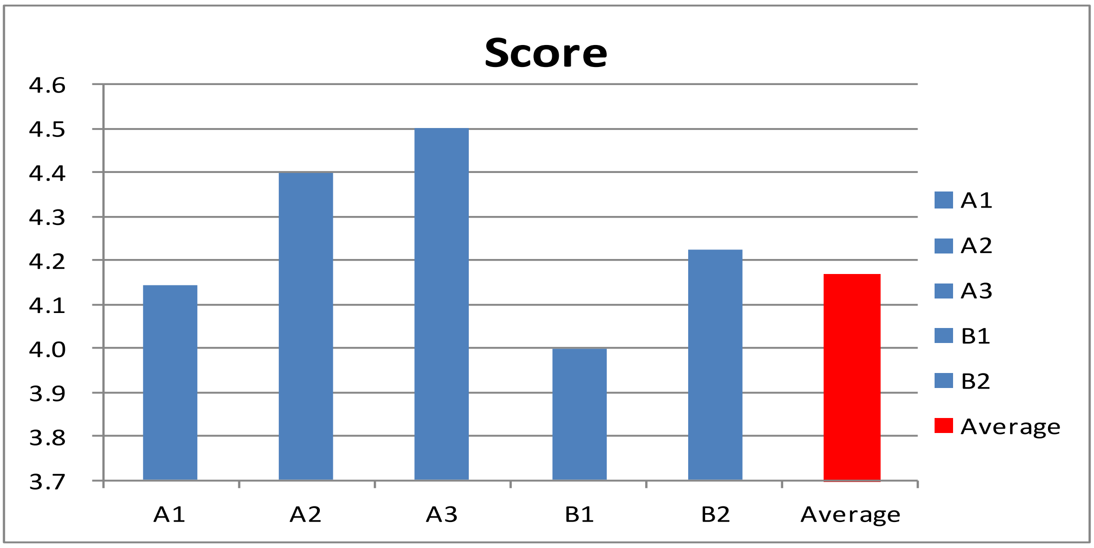
A set of 3 criteria; A1-A7-A8 (See Table A1.2) were assessed by the participants, using a scoring scale from 1 to 5, with 1= ''Strongly disagree'' or the lowest, most negative impression and 5=''strongly agree'', or the highest, most positive impression. The average score is 4.4 for criteria A (Figure A1.1): 100 percentile includes 3, 4 and 5 scorings whereas 82 percentile includes 4 and 5 scorings with no scores. In general, the participants were highly satisfied on most aspects related to the course organization, administration as well as design and contents.

The same scoring scale was used to assess another set of criteria; B1-B2 (See Table A1.2) related to the execution of the workshop. The average score is 4.1 for criteria B (Figure A1.1). Similarly, the participants' feedback was encouraging with 100% of the participants giving 3-4-5 scores or whereas (4-5 scores with 73 percentile) to issues such as Efficient and Effective Performance and Interaction by Participants as well as Efficient and Effective Facilitation. Many participants requested deeper analysis and longer time for discussions showing an interest in the activity and its results.

Table A1.2: List of criteria A1-A7-A8

A1	Good Handling of Invitations, Visa Support, Information Sharing and Smoothing Obstacles
A7	Procedural issues: Selection and Design of Methodology, Programme/Daily Agenda and Work Rules
A8	Presentations Correspond and contribute to the Planned Objectives and Conducive to Enhanced shared Understanding and participation of Relevant Issues
B1	Efficient and Effective Performance and Interaction by Participants
B2	Efficient and Effective Facilitation

Figure A1.1: A Criteria Scores



8. Detailed Workshop Agenda

9:00 Registration

9:30 Opening remarks

Dr. Fadi Comair, Director General at the Ministry of Energy and Water

9:45	Presentation of the General Context of the Cost Assessment of Water Resources Degradation in the Litani Basin Dr. Sherif Arif, Senior Water Expert, SWIM-SM
10:15	Questions and Answers
10:30	Coffee Break
11:00	Methodology and Cost Assessment of Water Resources Degradation of the ULB Mr. Fadi Doumani, Senior Water Economist Expert
12:00	Discussion
12:30	Lunch
14:00	Methodology and Assessment of Remediation Costs of Water Resources of the ULB Mr. Fadi Doumani, Senior Water Economist Expert
15:00	Discussion
15:30	Coffee Break
16:00	Conclusions and Recommendations Dr. Sherif Arif and Mr. Fadi Doumani
16:30	Discussion
17:30	Closing

9. List of Participants to the December 12 and December 19, 2013 Workshops

Table A1.3. Beirut SWIM Workshop Participant List, December 12, 2013

#	Name	Surname	Country	Position	e-mail
1	Sherif	ARIF	Washington	Non Key Expert SWIM-SM	sherifarif59@yahoo.com
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Table A1.4. Beqaa USAID Workshop Participant List, December 19, 2013

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10. Opening Speech by Dr. Fadi Comair

- Excellencies Members of the Lebanese Parliament

- Representatives of Lebanese institutions

- Representative of the EU Delegation to Lebanon

- Ladies and Gentlemen, representing the honorable organizations and institutions that support the water sector in Lebanon

I would like to thank you for being here today and for participating actively in this event that aims at sharing and discussing with you the findings of the study prepared in the framework of the EU-funded Sustainable Water Integrated Management-Support Mechanism (SWIM-SM) on the cost assessment of water resources degradation (CAWRD) of the Litani River basin.

This is part of one of the regional activities implemented by SWIM-SM with focus on 4 River Basins in the South Mediterranean (apart for the Litani in Lebanon, the Medjerda River in Tunisia, the Oum Er-Rbia in Morocco and the Seybouse in Algeria), all major water sources for their countries.

As we know all the challenges of the Litani Basin and its importance for our country we believe that this is a very useful activity for Lebanon and will assist us in identifying concrete actions to improve the current conditions and reduce the existing degradation, by complementing effectively our efforts towards an integrated management of the water resources in the country.

I am sure the Litani River Authority will say some words about this and about their undertakings to support the establishment of a Litani River Basin Agency to promote this integrated approach.

On my side I would like to stress the efforts we have done since more than 10 years to build and apply what by then was a new vision on water resources management for Lebanon that follows the principles of Integrated Water Resources Management (IWRM). This has been concretized in:

- a legislative reform and the overall restructuring of the water sector, including the set up of regional water authorities and new responsibilities for our Ministry;

- the drafting of the Water Code that represents a guiding framework for the water sector in Lebanon, to be hopefully endorsed soon;

- the approval of the 10 Years Strategy Plan driven by the need of promoting water efficiency in our country;

- the preparation and adoption of the National Water Sector Strategy under the supervision of His Excellency that is based on an Integrated Water Resources Management approach and has adopted a consultative approach with other relevant institutions.

As we are convinced of the importance to apply IWRM at the River Basin level, I would also like to stress here on the relevant work we are doing to achieve this in Lebanon, both in the framework of our Directorate’s activities and in my capacity as Honorary President of the Mediterranean Network of Basin Organisations (MENBO).

Recently, through another project funded by the EU and the Mediterranean Component of the EU Water Initiative and in collaboration with the Global Water Partnership- Mediterranean we have managed to draw, for the first time, our own delineation of all major River Basins in Lebanon and we have set-up a WEAP model for 6 of them, through a long process of collecting, processing and calibrating all relevant data existing at different relevant institutions.

This tool will allow us to build water availability/demand scenarios to support our work, and particularly the planning of specific actions that have to be taken to secure a sustainable management of the resources. The process of setting up the model has been accompanied by dialogue and collaboration with major Lebanese institutions that hold some of the data and /or can benefit from the model functions once fully operational.

At the present stage, we are trying to ensure funding to enrich the model with additional data so that we will be able to tackle in a suitable way the management of all waters in Lebanon based on the river basin approach. We are also very interested in supporting the creation of River Basin Organisations as models of cooperation and dialogue among all stakeholders involved in the management of the Basin.

At the international and Mediterranean levels we collaborate with major institutions, organisations and actors who promote IWRM at a river basin level and support important initiatives towards this aim. For example, we have recently signed in 2012 the Global Pact for Better Basin Management at the local, National and transboundary level while in 2011, in collaboration with the Global Water Partnership-Mediterranean (GWP-Med), we had started a collaboration with our colleagues at the Syrian Ministry for Irrigation to promote the joint management of the Al Kabir and Orontes Rivers, but unfortunately the war in Syria did not allow us to move further.

So, we consider every project that helps us applying this vision a very important contribution to the sustainable management of our water resources.

In this context, I would like to thank particularly the European Commission for its continuous support to this endeavor and all the other partners, some sitting in this room, for their invaluable contribution.

We wish us all a fruitful discussion and are ready to support as much as we can the implementation of the recommendations of this assessment in collaboration with all the relevant actors and stakeholders.

Annex II Methodology for the Cost Assessment Valuation

Water Category and Subcategories

Quality and treatment of drinking water. The treatment of drinking water can occur at two levels: at the drinking water treating station; and at the household level. The CAWRD is calculated by determining the change in production and thus, deriving the additional cost of treatment required at stations (for example, when the effluents discharged into the watershed without treatment) and determining revealed or stated preferences revealed at the household level (e.g., when a household incur additional cost to supplement water sources, buy bottle to ensure water quality, uses a filter, boil water, etc.). For the cost of the remediation, the benefits can be derived from water dilution (production change) when desalinated water is sought to be mixed with water for domestic consumption and other investments that cover all other sub categories in order to reduce the pollution of natural resource.

Quality of drinking and domestic water and sanitation in urban and rural areas as well as irrigation systems. The stated benefit is considered in this case and derived from the replacement costs associated with alternative sources of domestic water (bottles, wells, tanks, etc.). Or production costs associated with cleaning/scouring septic systems in the absence of services.

Quality of water resources. In this subcategory, it is exclusively anthropogenic origin and is affected by the discharge of domestic sewage, industrial effluents, mining and fisheries (fish in fresh water) as well as runoff due to nitrates and pesticides used in agriculture. The reduction of leachate is however covered under waste. Pollution of surface water and underground water affect water use (domestic, agricultural and industrial) ecosystem (eutrophication effects on direct, indirect and option values, etc.). Watershed and coastal areas, the cost of land, housing and apartments (hedonic) along the polluted areas, and eco-tourism (loss of opportunity especially along the river banks and polluted coasts). However, it is very difficult to assess the degradation of water quality by impact. Thus, using a contingent valuation surveys to derive the revealed preference (willingness to pay) of users to gauge the restoration of desired resource. This method is based on a transfer of benefits (see Annex III). Moreover, to restore the quality of the resource, investments usually include: a choice ranging from the use of simple and inexpensive WWTP processes such as natural ponds (common in wetland ecosystems) with primary treatment to secondary or tertiary treatments; industrial effluents treatment based on the polluter pay principle and a campaign to raise awareness among farmers is to optimize the use of pesticides and nitrates and promoting organic farming. In an extreme case where the resource is unrecoverable, a substitution of the resource by a remote water supply, and desalination and transportation of the water resources should be considered.

Salinity. The salinity of the surface water and groundwater is of natural and anthropogenic origin (soil erosion due to human activity), and effects on health if the water is used for domestic purposes (see above Drinking Water Quality), agricultural productivity and ecosystems. Only the effects on agriculture are taken into account in this case with the use of a production change to derive the CAWRD. The cost of remediation may include several alternatives: the salinity compensation using more fertilizer (however this is perverse because it pollutes water resources); dilution of groundwater resources by injecting normal wastewater treated; better land use by implementing a planning strategy that includes reforestation, responsible land management, prevention or mitigation of water and wind erosion soil etc. And in an extreme case where the resource is unrecoverable, a substitution of the resource by a remote water supply, and desalination and transportation of the water resources should be considered.

Waterborne diseases. The change in health status is considered in this subcategory. Some parameters of water quality do not affect the taste of water such as the excess of dissolved solids and sulfates. However, the bacteriological quality of the water can cause diseases such as typhoid, hepatitis A, trachoma and nematodes. In addition, the physico-chemical quality of the water can cause high blood levels of methemoglobin, high blood pressure and Blue baby syndrome which are respectively due to the excess of chlorides, sodium and nitrates. However, the causality between water quality and diseases is very difficult to establish definitively especially when it comes to cases of cancer associated with the ingestion of pesticides that contaminate drinking water or the food chain. Thus, the most reliable causality is that between the diarrhea that is transmitted through biological contamination on the one hand and the lack of water quality including water drinking water, inadequate sanitation status within the household and lack of hygiene (proper use of soap) by household members. Thus, a dose-response function, which has largely been established by a large number of studies, was used to value water-borne diseases, including premature mortality and morbidity from diarrhea affecting children under 5 years and morbidity affecting the 5 year and more age group. Thus, the prevalence of diarrhea in the region and the coverage of drinking water and sanitation were considered in the dose-response function to derive the results. Regarding mortality, it is difficult to assign a value on premature death and this is usually controversial. Yet the value of a human statistical life (VSL), which represents the reduction of risk of premature death, was used. Also, the cost of illness was considered for morbidity (hospitals, doctors, nursing assistants, medication, number of days of inactivity, etc.). The cost of remediation includes investments to increase the coverage of water supply and sanitation. This should be accompanied by a good performance in terms of operations and maintenance that are accounted in the analysis and the launch of an awareness campaign for a change in behavior with regard to hygiene in the households. Effectiveness of services. Opportunity costs can also be calculated for the technical losses in the distribution network, which are considered in this study, or lost time to carry water or clean / disgorge septic tanks. Furthermore, an increase in the efficiency of irrigation systems is done using the change in productivity.

Quantity. The scarcity of water resources could be a natural phenomena and/or anthropogenic, and it manifests itself by reducing the flow or runoff, which is exacerbated by the increased use of the resource to sustain population growth and economic activities. Moreover, the lengthening and disruption of cycles of drought (frequencies and intensities) affect surface water and drawdown groundwater. The lack of flow is usually offset: in an emergency, by the spontaneous use of wastewater treated or untreated, which could cause contamination of the food chain, in an intermediate case, by in-depth pumping (rapid drawdown or use of non-renewable fossil water) underground resources necessary to address domestic needs and/or maintain agricultural productivity. In an extreme case, a substitution of the resource requires a water supply augmentation via transfers or desalination that increase the transport cost. The change in production, opportunity costs (foregone) and replacement costs are considered when calculating the CAWRD while the cost of the remediation depends on the chosen alternative.

Erosion and Storage. Management of water resources is affected by erosion and exacerbated by climate changes that reduce storage capacity. The siltation and sedimentation of dams, hill lakes, riverbeds and coasts are compounded by inadequate land use upstream (such as deforestation, irresponsible management of soil, water and wind erosion of soils, etc.) and exacerbated by climate change through the increased frequency and intensity of floods sometimes during wet seasons. Replacement costs can be calculated by considering the reduction of the nutritional value of the soil that must be compensated by fertilizer, the opportunity costs (releases required to drain overflows) of water loss and damage to the ecosystem, defensive expenditures (dredging, construction of small lakes to absorb excess sedimentation), replacement costs (higher dams or building new dams), opportunity costs (loss of income) due to the reduction the volume of water stored and reducing the life of dams and hill lakes, and reduction of ecosystem services. Moreover, the costs of remediation are in some cases the same costs used to value the degradation such as investments for the construction of new dams. But the remediation costs might also include the implementation of a land use strategy that can include instruments such as reforestation, responsible land management, prevention or mitigation of water and wind soil erosion, etc.

Hydroelectricity. Reducing the output is recorded in case of droughts that could be exacerbated by climate change. The CAWRD considers the social opportunity cost of power generation by power plants using fossil fuels. This cost includes the effects of emissions of pollutants and greenhouse gases. The cost of remediation or adaptation includes in particular the replacement of power plants using fossil fuels by power plants using renewable energy.

Waste Category and Sub-categories

The solid waste chain in urban and rural areas including sludge from WWTPs. Pollution from domestic and agricultural waste is of anthropogenic origin. Thus, the mismanagement of domestic waste as well as sludge and agricultural waste can result in several impacts such as: air, soil and water (runoff leachate), noise, odor and sight pollution as well as discomfort and ill-health. Moreover, waste released in dumps can cause explosions and fires, reduce the price of land/buildings/apartments around the dumps, etc. The degradation costs consider the entire chain of waste. Collection: allocation of 1% of household disposable income for households without coverage for solid waste while the sludge is collected by providers, but generally released in nature (wadis, landfills, etc.). Discharge: cleaning cost per m3 of the generated waste that is not recycled or properly landfilled. Sorting and recycling: the opportunity cost of recyclables using the market rate for non- recycled materials. Shortfall of energy production when landfilling the organic waste. Reduction in land prices around the dumps (revealed preferences using the hedonic method) or wadis: lower prices for land, buildings and apartments: ± 15% in a radius up to 30 m of the discharge, and ± 10% of a circumference of 30 to 100 m around the dump. Methane capture in landfills: shortfall of energy production and carbon footprint in the absence of a sanitary landfill site. In addition, the cost of remediation depends on the selected alternatives for the collection, transfer stations, sorting stations and recycling, and landfill with or without methane capture. Chain of medical and hazardous waste. This is not considered in this study, but the impact could be more significant than domestic waste if services to manage medical and hazardous waste are not adequate.

Air Category

Background

Air pollution, which is caused by industrial and mining processes, energy production, various modes of transport, domestic energy use, other activities as well as natural causes (sand storms) is attributable to common but harmful pollutants such as notably ozone (O_3), fine respirable particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), sulfur monoxide and dioxide (SO_x), nitrogen monoxide and dioxide (NO_x) and lead (Pb), as well as volatile organic compounds (VOC). However, up to 98% of the health benefits attributed to the US 1990 Clean Air Act, 1970-90 came from reductions in PM and lead as the other compounds represented only 2%.[92] Moreover, while effects of short-term and long term exposures to high levels of outdoor air pollution are usually emphasized,[93] a study of the five criteria pollutants in the United States showed that long-term chronic exposure to lower concentrations of air pollutants can also affect human health.[94] Also, elevated levels of SO_2 and NO_x could have adverse effects as they can react with other substances in the atmosphere to form particulates, e.g., SO_4^{2-}. For the case of O_3 and VOC, short exposure to high levels could have serious health effects but WHO and EPA revoked the yearly exposure guidelines.

The methodology adopted for Zahleh and Baalbeck focuses only on the PM_{10} and $PM_{2.5}$ as other compounds emissions are not available. PM_{10} was estimated for both towns at 30 µg/m^3 on average per year and $PM_{2.5}$ is estimated at half the PM_{10} average. Epidemiological evidence suggests that there may be a link between ozone exposures and premature mortality, however possible confounding with PM-related mortality precludes its inclusion in the PM analysis. In the valuation, WHO air pollution guidelines[95] are considered.

Criteria Pollutants Thresholds and Health Effects

Drivers such demographic, urbanization and economic growth are responsible for urban air pollution from point and non-point sources emanating from within or outside the Bekaa urban areas. Pressures from these drivers cause damages to human health, biosphere, soil, water, buildings and materials but will only be considered within Zahleh and Baalbeck boundaries.

Table A2.1: Maximum Permissible Limits for Ambient Air Pollutants According to Various Sources

Pollutant	Exposure	Lebanon (52/1/1996) (µg/m^3)	Lebanon (8/1/2001) µg/m^3	WHO (µg/m^3)	USEPA
Sulphur dioxide (SO_2)	10 mns		500	500	
	1 hr	350			
	24 hrs	120			0.14 ppm
	1 year	80		20	0.03 ppm
Nitrogen dioxide (NO_2)	1 hr	200	500	200	
	24 hrs	150			
	1 year	100		40	0.053 ppm (100 µg/m^3)
Ozone (O_3)	1 hr	150			0.12 ppm
	8 hrs	100		100	0.075 ppm

92 Cropper (2003).
93 Pope et al. (1995); and Pope et al. (2002).
94 Kyle et al. (2002).
95 WHO website: <www.who.int>.

Pollutant	Exposure	Lebanon (52/1/1996) (μg/m³)	Lebanon (8/1/2001) μg/m³	WHO (μg/m³)	USEPA
	1 year			N.A.	
Carbon monoxide (CO)	15 mns 30 mns 1 hr	 30,000		100,000 60,000 30,000	 35 ppm (40 mg/m³)
	8 hrs	10,000		10,000	9 ppm (10 mg/m³)
Total suspended solids	24 hrs	120		Revoked	(75 μg/m³ but revoked)
PM_{10} (< 10 microns)	24 hrs 1 year	 80	200	50 20	150 μg/m³ (50 μg/m³ but revoked)
$PM_{2.5}$ (< 2.5 microns)	24 hrs 1 year	 20		25 10	35 μg/m³ 15 μg/m³
Lead (Pb)	3 months av. Quarterly av. 1 year	 1	30		0.15 μg/m³ 1.5 μg/m³
Benzene	1 year	5 ppb			

Note: For O_3, there is no sufficient evidence to recommend an annual guideline.

Source: MOE Decree 51/1 1996; MOE Decision 1/8 2001; and WHO (2005); METAP (2009).

The most important pollutants are (A2.1):

- Total Suspended Particulates: TSP that is now revoked by the World Health Organisation (WHO) and the United States Environment Protection Agency (USEPA) due to the adoption for more robust compounds, i.e., PM_x;
- Particulate matter: PM_{10}, $PM_{2.5}$ (Suspended Particulates Matter with diameter less than 10 and 2.5 micrometers);
- Nitrogen oxides: NO_x, NO_2;
- Sulphur dioxide: SO_2;
- Ozone: O_3 as more recent evidence underscores the need to focus on shorter exposure to higher levels rather than longer exposure to lower levels such as O_3;
- Carbon: CO, CO_2;
- Volatile organic compounds: VOC; and
- Lead: Pb.

Lebanon air pollution standards exceed WHO and the USEPA permissible thresholds (Table 3.2). Chronic exposure to criteria pollutants could lead to behavior change (condition), morbidity and premature mortality. A brief description of the health effects are derived from WHO and are illustrated in Table A2.2.

Table A2.2: Health Effects Associated with Primary Exposure to Criteria Pollutants and Noise

Pollutant	Health Effects
PM_{10} $PM_{2.5}$	Chronic exposure contributes to the risk of developing cardiovascular and respiratory diseases as well as of lung cancer. $PM_{2.5}$ penetrate deeply into the lungs and could lead to chronic obstructive pulmonary diseases (COPD) and possibly cancer. Chemical substances may adhere to or be incorporated into these particulates. The latter could also be electrically charged by electric magnetic fields and increase the chances of cancer. $PM_{2.5}$ can be transported the farthest by wind and deposited far away from the sources, causing not only local but also regional problems.
SO_2	Chronic exposure affects the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality increase on days with higher SO_2 levels.
NO_2	Chronic exposure leads to reduced lung function, lung cancer and bronchitis in asthmatic children increase in association with long-term exposure.
O_3	Chronic exposure can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases.
CO	Chronic exposure affects the brain, the cardiovascular system, namely lungs at very high concentration levels, exercising skeletal muscle and the developing fetus.
VOC	Chronic exposure can lead to intoxication.
Pb	Chronic exposure can lead to anemia, malaise, and damage to the nervous system. Children are particularly vulnerable to the neurotoxic effects of lead. Relatively low levels of exposure can reduce their IQ scores, cause learning disabilities, poor school performance, and violent behavior.
Noise	Noise exposure causes myocardial infarction, angina pectoris, hypertension and sleep disturbance.

Source: METAP 2009; and WHO website: <www.who.int>.

The DALY Metric

The Disability-adjusted life years (DALY), which is a metric that measures the decrement or increment in health state, was used to determine the burden of air pollution in health terms. Hence, the mortality and morbidity derived in Table A2.3 are denominated in DALY lost to quantify the health effects associated with the reduction or increase of the level of pollutants. The analysis will assign a value on the DALY lost (see below).

The DALY is a non-utilitarian metric that measures the burden of disease and expresses years life lost to premature death and years lived with a disability of specified and normalized severity (0 to 1) and duration (1 to 365 days). The DALY is *one lost year of healthy life* and could be interpreted in two different ways. A *DALY lost* stands for the magnitude of the burden of disease; and a *DALY averted* stands for the magnitude of the burden of disease to be reduced through a policy choice, project or intervention. The DALY life expectancy is set at 80 years for males and 82.5 years for females and the DALY [3,1] is discounted at 3% and includes the age weights whereby a year of healthy life lived at younger and older ages was weighted lower than the other ages, which remain controversial: the discount rate is considered a social discount rate to reflect people preferences with regards to a future disease or condition, e.g., smoking kills but young people keep on smoking which means that they put less weight on their future health than on their actual health, nevertheless, DALY lost could be calculated without the social discount and the age weights, and is usually represented as follows: DALY [0,0]. Hence DALY lost associated with premature death varies with age and is illustrated in

Table A2.2.[96] For more information on the severities and duration of the various diseases to derive DALY lost, see Murray and Lopez (1996) and WHO website: <www.who.int>.

Table A2.3: Life Expectancy and DALY Lost at selected ages by Gender

Age	Life expectancy		DALY lost at selected ages discounted at 3%	
	Male	Female	Male	Female
At Birth	80.0	82.5	33.0	33.0
5 years	75.4	78.0	36.5	36.7
15 years	65.4	68.0	36.8	37.0
30 years	50.5	53.3	29.6	29.9
45 years	35.8	38.7	20.2	20.7

Source: Murray and Lopez (1996).

Dose-Response

The valuation will use the exposure-based evidence from international literature by using the relative risk functions provided by Ostro et al. (2004) and Pope et al. (1995, 2002 and 2009). The impacts of PM_{10} and lead on morbidity are based on dose response coefficients from Ostro (1994) and Akeson et al. (1999) and are illustrated in Table A2.4:

- adult mortality related to cardiopulmonary diseases and lung cancer caused by long-term exposure to $PM_{2.5}$;

- Children under 5 year mortality related to respiratory diseases caused by short-term exposure to PM_{10};

- all-age morbidity related to exposure to PM_{10}, such as chronic bronchitis, hospital admissions of patients with respiratory problems, emergency room visits, restricted activity Days (RAD), lower respiratory infections in children, and general respiratory symptoms.

- adult mortality related to hard attack related to exposure to Pb;

- adult morbidity related to hard attack related to exposure to Pb;

- adult morbidity related to hypertension related to exposure to Pb; and

- Children under 5 year losses of IQ points.

An important question is whether the effects of short term and long term exposures can be aggregated when estimating the damages associated with air pollution. The general answer is yes, if the exposures affect different health endpoints. For example, in computing total health damages, it is certainly appropriate to add cases of acute respiratory illness associated with short term exposures to PM to cases of chronic bronchitis associated with long term exposures to PM.

The relationship between PM_{10} air pollution and short term premature mortality on children under 5 is usually assumed to be semi-logarithmic that may be applied to estimate the relative risk of mortality from concentration levels of PM_{10}:

[96] METAP (2009); and Murray and Lopez (1996).

Relative Risk =

(1) E(deaths) = exp[β(pollution) - (compound threshold)]

2) (Δdeaths)/deaths = β(Δpollution).

Equivalently, (βΔpollution) is the percentage change in deaths associated with a given change in pollution. This implies that a given change in pollution (e.g., 10 micrograms per cubic meter or $\mu g/m^3$ of PM_{10}) has the same percentage impact regardless of the level of pollution.

The relationship between $PM_{2.5}$ air pollution and long term premature mortality on adults greater than 30 years is usually assumed to be log-linear that may be applied to estimate the relative risk of mortality from concentration levels of $PM_{2.5}$:

Relative Risk = $[(X + 1)/(X_0 + 1)]^{\beta}$

Where X is annual concentration of $PM_{2.5}$; and X_0 is a threshold level below which it may be assumed that the relative risk of mortality from $PM_{2.5}$ is 1.0 (no mortality effect from $PM_{2.5}$). The β coefficient is 0.1551 for cardiopulmonary mortality and 0.2322 for lung cancer mortality.

The attributable fractions (AF) assess the proportion of cases in a population attributable to certain risk factors. One of the most frequently applied approaches calculating the AF is the Levin formula, which requires only the relative risk estimate (RR) and the prevalence of the risk factor (p):

AF = p*(RR-1)/1+p*(RR-1)

Where p is derived from WHO's Burden of Disease prevalence of risk factors and RR is derived from the above formulas.

End Points Used

The morbidity health endpoints considered are chronic bronchitis, hospital admissions of patients with respiratory problems, emergency room visits, restricted activity days, lower respiratory infections in children, and general respiratory symptoms. While this list is not exhaustive, it captures the health endpoints that are likely to have the largest monetary impact on total damages.

Table A2.4 summarizes the impact of the common air pollutants on other health endpoints, including the incidence (number of new cases) of chronic bronchitis, respiratory hospital admissions, respiratory restricted activity days and sub-clinical symptoms (itchy, watery eyes, runny nose). Estimates of the effects of air pollution on the incidence of chronic illness come from cross-sectional studies. Most of the remaining impacts rely on time series variation in air pollution to measure its impact on health.

Table A2.4: Dose Response Functions with the Main Criteria Pollutants: Central Estimates

Annual Health Effects and Pollutant standards	Age Group or % reduction	Effects of 1 $\mu g/m^3$ annual average ambient concentration				
		PM_{10}	$PM_{2.5}$	Pb	SO_2	NO_2
PM_{10} until reaching 20 $\mu g/m^3$						
Premature mortality	Under 5 years	0.084				
Chronic bronchitis	Per 100,000 of >15 years	0.87				
Hospital admissions	Per 100,000 of >15 years	1.2				

Annual Health Effects and Pollutant standards	Age Group or % reduction	Effects of 1 µg/m^3 annual average ambient concentration				
		PM_{10}	$PM_{2.5}$	Pb	SO_2	NO_2
Emergency room visits	Per 100,000 of >15 years	23.5				
Restricted Activity Days (RAD)	Per 100,000 of >15 years	5,750				
Acute Lower Respiratory Infection	Per 100,000 of < 5 years	169				
Respiratory symptoms	Per 100,000 of >15 years	18,300				
$PM_{2.5}$ until reaching 7.5 µg/m^3						
Premature mortality	% reduction		0.8			
Pb until reaching 1 µg/m^3						
Premature mortality	Per 100,000 adult males >45 years			35		
IQ Point Loss (points)	Per 1 child < 5 years			0.98		
Hypertension cases	Per 100,000 adult males >15 years			7,260		
Doctor's Visits: ½ the cases	Per 100,000 adult males >15 years			3,630		
RAD: 1 day	Per 100,000 adult males >15 years			3,630		
Non-fatal heart attack cases	Per 100,000 adult males >45 years			34		
Hospital admissions: 3 days	Per 100,000 adult males >45 years			17		
Emergency room visits: 1 day	Per 100,000 adult males >45 years			17		
RAD: 4 days	Per 100,000 adult males >45 years			136		
SO_2 until reaching 50 µg/m^3						
Premature mortality	% reduction				0.048	
Respiratory symptoms	Per 100,000 of < 5 years				0.0018	
Chest discomfort	Per 100,000 of >15 years				0.01	
NO_2 until reaching 40 µg/m^3						
Lung cancer	% reduction					0.108

Source: Adapted from Ostro (1994); Pope et al. (1995); Pope et al. (2002); Ostro (2004); Nafstad et al. (2004); WHO (2005); and Pope et al. (2009).

It should be noted that, while the impact of a change in pollution concentrations is usually measured in terms of a percentage change in the health endpoint of concern this is not always the case. When the impact is measured per person (for each person in the exposed population) care must be taken to compare the size of the estimated effect to the baseline number of cases of the illness to check that results are reasonable.

Valuation

Valuing mortality remains controversial. Still the human capital approach (HCA) and the value of statistical life (VSL, which is an expression of preferences for reducing risks of death in monetary terms) were used as the former to account for pain and suffering for DALY lost due to morbidity and the latter for premature mortality cases. Most importantly, these values are the social cost of premature death and are several times higher than real premature death compensation in Lebanon, e.g., the compensation provided by the public sector or the private sector (insurance company) are much lower than the values considered in the analysis that is considered in terms of welfare economics, which is a branch of economics that uses microeconomic techniques (stated or revealed preferences) to valuate economic well-being (Table A2.5).

Table A2.5: Cost of Illness Used in the Valuation, 2012

Item	Unit	Unit Cost in 2012
Hospitalization	LP/day	1,067,076
Emergency Visit	LP/visit	177,846
Doctor Visit	LP/visit	88,923
RADs	LP/day	106,708
HCA for morbidity DALY lost (pain and suffering)	LP/DALY Lost	14,630,879
VSL for premature mortality	LP/DALY Lost	89,937,042

Note: The benefit transfer used the Purchasing power parity (PPP) for the income differential because nominal exchange rates do not always reflect international differences in relative prices hence PPP rates allow a standard comparison of real price levels between countries, just as conventional price indexes allow comparison of real values over time; the income elasticity is assumed to be conservatively set at 1, which means that the percentage responsiveness of quantity demanded is exactly equal to the percentage change in income. The PPP$ conversion factor or international dollar is used for the GDP/capita, which is the number of units of a country's currency required to buy the same amount of goods and services in the domestic market as a U.S. dollar would buy in the United States.

Source: World Bank (2002); Viscusi and Adly (2003); and Authors.

The HCA, which is the value associated to the pain and suffering in terms of morbidity represented by DALY lost, is usually calculated by using the net present value at 5% of the foregone income from mortality from age 20 to 65 years (although women retirement is set at 60 years in Lebanon). The results is divided by 13 DALYs lost (average remaining life expectancy). For simplification purposes, the GDP per capita is applied per DALY lost. The VSL, which is the value associated with the risk to reduce premature death, adapts values derived internationally by using a benefit transfer method. In this particular case, the VSL meta-analysis figure of US$ 3.5 million in 2000 is provided by Viscusi and Adly (2003) and transferred to Lebanon. The VSL is divided by 20 DALY lost to determine the value per DALY lost (Table A2.5).

Biodiversity Category

Various encroachments are registered along the basin resulting in loss of ecosystem and medicinal plants. TEEB has been considered for the CAWRD (loss of services) while all the interventions of other sub-categories can be considered as restoration costs.

Natural Disaster and Global Environment Category

Natural disasters and climate change impacts are considered in a continuum from short to long term.

Natural Disasters. The intensity and frequency of floods, droughts, extreme weather events, fires, etc. are exacerbated over time. The costs of impacts include: health (mortality, injury, drowning, infectious diseases, psycho-physical stress), destroyed property, impaired assets (revealed preferences using the hedonic method) in areas likely to be most affected by floods (depreciation of land prices in flood zones), swell (depreciation of land prices in coastal areas due to the swell and coastal erosion), etc., disruption of services, infrastructure affected; resources (reduced resource and ecosystem effects) dilapidated, reduced economic productivity and so on. The cost of restoration and prevention depends on the preparedness and effectiveness of the response.

Green House Gas Emissions. As a result of past emissions of CO_2 and other greenhouse gases (GHG), the world is now on course for future climate change. The World Resource Institute identifies 2 tons of CO_2 per year per capita as the threshold not to be exceeded to limit the temperature growth to 2°C, above which irreversible and dangerous climate change will become unavoidable. So, the carbon that will be considered as damage cost will be the marginal carbon emissions that exceed 2 tons of CO_2 per year per capita.

The social cost of CO_2 is the present and future (2000-2099) damage from a ton of current emissions in terms of: floods, droughts, sea-level rise, declining food production, species extinction, etc. Several estimations are available for the social cost of CO_2 emissions ranging from US$ 3 to US$ 95 (Nordhaus, 2001; Stern, 2007; and IPPC, 2007). Recently, the European Commission (EC 2008 and DECC 2009) has reported US$ 6 per ton as a lower bound value of CO_2 and the French study (Centre d'analyse stratégique, 2009) as an upper bound value of CO_2 with US$ 11 per ton in 2009. A range of US$ 11-15 per ton of CO_2 in 2008 prices was considered as lower bound and higher bound based on Nordhaus, 2011, which estimated the social cost of carbon for the current time (2015) including uncertainty, equity weighting, and risk aversion at US$ 13.6 or LP 20,509 per ton of CO_2 and equivalent to US$ 46.1 or LP 69,473 per ton of carbon in 2012.

Annex III Specific Method for Water Resources Category

The TEV of water is a combination of use and non-use type of values (Table A3.1). Use values include direct use and indirect use values. Non-use values include existence values, option and bequest values. An example based on hypothetical improvements in river water quality has been chosen to explain each category:

*Use Value*s arise from the actual and/or planned use of the service by an individual, and be direct or indirect:

- Direct, such as when an individual makes actual use of the environmental asset improved, for example, fishing where it was not possible to catch a fish before the improvements in water quality took place;
- Indirect use values are the benefits derived from ecosystem functions gained, for example, where recreational activities are created or enhanced due to water quality improvements, individuals can benefit in the form of increased recreational opportunities without having to make a direct use of the resource (e.g., walking alongside the river bank).

Non-use values are often divided into:

- Existence values, which arise from knowledge that the service exists and will continue to exist, independently of any actual or prospective use by the individual. This type of use refers to the economic value people place on improvements to the quality of a river due to some moral and/or altruistic reasons, or for the mere pleasure of knowing that the river's water has been enhanced;
- Option values refer to the value place on resource's future use. Because individuals are not sure whether they will use the resource in the future, they are willing to pay to maintain the ability to use it;
- Bequest value is the value an individual places on the ability to preserve a resource so that it can be used by future generations.

Table A3.1 Types of benefits covered with the proposed method

Benefit	Types of water uses			Example
Potential water quality benefits	Current use benefits	Direct use	In stream	Recreational activities: Fishing, swimming, boating
		Indirect use	Near stream	Recreational activities: Hiking, trekking
				Relaxation, enjoyment of peace and quiet
				Aesthetics, enjoyment of natural beauty
	Non use		Option	Preferences for future personal use of the resource
			Existence	Maintaining a good environment for all to enjoy
			Bequest	Enjoyment from knowledge that future generations will be able to make use of the resource in the future

Source: Adapted from Baker et al. (2007).

The achievement of GES for surface waters in Lebanon is important because of the current trends in water pollution and availability. These are in most cases beyond the assimilative capacity of the aquatic ecosystems, which make freshwater quality a principal limitation for sustainable development.

In order to transfer the benefit functions from Baker et al. (2007), the following variables have been adjusted from the original model:

- Current fresh water quality levels in Lebanon (below standards);
- Average income levels per household in Lebanon (World Bank);
- Education levels in Lebanon (World Bank);
- Population number, Household Gender composition and Household occupancy in Lebanon (World Bank);
- Other socio-economic data: GDP in local currency and PPP conversion factors in Lebanon (World Bank).

These parameters are used in the WTP formulae to directly calculate the annual Willingness to Pay (WTP) for set improvements in freshwater quality per household per year.

Considering the benefits derived from water quality improvements is essential for making sound decisions regarding the country's aquatic ecosystems and habitats. Decisions could for example relate to efficient and equitable infrastructure investment in the water sector, to the efficient degree of waste water treatment and to the design of policy measures, including economic instruments such water pricing or taxes on water depletion and pollution.

Society's preferences for environmental improvements do not have a market value and have to be estimated in monetary terms by using valuation techniques. 'Non-market valuation' techniques must be applied to establish this portion of the TEV of water use. Valuation techniques are based either on revealed preference (based on observed market values that can be used as substitutes for the improved environmental resource) or on stated preferences (based on surveys of willingness to pay, especially for household water use and recreational services).

Determining the value of an individual's or community's use of water is very difficult, because water values are highly site-specific, dependent on type of uses, as well as season, water quality, availability and reliability. As for types of uses, people make different uses of water resources, which translate into different values. For example, the value of water for cooling purposes in hydropower is different to that of water used for irrigation in agriculture or for fishing in a lake.

Due to the lack of regional valuation studies on the topic, and the **impracticability, due to time and budget constraints,** to conduct an original valuation study, the Benefits Function Transfer (BFT) approach has been applied to estimate the TEV of cleaner water. This method allows for the incorporation of differing socio-economic and site quality characteristics between the original study site for which the original benefits estimates were obtained and the policy site under evaluation. Under this approach, typically only one original valuation study is selected. The main assumption made is that the statistical relationship between WTP values for improvements and independent variables are the same for both the study and policy site. In other words, the method assumes that preferences/tastes are the same for both locations and differences in WTP are only related to differences in socio-economic and/or environmental context variables.

For this report, the benefit functions from Baker et al. (2007) have been transferred to Lebanon. This study has recently estimated the economic value placed by English and Welsh households for water quality improvements at local and national level as a result of implementing the Water Framework Directive (WFD) in the UK. This study is one of few studies that employed a standard WFD ecological-based water quality metrics for description of baseline levels and improvements. As an additional feature, Baker et al. (2007) offers detailed results for two different WTP elicitation methods in the same survey instrument, i.e., Contingent Valuation (CV) using both payment card (PCCV) and dichotomous choice (DCCV) as payment mechanisms. The advantage behind the use of two different elicitation methods for the transfer exercise (the PCCV and the DCCV results) is the need to offer ranges of WTP estimates that are representative for policy purposes and illustrate the uncertainty surrounding the results (i.e., sensitivity analysis).

The benefits from water quality improvements covered in this section by the application of the BFT method are related with the quantifiable portion of the TEV of particular use and non-use types derived from the enjoyment of good water quality by local residents of the country. The specific types of water uses covered in the model are highlighted with examples in Table A3.1). It is important to note that it is not possible to disaggregate values for the different types of uses outlined and that other types of water uses are valued and assessed in other sections of this report.

The three scenarios retained in the Baker et al. (2007) study are as follows:

- Scenario 1: 33 percent Successive Improvement after 9 years, 15 years and 20 years;
- Scenario 2: 50% Improvement after 9 years, 30% after 15 years and 20% after 20 years; and
- Scenario 3: 100 percent Improvement after 9 years.

Table A3.2 WTP per Household Based on Payment Card and Dichotomous Choice Benefit Transfer, 2012

WTP	HH number	Scenario 1 33% Successive Improvement after 9 years, 15 years and 20 years (CL: 95%; CI ±2.5%)			Scenario 2 50% Improvement after 9 years, 30% after 15 years and 20% after 20 years (CL: 95%; CI ±2.5%)			Scenario 3 100% Improvement after 9 years (CL: 95%; CI ±2.5%)		
	#	US$/year			US$/year			US$/year		
	2008	2012			2012			2012		
		Low	**Mid**	High	Low	**Mid**	High	Low	**Mid**	High
Total	4.23	50	115	181	54	124	193	62	143	224

Note: $PPP GDP per capita was used to adjust income differential between the UK and Lebanon, and the income elasticity is conservatively considered at 1.

Source: Baker et al. (2007); World Bank (2010); and Authors.

Mean WTP values for the 85% overall water quality improvement scenario in Lebanon ranges between US$ 51.4 and US$ 185 per year per household (Table A3.2) depending on the two payment mechanisms used in the original contingent valuation method employed in Baker et al. (2007). Results are shown in a range to illustrate the degree of uncertainty associated with the benefits estimates that were elicited through a survey that used the Contingent Valuation (CV) methodology using both payment card (PCCV) and dichotomous choice (DCCV) as payment mechanisms. The lower end of the range represents mean values of the PCCV format and the upper-bound range is derived from the DCCV model. The benefit transfer provides "order of magnitude" results, in order to communicate the scale and significance of the potential benefits arising from improved surface water quality.

Considering the benefits derived from water quality improvements is essential for making sound decisions regarding the country's aquatic ecosystems and habitats. Decisions could for example relate to efficient and equitable infrastructure investment in the water sector, to the efficient degree of waste water treatment and to the design of policy measures, including economic instruments such water pricing or taxes on water depletion and pollution.

Society's preferences for environmental improvements do not have a market value and have to be estimated in monetary terms by using valuation techniques. 'Non-market valuation' techniques must be applied to establish this portion of the TEV of water use. Valuation techniques are based either on revealed preference (based on observed market values that can be used as substitutes for the improved environmental resource) or on stated preferences (based on surveys of willingness to pay, especially for household water use and recreational services).

Determining the value of an individual's or community's use of water is very difficult, because water values are highly site-specific, dependent on type of uses, as well as season, water quality, availability and reliability. As for types of uses, people make different uses of water resources, which translate into different values. For example, the value of water for cooling purposes in hydropower is different to that of water used for irrigation in agriculture or for fishing in a lake.

Due to the lack of regional valuation studies on the topic, and the **impracticability, due to time and budget constraints,** to conduct an original valuation study, the Benefits Function Transfer (BFT) approach has been applied to estimate the TEV of cleaner water. This method allows for the incorporation of differing socio-economic and site quality characteristics between the original study site for which the original benefits estimates were obtained and the policy site under evaluation. Under this approach, typically only one original valuation study is selected. The main assumption made is that the statistical relationship between willingness-to-pay (WTP) values for improvements and independent variables are the same for both the study and policy site. In other words, the method assumes that preferences/tastes are the same for both locations and differences in WTP are only related to differences in socio-economic and/or environmental context variables.

Annex IV Specific Methods for the Valuation of the Solid Waste Category

Collection cost. The cost of collection in urban and rural areas for 5% of the population that has no coverage in ULB is equivalent to 1 % of their gross national income per capita of LP 14,418,453 per year[97] with a ± 10% variation per household. The cost of the degradation of the non-collection is equivalent to LP 7.6 billion in 2012 with a range from LP 6.1 to 9.2 billion.

Cleaning cost of waste discharged into dumps. The population considered is ULB population not served by the Zahleh landfill where the municipal waste generated per capita reaches 0.64 kg[98] per capita per day.

The following assumptions are used:

- the depth of discharge is from 1 meter.
- The average density of waste dumped is 340 kg/m³ .
- Reducing the volume through the uncontrolled landfill fires is 2/3, and leaving a balance of 1/3.

The total municipal waste generated that is not properly handled has the potential to pollute 195,969 m^2 = (547.6 ton/day * 365) * 1/3 * 1/340 . For cleaning dumps, LP 25,884 m^3 per ton (1 m^2 per 1 meter deep) was adopted.[99] The cost of cleaning up to LP 5.1 billion 2012 with a variation from LP 4.1 to 6.1 billion.

Recycling. Waste management in Lebanon has developed formal and informal systems of recovery of waste materials with large impacts on the volume and weight of municipal waste collection and final disposal. The results are shown in Table A4.1 and the cost of the damage amounts to LP 18.2 billion in 2012 with a variation from LP 12.7 to 21.8 billion.

Table A4.1: Potentially Recyclable Waste in ULB, 2012

	Population	Generated Waste that is mishandled		Metal	Glass	Paper/ Cardboard	Plastic	Compost Certified Grade	Total LP Billion
	#	kg/day	Ton/an	5.0%	3.0%	11.0%	11.0%	60.0%	
Total	1,565,463		370,263	9,994	5,997	21,988	21,988	119,933	
Cost/ton (LP/ton)				401,290	45,099	60,133	160,489	75,301	
CAWRD LP Billion				**4.0**	**0.3**	**1.3**	**3.5**	**9.0**	**18.2**
Lower bound LP Billion									*12.7*
Upper Bound LP Billion									*21.8*

Source: Bassi et al. (2011); World Bank CEA (2011); GIZ-SWEEPNET Lebanon Report (2012); and Authors.

97 World Development Indicator (2013).
98 MOE/UNDP/ElArd. 2011. Op. cit.
99 Bassi et al. (2011).

Land value depreciation surrounding the dumps. The methodology of hedonic costs was used to derive the cost of depreciation of land surrounding the dumpsites.[100] The dumpsites are considered in a circle shape to derive the first ring and the second ring of value depreciation: ± 15 % reduction in land prices in a radius up to 30 m around the discharge, and ± 10% price reduction land in a radius from 30 to 100 m around the landfill. Apartments and buildings were not considered while a larger depreciation could be calculated when better data is available. No distinction was made between wild and semi-controlled discharges in the ULB. The results are shown in Table A4.2.

Lost electricity generation and GHG emissions due to the non-capture of methane in the future. The solid waste generation that is mishandled in the ULB amounts to 370,263 tons. By year 3, 5.1 MCM of methane could be used to generate electricity and 3,466 tons of methane could be avoided being released in the atmosphere. Only one year has been considered in the future for simplicity purposes while capturing flows may extend over several years. The production of electricity that can be generated is 49.3 million kW/h using the following formula: 1 m^3 CH_4 = 9.8 kW/h with 100% efficiency. The monetary equivalent is LP 6 billion in 2012 when the NPV is calculated using a discount rate of 5% with an average rate of LP 127 per kW/h (EDL production rate) to consider these lost benefits at the present time. The emission of methane that could be avoided by year 3 is equivalent to 86,652 tons of CO_2 equivalent. The monetary equivalent of LP 1.4 billion in 2012 when the NPV is calculated using a discount rate of 5%.

[100] Nelson (1978).

Table A4.2: Hedonic valuation of land value depreciation surrounding dumpsites in ULB, 2012

Area	Number of Dumpsite with 0.5 ha per dumpsite on average	Total Area	D^2= S/Pi/4	Original Diameter	Original Radius	Radius 30 m	Radius 100 m	Area 30 m	Area 100 m	Losses 30 m	Losses 100 m	Land Price	Losses 30 m 15% of Price	Losses 100 m 10% of Price
		m^2		m	m	m	m	m^2	m^2	m^2	m^2	LP/m^2	LP	LP
ULB	**71**	71,000	**452,000**	**672**	**336**	**366**	**405**	**421,191**	**515,694**	**66,191**	**94,502**	**50,000 (40,000-60,000)**	**496,433,319**	**472,512,339**
Total														**968,945,657**
Lower bound at LP 40,000/m^2														*775,156,526*
Upper bound at LP 60,000/m^2														*1,162,734,789*

Source: Nelson (1978); Bassi et al. (2011); MOE/UNDP/ElArd (2011); GIZ-SWEEPNET Lebanon Report (2012); and Authors.

Annex V Specific Method for Air Valuation Category

The degradation cost of air pollution in Zahleh and Baalbeck was calculated using the method developed in Annex II. The results are shown in Tables A5.1, A5.2 and A5.3.

Table A5.1 : CAWRD due to Air Pollution in Zahleh, 2012 in LP

Dataset	Total
Crude mortality rate (per 1,000)	4.4
Annual Average PM10 (µg/m^3)	30
Annual Average PM2.5 (µg/m^3)	15
Exposed Population 90% (million)	0.092
Exposed adults >= 30 years (million)	0.041
Children <= 14 years (million)	0.025
Children < 5 years (million)	0.005

Category	Unit	Impacts per 1 µg/m^3	DALYs per 10,000 cases	Cases	DALYs lost	Unit Cost LP	HCA/ DALY LP	VSL/ DALY LP	Total LP
Premature mortality for <5 ys	±% Crude mortality rate	0.084	100,000	0.2	2			89,937,042	164,766,643
Premature mortality for >30 ys	(see Annex II)		130,000	10	129			89,937,042	11,626,070,211
Chronic bronchitis	per 100,000 adults	0.87	22,000	6	13		14,630,879		188,856,944
Hospital admissions	per 100,000 population	1.2	160	11	0	1,067,076	14,630,879		14,396,730
Emergency room visits	per 100,000 population	23.54	45	217	1	177,846	14,630,879		52,891,241
Restricted activity days	per 100,000 adults	5,750	3	38,778	12	106,708	14,630,879		584,001,554
Lower respiratory illness	per 100,000 children	169	65	418	3	88,923	14,630,879		77,013,865
Respiratory symptoms	per 100,000 children	18,300	1	123,416	12		14,630,879		180,568,551
Total Health					172				12,888,565,738
Mortality					*131*				11,790,836,854
Morbidity					*41*				596,313,495
COI									501,415,390

Table A5.2: CAWRD due to Air Pollution in Baalbeck, 2012 in LP

Dataset	Total
Crude mortality rate (per 1,000)	4.4
Annual Average PM10 (µg/m^3)	30.0
Annual Average PM2,5 (µg/m^3)	15.0
Exposed Population 90% (million)	0.17
Exposed adults >= 30 years (million)	0.08
Children <= 14 years (million)	0.05
Children < 5 years (million)	0.01

Category	Unit	Impacts per 1 µg/m^3	DALYs per 10,000 cases	Cases	DALYs lost	Unit Cost LP	HCA/ DALY LP	VSL/ DALY LP	Total LP
Premature mortality for <5 years	±% Crude mortality rate	0.084	100,000	0.2	2		0	89,937,042	213,901,955
Premature mortality for >30 years	(see Annex II)		130,000	12	151		0	89,937,042	13,589,904,759
Chronic bronchitis	per 100,000 adults	0.87	22,000	8	17		14,630,879		245,176,261
Hospital admissions	per 100,000 population	1.2	160	14	0	1,067,076	14,630,879		18,690,001
Emergency room visits	per 100,000 population	23.54	45	282	1	177,846	14,630,879		68,664,018
Restricted activity days	per 100,000 adults	5,750	3	50,342	15	106,708	14,630,879		758,157,548
Lower respiratory illness in children	per 100,000 children	169	65	543	4	88,923	14,630,879		99,980,287
Respiratory symptoms	per 100,000 children	18,300	1	160,220	16		14,630,879		234,416,174
Total					206				15,228,891,003
Mortality					153				13,803,806,713
Morbidity					53				774,141,051
COI									650,943,238

Table A5.3: CAWRD due to Air Pollution in the Upper Litani River, 2012 in LP

Input	**Total**
Burden of Disease	28,117,456,741
Mortality	*25,594,643,567*
Morbidity	*1,370,454,546*
COI	*1,152,358,628*
Agricultural productivity	1,883,869,602
Infrastructure decaying	1,265,285,553
Grand Total	**31,266,611,896**
Lower bound	*28,139,950,706*
Upper bound	*34,393,273,08*

Annex VI Remediation Results

Gains associated with access to improved sanitation and drinking water are shown in Table A6.1. Scenarios 1 and 2 of the Qaraoun Depollution investment BCA flows are illustrated in Tables A6.2 to A6.5.

Table A6.1 : Gains associated with access to improved sanitation and drinking water, 2012, in LP Billion

Population without improved access	2012	Reduction of Diarrhea	Reduction of mortality cases	Reduction of Diarrhea cases	Value per case	Gains in 2012
	#	#	#	Million	LP Million	LP Billion
Without Improved Sanitation (million)	0.267					
Birth rate (newborn per 1,000 inhabitants)	13.0	0.150	3		1,798.7	5.5
Population < 5 years (million)	0.014	1.150		0.016	0.089	1.4
Population ≥ 5 years (million)	0.252	0.225		0.057	0.042	2.3
Sub-Total						**9.3**
Without Improved Water and Sanitation (million)	0.421					
Birth rate (newborn per 1,000 inhabitants)	13.0	0.180	6		1,798.7	10.5
Population < 5 years (million)	0.023	1.380		0.031	0.089	2.8
Population ≥ 5 years (million)	0.399	0.270		0.108	0.042	4.3
Sub-Total						**17.6**
Total						**26.9**

Sources: adapted from Bassi et al. (2011); World Development Indicators (2013); and Authors.

Table A6.2: Ongoing, Planned and Additional Qaraoun Depollution Investment BCA Flows 2012-2020, LP Billion

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cost	171.1	171.1	171.1	25.7	26.4	27.2	28.0	28.9	29.8
Benefit		28.4	30.0	69.6	72.4	75.3	78.4	81.5	84.9
Benefit/Cost	(171.1)	(142.7)	(141.1)	44.0	46.0	48.1	50.3	52.7	55.1

Source: MOE/UNDP/ElArd (2011); CDR Progress Report (2013); and Authors.

Table A6.3: Ongoing, Planned and Additional Qaraoun Depollution Investment BCA Flows 2021-2031, LP Billion

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cost	30.6	31.6	32.5	33.5	34.5	35.5	36.6	37.7	38.8	40.0	41.2
Benefit	88.4	92.0	95.8	99.8	104.0	108.3	112.9	117.7	122.7	127.9	133.4
Benefit/Cost	57.7	60.4	63.3	66.3	69.5	72.8	76.3	80.0	83.9	88.0	92.3

Source: MOE/UNDP/ElArd (2011); CDR Progress Report (2013); and Authors.

Table A6.4: Additional Qaraoun Depollution Investment BCA Flows 2012-2020, LP Billion

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cost	68.1	68.1	68.1	10.2	10.5	10.8	11.2	11.5	11.8
Benefit				38.0	39.1	40.2	41.3	42.4	43.6
Benefit/Cost	(68.1)	(68.1)	(68.1)	27.8	28.6	29.3	30.1	30.9	31.7

Source: MOE/UNDP/ElArd (2011); CDR Progress Report (2013); and Authors.

Table A6.5: Additional Qaraoun Depollution Investment BCA Flows 2021-2031, LP Billion

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cost	12.2	12.6	12.9	13.3	13.7	14.1	14.6	15.0	15.5	15.9	16.4
Benefit	44.8	42.8	44.1	45.4	46.8	48.2	49.6	51.1	52.6	54.2	55.8
Benefit/Cost	32.6	30.2	31.1	32.1	33.0	34.0	35.0	36.1	37.2	38.3	39.4

Source: MOE/UNDP/ElArd (2011); CDR Progress Report (2013); and Authors.

Annex VII Disaggregated Results of the Cost Assessment of Water Resources Degradation

Table A7.1: Disaggregated Results of the Cost Assessment of Water Resources Degradation

Category/Sub-category	Upper Litani Basin	Lower Bound	Upper Bound	Relative %	In % of Lebanon GDP	Lower Bound	Upper Bound
Category							
Water	263.5	218.8	312.2	77%	0.4%	0.3%	0.5%
Waste	37.8	29.5	44.3	11%	0.1%	0.0%	0.1%
Air	31.3	28.1	34.4	9%	0.0%	0.0%	0.0%
Biodiversity	0.3	0.2	0.3	0%	0.0%	0.0%	0.0%
Global Environment	9.8	8.0	11.6	3%	0.0%	0.0%	0.0%
Total	342.6	284.6	402.8	100%	0.5%	0.4%	0.6%
% of Litani GDP							
Water	1.7%	1.4%	2.0%				
Waste	0.2%	0.2%	0.3%				
Air	0.2%	0.2%	0.2%				
Biodiversity	0.0%	0.0%	0.0%				
Global Environment	0.1%	0.1%	0.1%				
Total	2.2%	1.8%	2.6%				
Sub-Category							
WATER	263.5	218.8	312.2	76.9%			
Waterborne Diseases	73.8	59.7	92.0	21.5%			
Drinking Water Quality and Quantity	85.3	72.5	98.1	24.9%			
Water Resource Quality	43.3	38.6	48.0	12.6%			
Agriculture Salinity	0.01	0.01	0.01	0.0%			
Municipal Water Services	7.6	6.1	9.1	2.2%			
Irrigation Services	40.8	32.7	49.0	11.9%			
Dam Sedimentation	0.02	0.02	0.03	0.0%			
Agriculture Erosion	3.9	1.9	5.8	1.1%			
Agriculture Drawdown	0.5	0.4	0.7	0.2%			
Dam Storage Forgone Opportunities	8.3	6.9	9.5	2.4%			
WASTE	37.8	29.5	44.3	11.0%			
Collection	7.6	6.1	9.2	2.2%			
Clean up	5.07	4.06	6.09	1.5%			
Sorting/Recycling/Composting	18.2	12.7	21.8	5.3%			
Land Value Depreciation	1.0	0.8	1.2	0.3%			
Energy	6.0	5.8	6.1	1.7%			
AIR (Zahleh and Baalbeck)	31.3	28.1	34.4	9.1%			
Air Burden of Disease	28.1	25.3	30.9	8.2%			

Category/Sub-category	Upper Litani Basin	Lower Bound	Upper Bound	Relative %	In % of Lebanon GDP	Lower Bound	Upper Bound
Agricultural productivity	1.9	1.7	2.1	0.5%			
Infrastructure decaying	1.3	1.1	1.4	0.4%			
BIODIVERSITY	0.3	0.2	0.3	0.1%			
Ecosystem Services	0.3	0.2	0.3	0.1%			
NATURAL DISASTER AND GLOBAL ENVIRONMENT	9.8	8.0	11.6	2.9%			
Flooding/Disruption due to heavy rain	8.4	6.7	10.0	2.4%			
Forgone carbon sequestration due to Forest loss/fire	0.01	0.01	0.01	0.0%			
Emissions not captured from landfill	1.4	1.3	1.5	0.4%			
Emissions not captured from forgone electricity production	0.23	0.20	0.25	0.1%			
-Total GHG	*1.6*	*1.5*	*1.8*	0.5%			

Source: Authors.