REGIONAL
GOVERNANCE AND KNOWLEDGE GENERATION PROJECT

STRATEGIC ENVIRONMENTAL ASSESSMENT
FOR
THE NEW WATER SECTOR STRATEGY FOR LEBANON

DELIVERABLE 4

FINAL SEA REPORT

19 May 2015

Prepared and Submitted by the ECODIT-led Consortium:

ECODIT

CONSULTATION & RESEARCH institute
مؤسسة البحوث و الإستشارات

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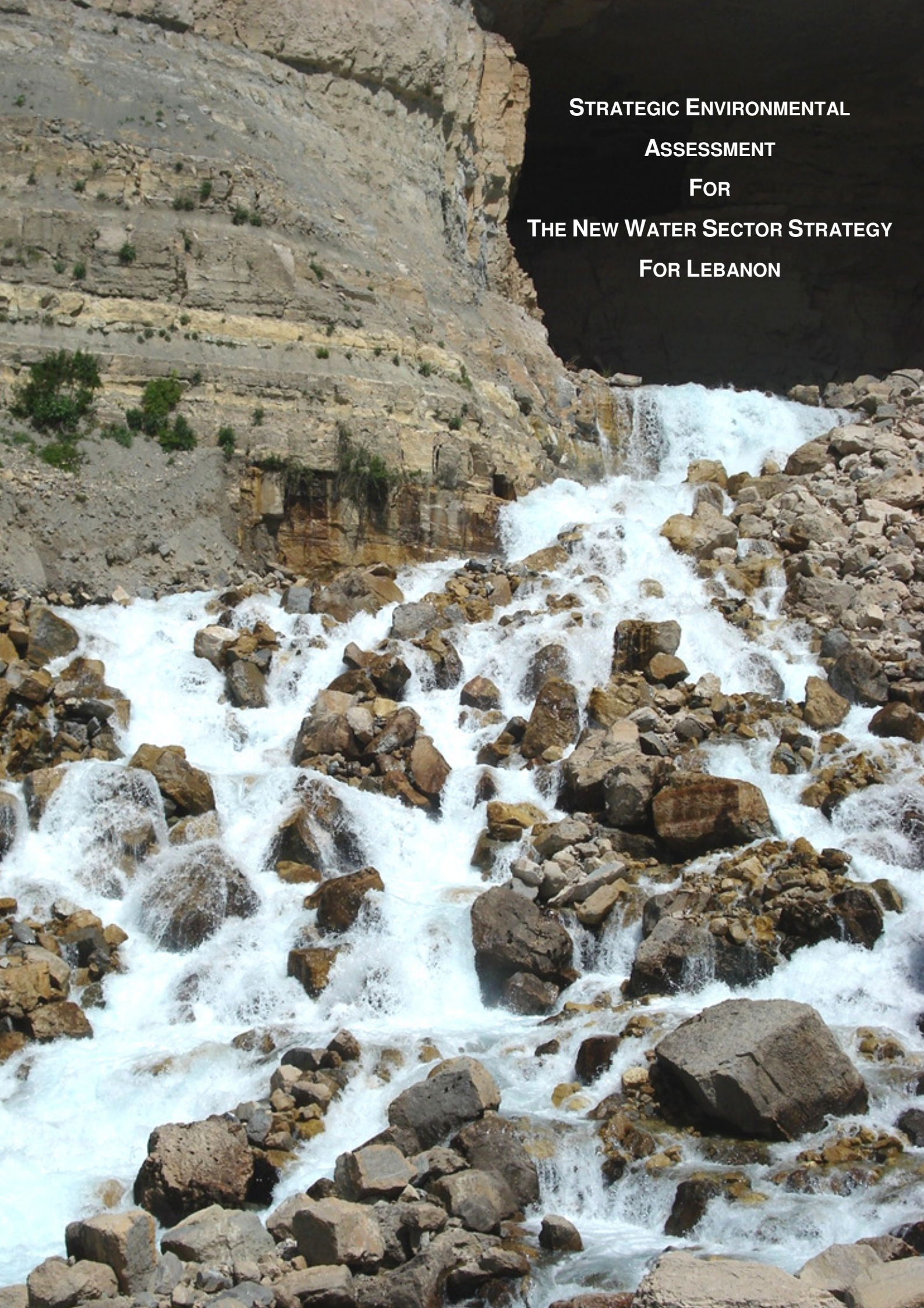


Strategic Environmental Assessment For The New Water Sector Strategy For Lebanon

Project Title	STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE NEW WATER SECTOR STRATEGY FOR LEBANON
Deliverable Name	Final SEA Report
Deliverable Number	4
Client	Plan Bleu and the Ministry of Energy and Water
Funding	World Bank – GEF REGIONAL – GOVERNANCE AND KNOWLEDGE GENERATION PROJECT
Consultant	ECODIT LIBAN
Project Team	**Karim El Jisr** (Team Leader), **Raymond Colley** (Senior SEA Advisor), **Zuhier el Hassan** (Water Resources Specialist), **Ghassan Jaradi** (Ecologist and Biodiversity Specialist), **Redha Hamdan** (Social Scientist), **Osama Abu Rayan** (Environmental Economist), **Naji Tannous** (Energy Specialist), **Capricia Chabarekh** (Pollution Specialist), and **Rita Stephan** (GIS and Land Management Specialist)
Contract Number	Plan Bleu 2013-012

Disclaimer

The Strategic Environmental Assessment of the National Water Sector Strategy (2010-2020) was prepared in compliance with Lebanon's Decree 8213/2012. The SEA is prepared for and on behalf of the Ministry of Energy and Water, and is reviewed by the Ministry of Environment.

Despite efforts by the Consultant and the Ministry of Environment to solicit the views and comments of the MEW on the draft and revised SEA report, the MEW chose not to provide comments. The Final SEA Report therefore was compiled and submitted without the endorsement of the MEW.

The following chronology of events and correspondence summarize the SEA process:

June 6, 2013	Contract signature between Plan Bleu pour l'Environnement et le Développement en Méditerranée and ECODIT
July 12, 2013	Plan Bleu informs former ministers of Environment and Energy and Water of the contract award and duration
June 21, 2013	Environment Minister appoints a review committee for the SEA of the National Water Sector Strategy (MOE Decision 170/1)
Jul. 23, 2013	ECODIT submits *draft* Literature Review Report to MEW
Nov. 18, 2013	ECODIT submits *draft* Scoping Report to MEW
May 15, 2014	ECODIT submits *draft* SEA Report to MEW and Plan Bleu
Aug. 11, 2014	National Council for the Environment (NCE) invites ECODIT to present preliminary SEA findings of the National Water Sector Strategy[1]
Sept. 30, 2014	ECODIT submits *revised* SEA Report to MEW and Plan Bleu.
Nov. 11, 2014	ECODIT resubmits *revised* SEA Report (dated Sept. 30) to MEW's minister's office
Dec. 23, 2014	ECODIT receives a request from the Directorate General of Hydraulic and Electric Resources to provide all previous project documentation and minutes of previous meetings to facilitate the review process (Ref 1009/S).
Dec. 29, 2014	ECODIT submits all the requested project documentation and minutes of previous meetings to the MEW (Ref 7896) _ copy registered at MOE (Ref 5818 / B)
Jan. 12, 2015	MOE sends a memo to MEW reiterating the objectives of the SEA study and its importance to Lebanon's water sector, and recommending the organization of a joint press conference (MEW and MOE) to present the SEA findings to the media (Ref 5818/B).
Mar. 5, 2015	ECODIT sends a follow-up memo to the Directorate General of Hydraulic and Electric Resources requesting a meeting to solicit and discuss the comments of the Directorate on the draft SEA while focusing on the 12 key SEA issues (Ref 1279)
Mar. 11, 2015	MOE sends a follow-up memo to MEW to solicit the ministry's comments on the draft SEA report by March 31, 2015 (before contract expiry) (Ref 5818/B).
Mar. 27, 2015	MEW responds to MOE explaining that it cannot approve the SEA Report because references to *Ibl es Saqi* dam and its impact on the Hasbani-Wazzani river system are erroneous and contrary to Lebanon's national interest.

[1] The NCE meeting on August 11, 2014 was attended by all the members of the Council including the MEW.

Mar. 25, 2015	Plan Bleu sends a memo to MEW informing the Ministry that the SEA contract with ECODIT was extended until March 31 "in order to accommodate any comments from the Ministry of Energy and Water on the final report" and that Plan Bleu would be willing to extend the consulting contract one last time until April 30 "on condition that MEW can make a formal commitment to provide comments on the final report to the consulting firm ECODIT." Ref 1384/15/HR/SD)
Mar. 31, 2015	MOE responds to MEW's memo dated March 27 emphasizing the importance of producing a final SEA report that is endorsed by both ministries (Energy and Water, and Environment) and presenting two options going forward: (1) the preferred option: MEW provides comments by April 13 to ECODIT and Plan Bleu, and (2) the SEA Report is finalized and released after correcting all references to *Ibl es Saqi*.
Apr. 30, 2015	MEW sends a final memo to MOE rejecting the SEA Report and confirming its intent not to provide comments. MEW also requests the preparation of a new SEA Report under the supervision of the MEW's Directorate General of Hydraulic and Electric Resources.

Based on the above,

The SEA consultant, ECODIT, prequalified by the Council for Development and Reconstruction to conduct environmental studies, prepared the Final SEA Report without receiving official comments from the MEW.

Therefore,

The present SEA study of the National Water Sector Strategy is released to the public, in full compliance with Decree 8213/2012, but without MEW approval.

Acknowledgement

ECODIT wishes to thank the following individuals and institutions for their valuable contribution and critique of previous deliverables under this contract:

- Mr. Abdo Tayar (MEW)
- Mr. Ziad Zakhour (MEW)
- Mr. Ziad Khayat (MEW-UNDP)
- Ms. Manal Moussallem (MOE-UNDP)
- Mr. Vahakn Kabakian (MOE-UNDP)
- Mr. Samer El Hachem (MOE Review Committee)
- Mr. Bassam Sabbagh (MOE Review Committee)
- Ms. Samar Malek (MOE Review Committee)
- Mr. Jean-Roger Mercier (Plan Bleu – World Bank)
- Ms. Lina Tode (Plan Bleu)

The preparation of the Strategic Environmental Assessment report was the coordinated effort of the entire ECODIT LIBAN team including:

- Raymond Colley (Senior SEA Advisor),
- Zuhier el Hassan (Water Resources Specialist),
- Ghassan Jaradi (Ecologist and Biodiversity Specialist),
- Redha Hamdan (Social Scientist),
- Osama Abu Rayan (Environmental Economist),
- Naji Tannous (Energy Specialist),
- Capricia Chabarekh (Pollution Specialist), and
- Rita Stephan (GIS and Land Management Specialist)

It is hoped that this SEA has contributed to enhancing the political, scientific, and environmental dialogue on Lebanon's water sector, and to narrowing the gaps between policy making and public opinion.

Karim El-Jisr
Team Leader

*The Minister of Environment appointed a committee to review the NWSS SEA on 21/6/2013 (MoE Decision 170/1)

EXECUTIVE SUMMARY

The Ministry of Energy and Water (MEW) prepared in 2010 a National Water Sector Strategy (NWSS). The strategy was endorsed by the Council of Ministers on March 9, 2012.[2] The strategy presents a detailed road map for improving water conditions and service delivery in the country, and recommends the preparation of a Strategic Environmental Assessment (SEA). The Terms of Reference for the SEA study were prepared by Plan Bleu in consultation with MEW and the Ministry of Environment, and based on Decree 8213/2012. Plan Bleu funded the SEA under the Global Environment Facility project "Regional Governance and Knowledge Generation" and commissioned ECODIT, a Lebanese consulting company, to carry out the study.

Description of the National Water Sector Strategy

The National Water Sector Strategy articulated seven objectives:

(1) Maximizing the potential and improving the quality of surface water resources,
(2) Improving the management and protection of groundwater resources,
(3) Fulfilling deficits through groundwater and/or surface water,
(4) Ensuring proper and continuous access to high quality water supply,
(5) Providing adequate quantities and quality of water for irrigation,
(6) Increasing coverage of wastewater collection networks and treatment capacities, and
(7) Optimizing current wastewater treatment processes and sludge disposal.

The NWSS is divided into two parts: seven infrastructure initiatives and five water sector initiatives. The infrastructure initiatives are summarized in Table A.

Table A. Summary of NWSS Infrastructure Initiatives and Cost Estimates

Strategy Initiatives	*Summary Description*	*Cost Estimate ($M)*
1. Optimizing surface water storage	• 64 million CM of additional water	$2,206 (29% of total CAPEX)
2. Artificial recharge of groundwater aquifer	• Up to 200 million CM of additional water by artificial recharge (during the wet season / excess flow)	
3. Surface storage: dams and hill lakes	• Up to 670/880 million CM of water storage (static/dynamic) • 46 sites identified as suitable for surface storage incl. dams and hill lakes (<1 million CM)	
4. Water supply transmission	• 2800 km of transmission pipes • 191000 m^3 of storage in 561 tanks	$1,790 (23%)
5. Water supply distribution	• 9600 km of distribution pipes • About 1 million water meters	
6. Irrigation rehabilitation and expansion	• Up to 30,000 ha irrigated by 2020 • Additional 60,000 ha irrigated by 2035	$577 (7%)
7. Wastewater collection & treatment	• 12 coastal STPs planned to serve 5,597,000 people-equiv. • 42 inland STPs planned to serve 1,977,750 people-equiv.	$3,104 (40%)

[2] The NWSS was approved a few weeks before the SEA Decree 8213/2012 was enacted by the Council of Ministers; it was therefore not possible to commission the SEA earlier, i.e., before the formal endorsement of the NWSS.

These initiatives can be grouped into three programs:

(1) Production
(2) Transmission and Distribution, and
(3) Wastewater

The total CAPEX of the NWSS amounts to approximately $7.6 billion. Total OPEX amounts to $2.1 billion ($210 million per year). The water sector objectives can be categorized into five headings:

(1) Tariffs
(2) Water and wastewater quality
(3) Research and monitoring
(4) Demand management, and
(5) Water conservation

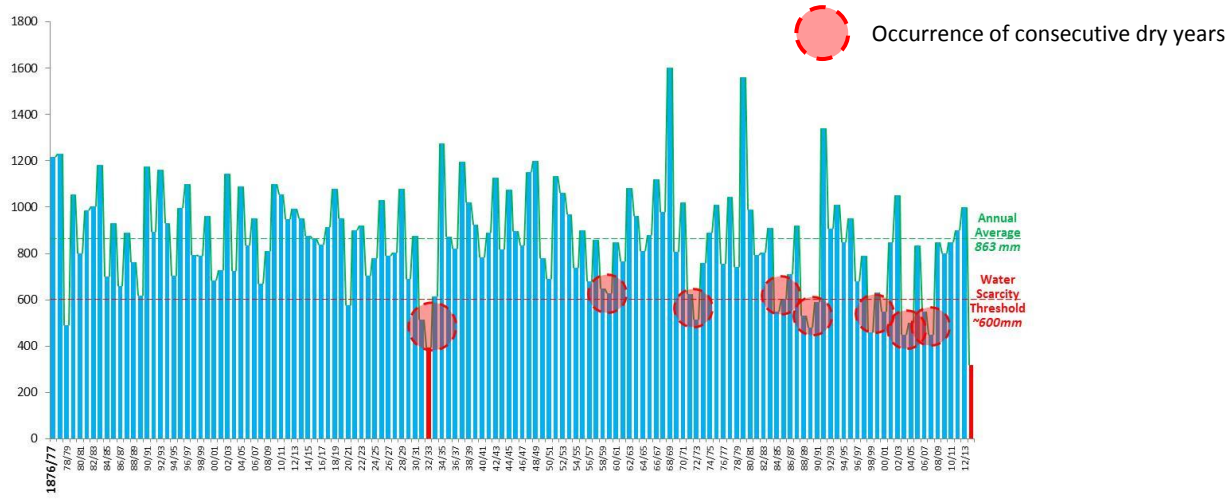
The NWSS assembled a patchwork of initiatives and local investments that were developed in response to immediate local needs and build them into a coherent strategy to serve the national interest over a period of 20 years or more. Therefore, although the NWSS was formally endorsed in 2012, it includes many investments (dams, conveyance systems, irrigation schemes, and wastewater treatment plants) that MEW, CDR, and LRA started planning and building many years ago.

Assessment of Baseline Conditions – Water Data

Much of the NWSS is based on water data that was analyzed and published decades ago. Lebanon's 1970 assessment of total and available water resources is obsolescent and is in dire need of update. Recent groundwater studies by MEW and the UNDP have started to update the old data but much more work remains to be done to effectively evaluate Lebanon's current water balance, including the Net Exploitable Resources. Producing reliable water data is without a doubt the cornerstone of any water planning strategy.

Although Lebanon is in a relatively fortunate hydrological position, a recent compilation of precipitation data in Beirut by the American University of Beirut shows significant fluctuations in annual rainfall as well as recurring dry years. The occurrence of consecutive dry years (drought) is increasing as evidenced by at least five such incidents in the last 30 years, compared to only three such incidents in the 100-year period from 1876 to 1975.

Figure A. Precipitation in Beirut and the Occurrence of Consecutive Dry Years (1876 – 2014)



Assessment of potential impacts resulting from the NWSS

Based on a targeted assessment of baseline conditions, the SEA Team identified 12 SEA Key Issues from a much longer list of environmental, social and economic issues. Many issues were deselected during scoping because it was determined that they did not carry national and/or *strategic* importance and therefore should be addressed in project-specific EIA studies. The SEA team assessed and described the potential environmental and social impacts of NWSS programs and initiatives, both individually and cumulatively:

SEA Key Issues	**Production**	**Transmission & Distribution**	**Wastewater**
Climate change adaptation	✓		
Effects on Ecology and Ecosystems	✓		✓
Effects on Marine Environment and Coastal Waters	✓		✓
Effects on Underground Water and Karst	✓	✓	✓
Water-Energy Nexus	✓	✓	
Man-Made Water Bodies and Buffers	✓		
Catastrophic Failure and Emergency Planning	✓		✓
Water-Poverty Nexus		✓	
Treated Sewage Effluent and Sludge Reuse			✓
Construction and Excavation Waste	✓	✓	✓
Operation and Maintenance	✓	✓	✓
Transboundary Waters	✓		

Key impacts related to each program are summarized below.

(1) Environmental and Social Impacts of NWSS Production Program

Production includes optimization of surface water resources, artificial recharge of groundwater aquifers, and surface storage (dams and hill lakes). The NWSS aims to mobilize an additional 935 MCM of water by optimizing spring capture (65 MCM), artificial groundwater recharge (200 MCM), and the construction of up to 18 dams and 23 hill lakes (670 MCM).[3] Impoundments including dams and water reservoirs have many valuable functions, such as supplying water for domestic and irrigation purposes, particularly in drought prone areas, and providing hydroelectric power. They can also create a milder local climate for species threatened by human activities.

Production, mainly dams and related installations, have many environmental and social effects:

- Planned dams and hill-lakes will supply much-needed water to households, farmers and the tertiary sector.
- Dams and impoundments are land greedy and will require extensive and expensive expropriations.
- Dams will potentially encroach on protected areas and sites.
- Some dams will inundate forests and/or riparian ecosystems as well as rare species.
- Dams and impoundments will require extensive excavation and will significantly alter landforms and landscapes.

[3] The number of dams and hill lakes may vary based on site conditions and further feasibility studies

- Dams will create Man-made water bodies that require buffers zones and management.

(2) Environmental and Social Impacts of NWSS Transmission & Distribution

This program also includes irrigation rehabilitation and expansion. The NWSS aims to replace 2,800 km of existing over-aged transmission systems and associated equipment and bulk meters and improve leakage detection. This program will also expand the transmission systems to meet growing water demand by, for example, completing the Awali-Beirut conveyor (domestic water) and the Canal 800 (irrigation water). The program will replace existing over-aged distribution networks including house connections (about 9,600 km of pipes) and install almost 1 million water meters.

The most significant effects of water conveyance are linked to excavation and waste disposal, and energy intensity:

- Conveyance may require costly and extensive excavation works.
- Conveyance and distribution are energy demanding; unfortunately the capacity of Water Establishments to monitor their energy consumption is very weak.
- The supply of irrigation water (and to a lesser extend domestic water) from proposed storage dams will help reduce groundwater abstraction.
- Large-scale irrigation schemes will reduce hydropower potential, mainly on the Litani River (Lebanon's largest hydro-electric producer), and thereby compromise Lebanon's ability to meet its 2020 pledge to meet 12% of its energy consumption from renewables.
- Irrigation schemes will provide much needed irrigation water to poverty areas and help displace rainfed crops in favor of high-value crops; reduced subsidy can in turn free up resources to support new crops and efficient irrigation methods.

(3) Environmental and Social Impacts of NWSS Wastewater Program

Wastewater including collection, treatment and disposal will have far-reaching and welcome effects on the natural environment and public health. Whereas inland Sewage Treatment Plants (STPs) will help curb surface and groundwater pollution, coastal STPs will also reduce land-based sources of pollution into the Mediterranean Sea. Improved quality of coastal waters will stimulate the tourism industry and associated economies. The most significant effects of the on-going wastewater program are:

- Wastewater treatment will reduce pollution loads into the Mediterranean Sea by up to 80% when all coastal and major inland STPs are completed and running.
- Wastewater treatment efficiency will depend on O&M performance and the capacity of the Water Establishments to either run these facilities or outsource O&M services to private contractors; chronic understaffing and financial constraints has so far crippled the WEs and forced the CDR to include O&M services in the STPs construction contracts.
- STPs will produce Treated Sewage Effluent (TSE) and sludge. Illegal intrusion of industrial wastewater can hamper wastewater treatment systems resulting in substandard TSE and sludge quality. TSE and sludge reuse remain unregulated though draft guidelines were prepared in 2010.

- Direct TSE discharge into watercourses may lead to pollution if this practice is unregulated; direct discharge must be calibrated based on TSE quality and volume, and the volume of the receiving water.

Analysis of Alternatives and Selection of the Most Suitable Strategic Option

No-Action Alternative

Normally, an SEA would explore and evaluate the No-Action Alternative. In this case, the NWSS is well underway and some of its momentum cannot be reversed. For example, the sewage program is ongoing and cannot be reversed considering the vast resources already invested in the sector. Dealing with O&M as well as environmental issues remains an urgent priority.

There is a *conceivable* No Action Alternative on the dams program, which would entail halting the commissioning of further dams (nine dams are already under construction or in advanced planning stages). But Lebanon is facing a water shortage. It could perhaps be addressed in the short term with effective demand management and effective institutions. It is clear from the analysis presented in the NWSS however that **without effective action to increase supply, that even under conservative demand scenarios, Lebanon would be in danger of facing severe water shortages in the near future, particularly if rainfall is low.** In summary, a realistic No-Action Alternative would entail completing the ongoing initiatives that are already in advanced planning and the construction that is already underway, **provided there are no outstanding environmental issues of major significance to Lebanon's ecology and natural heritage**, but holding off on new investment.

Other Options and Complementary Measures for Achieving NWSS Goals

Strategically, and as outlined in the NWSS, it is important to assess and accelerate the water reform process, increase efficiency, reduce losses (Unaccounted for Water, UfW), and augment water resources *concomitantly*. Some of this can be achieved by facilitating Private Sector Participation. It is equally important that the NWSS remains flexible and that MEW engages interest groups and water stakeholders in a sustained dialogue. Because water is a cross-sectoral commodity, the MEW cannot implement the strategy alone. For example, the Civic Influence Hub launched in 2013 a water program coined "Blue Gold" which, although similar to the NWSS, presents interesting nuances and design variations that should be considered and further studied by MEW. Those include inter-basin connectivity, the capture of freshwater submarine springs, and a greater push for private sector participation in the delivery of water services under the framework of a federative economy.

Equally important for the success of the NWSS is the acceleration of the (limping) water reform process. In addition to Laws 221/2000 and 241/2000 reorganizing the country's water institutions, Lebanon also needs a National Water Council to oversee all water planning and implementation programs. This Council, explicitly mentioned in the draft Water Code, would be expected to:

(1) Prioritize the general objectives in the water sector
(2) Approve the general master plan
(3) Agree on all national and regional projects related to organizing and distributing water
(4) Follow-up on the implementation of related conventions and protocols
(5) Enhance coordination between line ministries.

Augmenting available water resources is a national priority. On the supply side, the NWSS has considered the most readily available options including optimizing surface water storage, artificial

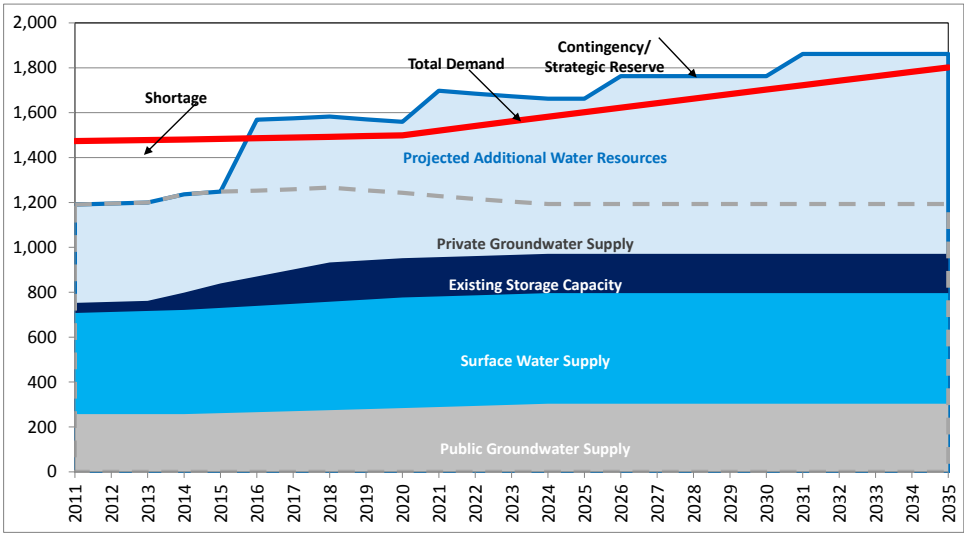
recharge of groundwater aquifers, and storage dams and hill-lakes. The effectiveness of storage dams is however highly sensitive to uncertainty due to climate change and hydrogeology.

The other conceivable options to increase water supply include submarine freshwater springs, and desalination. Lebanon's mountain range topography is conducive to the emergence of such springs in its territorial waters and within short distances from the shoreline, primarily in the regions of Tyre and Chekka. Although preliminary analysis indicated that capturing freshwater submarine springs was at the time technically and financially not feasible, onshore exploitation of submarine springs through inland wells of differing depths was found to be economically feasible for several tested scenarios (different flows and depths). To assess the commercial viability of capturing submarine freshwater springs, MEW would need to study further their locations, flow rates including seasonal fluctuations, quality including potential pollution from inland sources, and cost. This complementary action clearly deserves increased attention in the NWSS.

Priority Actions and Emergency Solutions for Deficit Reductions

The NWSS demand and supply forecasts for the period 2010-2020 shows a significant water deficit of about 283 MCM until 2015-2016, after which the projected additional water resources (from artificial recharge, treated wastewater reuse, and surface storage) will begin to materialize (see Figure B). Although the NWSS correctly anticipated deficits, it could not foresee the scale or severity of the water deficit – partly due to unforeseeable factors (Syrian refugees and drought). The NWSS does not have emergency contingency provisions within it except when all production initiatives have been implemented. The SEA therefore concludes the NWSS is deficient in terms of planning for emergency responses and urgent short-term solutions need to be developed outside the framework of the NWSS. These solutions (increased efficiency, more aggressive Water Demand Management, and new water sources) should comply with Lebanon's policy framework and regulations, as well as the pending Water Code.

Figure B. Supply & Demand Planning in Lebanon for a Moderate Dry Year (2011 – 2035)



Selection of the Most Suitable Strategic Option

The requirement to select the most suitable strategic action in the SEA report is based on the assumption that the SEA study takes place in the ideal situation, i.e. where a number of alternative

strategic plans are being considered before implementation has started. In the case of NWSS, implementation has already begun and no complete alternatives for achieving the same strategic objectives have been systematically set out in the strategy itself or in the documentation supporting the strategy. The above notwithstanding, it is possible to draw some useful conclusions about the environmental and social suitability of the NWSS against the No Action Scenario and some of the partial alternatives that have been discussed in Lebanon or elsewhere in the region.
Namely:

- The NWSS provides a coherent strategy in an area where action is vital. This is because of the future potential for severe water shortages and pollution of water courses coupled with potential economic disruption associated with small farmers who are reliant on irrigation water.
- There are several potentially significant negative environmental and social impacts that may be associated with implementation of the NWSS (land take, ecological effects, risk associated with large dams) but most of these can either be satisfactorily addressed through well-designed management measures and/or, the impact would not be significantly lessened by adoption of an available alternative.
- Where alternative approaches have been identified that might yield better environmental and social outcomes (for example use of grey water, submarine freshwater springs, agricultural reform), these are not precluded by adoption of the NWSS, which can be adapted and enhanced to accommodate more effective approaches as they become available.

With the above in mind it is reasonable to conclude that **the NWSS is the most suitable strategic option from an environmental and social perspective, and is a necessary strategy which does not have irremediable negative impacts and for which there are no clearly superior available alternatives.** However, we cannot say this, with the same conviction, when we refer to the dams program. As explained in this report, **the dams programs must be reviewed and potentially framed and implemented so as to minimize its cumulative impact on Lebanon's ecology and natural heritage.** Lebanon's dam experience to date (Qaroun and Chabrouh) provides invaluable opportunities for learning, and this learnt knowledge, should be harnessed to benefit the planning, construction, and operation of future dams.

The SEA has compiled a list of policy responses (some of which are already embedded in the NWSS), organized into three stakeholder groups: MEW, MOE, and other. Other agencies with policy responsibilities include the Council of Ministers, Council for Development and Reconstruction, the Ministry of Agriculture, regional Water Establishments, the Directorate General of Urban Planning, and organizations with specific mandates such as the Higher Relief Council, and the National Center for Marine Sciences. See policy responses in Table B overleaf.

However, it is vital that the NWSS remains flexible, in that it allows for adjustment of the elements and targets of the strategy as time progresses and more information comes available. The NWSS can be greatly enhanced by researching and adopting other options and/or complementary measures for achieving the same goals. For these measures to unfold, it is important that MEW continues to moderate an open-minded and transparent discourse on Lebanon's water strategy with all relevant stakeholders. In other words, water planning must not end in 2010 when the NWSS was compiled but, rather, should adapt to the growing uncertainties and emerging opportunities in the water sector.

Table B. Policy Framework for Optimizing the Environmental and Social Effects of the NWSS

Key SEA Issues Requiring NWSS or Related Policy Response	*MEW*	*MOE*	*Others*
1. Climate Change adaptation	• Develop and implement drought management plans (incl. WDM strategies) for domestic, agricultural and industrial sectors • Extend the work and mandate of the recently completed UNDP "Groundwater Assessment Database Project" to support decision-making and update Lebanon's water budget	• Mobilize resources for next Climate Change report and share latest findings and CC scenarios with MEW to guide NWSS updates	• COM: prioritize climate change knowledge by significantly increasing funding for it • LRA: revamp its river hydrometric system (equipment and knowhow) • MEW-DGUP: Develop watershed management plans for all dams • COM: Review Disaster Management Planning (and panoply of redundant committees)
2. Effects on ecology and ecosystems	• Accelerate coordination of NWSS-related EIAs (notably dams) with MOE, including obsolescent EIAs; share EMPs for all STPs and dams with MOE for review and approval; incorporate approved EMPs in tender documents • Develop Guidance Notes for the construction and O&M of water projects (production, conveyance, wastewater)	• Identify biodiversity hotspots, determine vulnerabilities and trends, and make guidance for management of water bodies including minimum environmental flows • Request EIA consultants to conduct comprehensive ecological baseline surveys for all dams	• NCSR and Universities: monitor the effects of impoundments on riparian ecosystems and species • MOA-MOE-Higher Council for Hunting: extend nascent hunting regulation to water-body dependent species • MOA**:** Review with MOE policy on "replacement trees" in favor of ecological restoration of affected ecosystems
3. Effects on marine environment and coastal waters	• Coordinate the completion and handover of STPs from CDR to WEs • Resolve all power supply issues to operate and maintain TSPs	• Monitor BOD_5 discharges into the Mediterranean Sea based on MOE Decision 8/1 (2001)	• *NCSR-Pressure NGOs:* Monitor bathing water quality along the coastline and inform the public (blue flag program)
4. Effects on underground water and karst	• Assess the potential impacts of NWSS dams program on underground water and karst (at project EIA level)	• Include in EIA Guidance Note the assessment of dams on underground water and Karst; request impact modeling and tracer studies as part of the EIA.	• *Speleologists and caving groups:* Participate in the discourse on the impact of dams and lobby for the protection of important Karst formations (e.g., Balaa)

Key SEA Issues Requiring NWSS or Related Policy Response	*MEW*	*MOE*	*Others*
5. Water-Energy Nexus	• Establish management information system to collect energy consumption data by the water sector (at WE level) • Analyze energy savings from Chabrouh Dam due to gravity transmission and distribution; extrapolate to other dams to establish a net energy balance • Review and update Lebanon's hydropower production potential post NWSS based on the preliminary work of SOGREAH	• Accelerate the review of all EIAs of proposed renewable energy projects (to offset lost hydropower production on Litani River –by NWSS)	• COM and RE stakeholders: review RE 2020 target and develop roadmap to get there (not limited to hydropower) • Remove barriers to hydropower production and clear-up the legal framework to incentivize the private sector
6. Man-made water bodies and buffers	• Coordinate the delineation of buffer zones for dams program based on the NLUMP (Zones N, P and S) in coordination with relevant agencies (MOA, MOPWT – DGUP) • Incorporate "buffer zones" in the planning and design of dams to protect the resource and prevent contamination	Prepare Guidance Notes (guidelines): 1. Man-made water bodies (specifying which activities are sanctioned, buffer zones, and erosion control-measures) in coordination with: MEW, MOA, and DGUP. 2. TSE discharge into watercourses based on TSE quality and volume of receiving water 3. Restoration of riparian habitats around man-made water bodies	• MEW-MOE-MOA: Develop Guidance Note on man-made water bodies; coordinate the management of buffer zones with Urban Planning agencies • MOA: prepare Guidance Note on erosion control measures to protect soils and slow down siltation around reservoirs
7. Catastrophic Failure and Emergency Planning	• Adopt (or adapt) the World Bank's classification system for dams • Capitalize on the recent work of the LRA to develop a template Emergency Action Plan for all large dams and STPs (emergency levels, notifications, actions, and termination) • Test EAPs with relevant authorities and downstream communities	• Include mandatory Emergency Action Plans for large dams and large STPs	• Presidency of the COM: Reorganize previously established committees for disaster response and management (see Climate Change policy response) • Discuss potential role of the Lebanese Armed Forces in protecting strategic reservoirs against sabotage

Key SEA Issues Requiring NWSS or Related Policy Response	*MEW*	*MOE*	*Others*
8. Water-Poverty Nexus	• Developing a fair and affordable water and wastewater pricing strategy that allows for cost recovery without penalizing the lowest-income groups • Assess periodically the water and sanitation needs of unserved areas and groups including refugees	• Mainstream the recommendations and goals of water and poverty policy documents: MDG, Horizon 2020, Rio+20 National Report.	• MOA: Start planning for new crops in South Lebanon in anticipation of large conveyance and irrigation projects • DGUP and local municipalities: Conserve agricultural lands that will benefit by large scale irrigation schemes incl. Canal 900 (West Bekaa) and Canal 800 (South Lebanon)
9. Treated Sewage Effluent and sludge reuse	• Endorse guidelines for TSE and sludge reuse in agriculture and landscaping in coordination with the FAO and MOA • Capture opportunities for TSE reuse in the coastal area using storage ponds if needed (and thereby minimize direct discharge)	• Review and endorse MEW-FAO guidelines for TSE and sludge reuse • Develop with MEW guidelines for TSE discharge into water courses (inland STPs) to avoid loading the receiving waters.	• MOA-WE's**:** Monitor TSE and sludge reuse in agriculture and land reclamation; troubleshoot as needed.
10. Construction and excavation waste	• Enforce EMP mitigation measures for all excavation works and ensure site restoration before handover over	• Require site cleanup and restoration as part of construction close-out procedures (before reception of works) • For networks and large conveyance projects, develop guidance on EIA screening or initial EA (e.g., construction methods, soil conservation, archaeology)	• CDR: Include site cleanup and restoration in tender documents and as a precondition for final reception of works
11. Operation and Maintenance	• Enhance O&M systems (maybe license operators and require a training system as a licensing condition) • Enhance the O&M capabilities of WEs and/or improve their PSP skills (contract management and supervision)	• Ensure that Guidance Note on construction and O&M address this key SEA issue, with penalties for violators	• MOI: Enforce with MOE the mandatory pre-treatment of industrial wastewater according to MOE Decision 8/1 (2001) to avoid loading STPs
12. Transboundary Waters	• Respect all bilateral agreements (with Syria) regarding the damming of two transboundary rivers: Kebir and Aassi		• Strategically, COM must continue to declare and plan investment projects on all trans-boundary waters to reserve / secure Lebanon's water rights

Recommendations for integrating SEA findings in the NWSS

The SEA Report identified 12 key issues potentially affected by the NWSS. It also presented several policy responses that would help mitigate or alleviate the environmental, social, and economic burden of the NWSS. Priority recommendations for integrating SEA findings in the NWSS include:

(1) Mid-term appraisal of the NWSS. There is a strong case for a "mid-term appraisal" of the NWSS through which lessons from experience so far could be learned, targets and methodologies could be re-assessed, and SEA safeguards could be implemented. MEW can now refer to actual experience to see, in part, where NWSS worked, was too ambitious, or was derailed by unforeseen events (budget overruns, Syrian refugee crisis, and 50-year drought occurrence). For example, if the levels of investment predicted by NWSS are shown to be far in excess of anything yet achieved, these must be revised or MEW must explain what new mechanisms are in place to transform their performance.

(2) Iterative process for NWSS revisions. Based on this mid-term appraisal, the MEW should review the NWSS and its strategic roadmap (2010-2020) and consider scaling-back its dams program in light of social, economic, and environmental constraints. NWSS revisions must be realistic and implementable in a resource-constrained environment.

(3) Implementation Unit for oversight and monitoring. There is an urgent need to clearly assign responsibility for oversight and monitoring of the NWSS in one office (Implementation Unit) at the MEW which annually reports to the Council of Ministers. This office will need resources to discharge its mandate; there may be strong donor interest for capacity building in monitoring systems and information management.

(4) National water dialogue. Since the MEW does not have direct power to require ministries and bodies outside its jurisdiction to undertake any action related to the NWSS, it has to rely on dialogue. The proposed National Water Council would be able to address actions that require broad cross-sectoral co-operation including data sharing, catchment protection, climate change adaptation, and Water Demand Management.

(5) Regulations, Guidance and Standards. This SEA Report has identified several areas where guidance and/or regulations are urgently needed to complement the NWSS interventions and protect natural resources. The following guidance and regulations are needed:

- Classification system for dams (small and large, based on World Bank's OP 4.37), which will guide the need for Emergency Action Planning.
- Guidance Notes for the construction and O&M of water projects (production, conveyance, and wastewater).
- Guidance Notes on man-made water bodies specifying land use activities, buffer zones, erosion control-measures, and ecological restoration measures.
- Guidance Notes on Treated Sewage Effluent discharge into water courses to avoid pollution of the receiving waters.

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List of Abbreviations and Acronyms

AEWA	Agreement on the Conservation of African-Eurasian Migratory Water Birds
BCM	Billion m^3
CBD	Convention of Biological Diversity
CDR	Council for Development and Reconstruction
CEPF	Critical Ecosystem Partnership Fund
CITES	Convention on International Trade in Endangered Species
CNRS	National Council for Scientific Research
COM	Council of Ministers
EMP	Environmental Management Plan
EOI	Expression of Interest
EPP	Emergency Preparedness Plan
GEF	Global Environment Facility
GOL	Government of Lebanon
ICOLD	International Commission for Large Dams
IFI	International Financial Institutions
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LCWMC	Lebanese Center for Water Management and Conservation
LRA	Litani River Authority
MCE	Maximum Credible Earthquake
MCM	Million m^3
MEA	Multilateral Environmental Agreement
MEW	Ministry of Energy and Water
MOE	Ministry of Environment
NCE	National Council for the Environment (Lebanon)
NCMS	National Center for Marine Sciences
NLUMP	National Land Use Master Plan
NWC	National Water Council
NWSS	National Water Sector Strategy
PCM	Presidency of the Council of Ministers
PE	People-Equivalent (used in connection with sewage treatment)
RE	Renewable Energy
RFQ	Request for Proposals
ROR	Run-of-the-river (used in connection with hydropower generation)
RWA	Regional Water Establishment (same as WWE)
SEA	Strategic Environmental Assessment
SNC	Second National Communication (to the UNFCCC)
STP	Sewage Treatment Plant
TARS	Total Annual Rainfall and Snow
TSE	Treated Sewage Effluent
UNCCD	United Nations Convention to Combat Desertification
UNCSD	United Nations Conference on Sustainable Development
UNFCCC	United Nations Framework Convention on Climate Change
WBDS	Water Bodies Dependent Species
WWE	Water and Wastewater Establishment

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1. INTRODUCTION

1.1 BACKGROUND

The Ministry of Energy and Water (MEW) prepared in 2010 a National Water Sector Strategy (NWSS). The strategy was subsequently endorsed by the Council of Ministers on March 9, 2012. The strategy presents a detailed road map for improving water conditions and service delivery in the country, and recommends the preparation of a Strategic Environmental Assessment (SEA) as part of one of its water sector "management" initiatives. The Terms of Reference for the study were drawn up by Plan Bleu in consultation with the MEW and the Ministry of Environment (MOE). Plan Bleu funded this SEA under the Global Environment Facility project "Regional Governance and Knowledge Generation" and commissioned ECODIT LIBAN, a Lebanese consulting company, to carry out the study.

This document is the Final Report of the recommended SEA.

1.2 SEA OBJECTIVES

This SEA Report seeks to satisfy the following objectives:

(1) Conduct a systematic assessment of the environmental and social effects of the National Water Sector Strategy

(2) Provide recommendations and high level policy advice to the MEW for optimizing the National Water Sector Strategy and limiting potential adverse effects

(3) Provide feedback to the MOE on the practical application of the SEA regulation in Lebanon (Decree 8213/2012) and recommendations for streamlining the process.

Because Lebanon has to date conducted only a small number of formal SEAs, we have prepared a schematic diagram to show the overlap between the SEA and the project cycle. The schematic shows the SEA in relation to other environmental planning tools (EIA, EMP, and EMS). See Figure 1 on page 4.

1.3 METHODOLOGY

To conduct this SEA, ECODIT mobilized a multi-disciplinary 9-member team:

- *Karim El-Jisr*, Team Leader
- *Raymond Colley*, SEA Expert
- *Zuhier el Hassan*, Water Resources Management Expert
- *Ghassan Jaradi*, Ecology Expert
- *Redha Hamdan*, Social-Scientist
- *Osama Abu Rayan*, Environmental Economist
- *Naji Tannous*, Energy Expert
- *Capricia Chabarekh*, Environmental Specialist
- *Rita Stephan*, GIS and Land Management Specialist

Their qualifications and contributions to the SEA Report are summarized in **Annex 12.1**

Prior to this Final SEA Report, the ECODIT team submitted three previous deliverables:

Deliverable	*Draft*	*Revised*
1. Literature Review Report	Jul. 23, 2013	Aug. 2, 2013
2. Scoping Report	Nov. 18, 2013	Dec. 17, 2013
3. Draft SEA Report	May 15, 2014	Sep. 30, 2014

The Scoping Report presented a set of key issues which were endorsed by the Joint-Review Committee. Those key issues, listed in Chapter 2, form the basis for the SEA Report.

The ECODIT team then completed the following methodological steps:

(1) Conducted interviews and consultations with key stakeholders including government/regulators, water utilities, design consultants and technicians, non-governmental pressure groups, as well as affected individuals. See list in **Annex 12.2**

(2) Visited selected sites and infrastructure to better understand key issues and options. Our visits targeted dams (completed and under construction), water treatment and pumping stations, irrigation channels, and wastewater treatment plants. See list in **Annex 12.3**

(3) Literature review. We identified and reviewed hundreds of references and legislation. Technical references included government decision and circulars, technical reports, progress reports prepared by water utilities, the World Bank and several UN agencies, SEA reports previously conducted in Lebanon and beyond, as well as SEA sourcebooks. For a complete list of consulted and cited references, see ***Chapter 10***

(4) Held one public hearing with the National Council for the Environment (NCE) on 11 August 2014. The NCE was presided by HE Minister Mohamad Al Mashnouk and attended by all the members of the committee. The Consultant presented summary findings (Powerpoint presentation) and solicited feedback and comments to support the preparation of a Revised SEA Report of the NWSS.

1.4 DATA SOURCES AND CONSTRAINTS

The SEA team consulted dozens of references and technical reports. A preliminary list of references was presented in the "Literature Review Report." Data sources can be grouped into:

- Technical reports prepared by consultancy firms
- Technical reports prepared by or for the water utilities
- Bulletins published by the Central Administration of Statistics
- Other statistics from relevant GOL programs (agricultural census) and UN agencies (UNHCR)
- Progress Reports by the Council for Development and Reconstruction
- Energy consumption data by utilities (Excel files)
- Prior research and compiled species lists
- Online databases

The SEA team also faced data limitations and constraints. For example:

- Lack of aggregated energy consumption data by the water sector
- Lack of unified reference on biological hotspots in Lebanon

- Inability to review the draft Water Code because it is still under review by the Council of Ministers
- Difficulties in substantiating certain conclusions that are widely accepted (e.g., impact of large-scale public interest projects on land value and speculative behavior).

A complete list of cited references is presented in Chapter 10 at the end of the SEA Report.

1.5 REPORT STRUCTURE

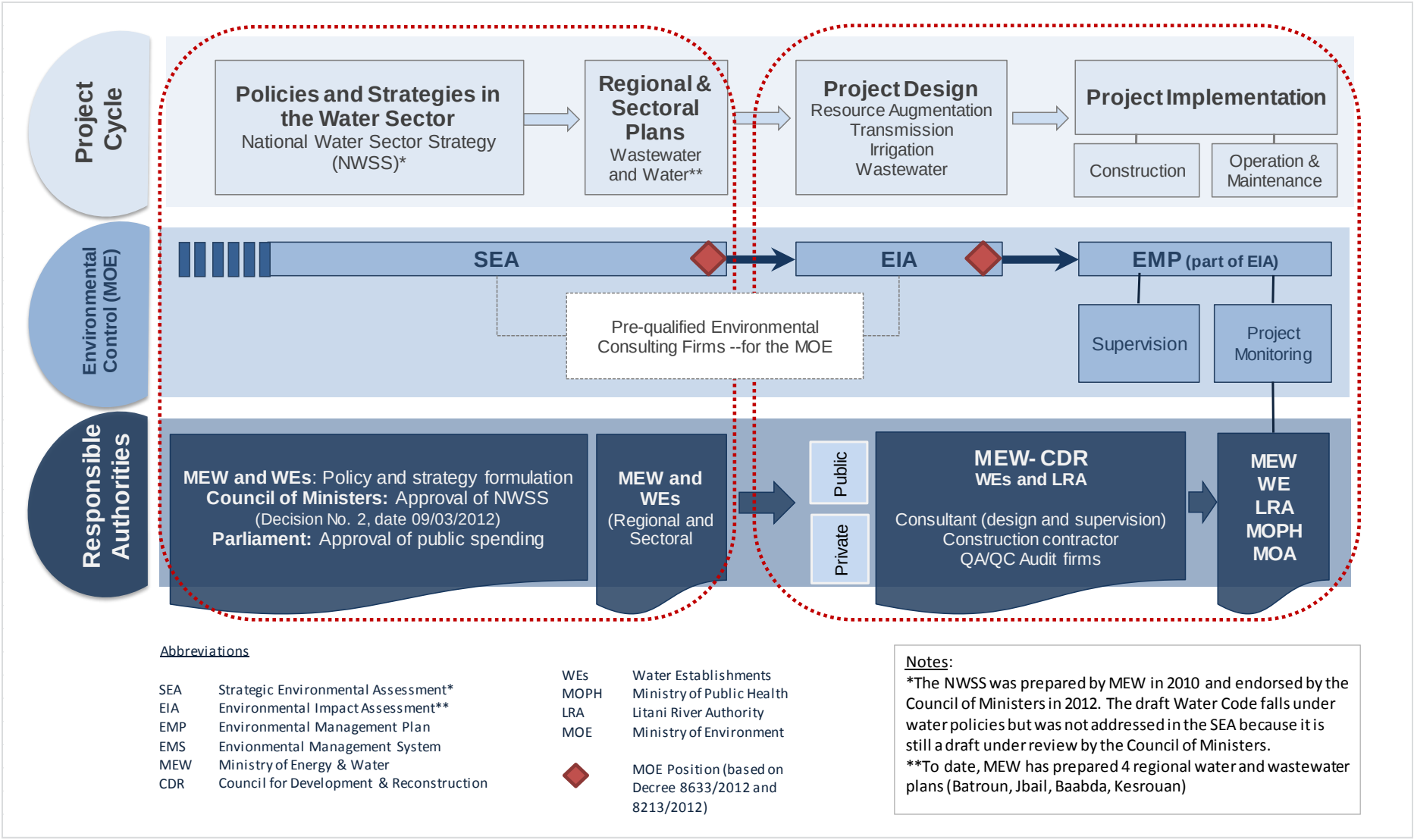
This report generally follows the SEA outline prescribed in Annex 2 of the SEA decree (Decree 8213/2012). The outline consists of an Executive Summary, a Main Report (10 Sections), References, and Annexes:

Executive Summary	English and Arabic
Main Report	(1) Introduction (2) Determining the Scope of the SEA Study (3) Description of the Proposed Strategic Action (4) Assessment of Baseline Conditions (5) Assessment of Potential Impacts Resulting from the NWSS (6) Analysis of Alternatives to the Proposed Strategic Action (7) Selection of the "Most Suitable Strategic Option" (8) A Framework to Optimize the Environmental & Social Effects of the NWSS (9) Recommendations for Integrating SEA Findings in the NWSS
Cited References	(10) List of Cited References
Annexes	(11) Technical (12) Administrative

To streamline and strengthen the report, we occasionally departed from the prescribed Terms of Reference in the SEA Decree. Key changes include:

- New section on "Determining the scope of the SEA study" (Chapter 2). This chapter is necessary to explain how the scoping phase contributed to identifying the key issues and to deselecting other issues that are better addressed at the EIA level.
- Merged "Coherence of the Proposed Strategy with Legal, Institutional, and Planning Frameworks" with "Assessment of Potential Impacts Resulting from the Implementation of the NWSS" (Chapter 5). The analysis of the coherence of the NWSS with legal, institutional, and planning frameworks cannot be dissociated from the assessment of impacts as coherence and the lack thereof give rise to impacts.
- Changed "Development of a Relevant Environmental Management Plan to Mitigate Negative Impacts" (Chapter 8) to "A Framework to Optimize the Environmental and Social Effects of the Strategy" because one of the SEA goals is to optimize the strategy by reducing or neutralizing the potential adverse effects but also enhancing the positive effects. Also, the SEA should focus on strategic issues and options and refer site-specific recommendations to corresponding EIAs. Instead of focusing on cause-and-effect relations, the proposed framework identified NWSS and/or policy responses by MEW, MOE and other government agencies and institutions.

Figure 1. The SEA Process in Relation to the Project Cycle



Abbreviations

SEA	Strategic Environmental Assessment*
EIA	Environmental Impact Assessment**
EMP	Environmental Management Plan
EMS	Envionmental Management System
MEW	Ministry of Energy & Water
CDR	Council for Development & Reconstruction
WEs	Water Establishments
MOPH	Ministry of Public Health
LRA	Litani River Authority
MOE	Ministry of Environment

◆ MOE Position (based on Decree 8633/2012 and 8213/2012)

Notes:
*The NWSS was prepared by MEW in 2010 and endorsed by the Council of Ministers in 2012. The draft Water Code falls under water policies but was not addressed in the SEA because it is still a draft under review by the Council of Ministers.
**To date, MEW has prepared 4 regional water and wastewater plans (Batroun, Jbail, Baabda, Kesrouan)

2. DETERMINING THE SCOPE OF THE SEA STUDY

The following chapter highlights the role of the consultation process and justifies the remainder of the report. It is intended to benefit those readers who were not involved in the scoping phase, and serve as a quick aide-memoire to all other readers.

The SEA Team identified during the scoping[4] phase **key issues** based on a much longer list of environmental, social and economic issues**.** Many issues were deselected during scoping because it was determined that they did not carry national and/or *strategic* importance and therefore should be addressed in project-specific EIA studies. The rationale for selecting the key issues listed in Table 1 was based on many factors including scale, sensitivity of the receptor, cumulative impact, transboundary effect, level of concern of stakeholders, and/or priority accorded in government/international policies and development goals.

Table 1. SEA Key Issues and Rationale

Key Issue	*Link to NWSS*	*Rationale – Why is this a Key Issue?*
Climate change adaptation and mitigation	I.1, I.2, I.3 II.4	• Lebanon is a signatory to the UNCCD and UNFCCC • Lebanon's SNC to the UNFCCC as well as other climate change models predict significant climate change effects on Lebanon's water resources • NWSS recognizes uncertainties in water availability / supply data and emphasizes the need to refine climate change knowledge • Lack of certainty in water availability and flows indicates a need to review the resilience of planned infrastructure to climate shocks (e.g. drought and flash floods, and landslides)
Uncontrolled urbanization in the mountains and near river beds and flood plains is threatening the resource	I.3, II.3, II.4	• Haphazard urbanization is pandemic in Lebanon; it degrades recharge areas and impedes water flow in floor plains and near riverbeds • Protection of recharge zones (all lands above a threshold altitude) and "dollines" is a national priority according to the SDATL (endorsed by the COM in 2005), the 2010 SOER (endorsed by the MOE in 2009) and Lebanon's National Report to the UNCSD (June 2012) • This initiative currently lacks regulation (but MOE has submitted a formal request to the COM to address the protection of summits)
Land take and acquisition (compulsory acquisition of land and compensation for the loss of land rights)	I.3, I.7	• Storage dams are land greedy; the affected lands are located in all catchments (national); Proposed reservoirs may limit access to other lands • Compensation and support for resettlement may not be effective at maintaining the living standards of affected people; poor people and marginalized groups and female-headed households may be disproportionately affected

[4] The purpose of scoping is to identify the matters which should be covered in the SEA and, in particular to identify the matters which are of most importance so that these can be addressed in most detail.

Key Issue	*Link to NWSS*	*Rationale – Why is this a Key Issue?*
Haphazard waste disposal and landscapes	I.3	• Experience in Lebanon shows that dams produce a lot of aggregates/rubble that require disposal • Unregulated disposal of aggregates/rubble is affecting LANDSCAPES and many cave systems in Lebanon
Operation & Maintenance capacities of MEW and Water Establishments is severely lacking	All in particular I.3 and I.7	• The continued lack of O&M capabilities will jeopardize the benefits of implementing costly investments • Substandard O&M capabilities can also lead to physical malfunction affecting natural resources and the environment • NWSS recognizes the need for increased O&M capabilities but so far Water Establishments are reluctant to take-on WWT responsibilities
Treated Sewage Effluent disposal and reuse	I.7 II.2, II.3	• Widespread use of raw sewage (wastewater theft) causes reduced inflows and inefficient STP operation • Inflow of industrial wastewater into the public sewer remains unregulated and can hamper wastewater treatment systems • TSE reuse can reduce abstraction for irrigation and therefore help protect the resource • This initiative currently lacks regulation and environmental guidelines
Inadequate sludge disposal including reuse and/or biogas production	I.7, II.3	• Sludge management is a SWM issue and a potential biogas generator • Sludge management is currently unregulated
Heavy pollution of coastal water quality (STP and other pollution abatement control)	I.7, II.4	• Effluent discharge into the sea has a transboundary effect • Lebanon is a signatory to the Barcelona Convention and therefore has an obligation to reduce environmental loads in the Mediterranean Sea • Improved quality of coastal water has potential to help stimulate tourism industry and contribute to economic growth
Groundwater quality (irrigation, impoundments, and abstraction controls)	I.3, I.6	• Potential nitrate (and phosphate) build-up in groundwater from agro-chemicals may one day render large resources unfit for safe human consumption and/or impose ever increasing treatment costs on suppliers • Seawater intrusion into coastal aquifers is widespread • Pollution of surface aquifers with sanitary waste is widespread

Key Issue	*Link to NWSS*	*Rationale – Why is this a Key Issue?*
Managing man-made water bodies; birds, tourists, hunters, and developers	I.3	• Lebanon is a signatory to the CBD, AEWA and RAMSAR and therefore has an obligation to protect biodiversity, incl. migratory soaring birds • Hunting laws and regulations lack enforcement. Bird watching as an economic activity remains timid in Lebanon, and is overshadowed by abusive hunting, and violations of Lebanon's international obligations for bird protection (e.g., migratory soaring birds) • Experience shows that well-managed water bodies have the potential to increase property value significantly and also present opportunities for leisure and recreation water activities which need to be regulated (public safety, pollution prevention, etc.)
Loss of known and unknown biological diversity	I.3	• Lebanon is a signatory to the CBD and therefore has an obligation to protect biodiversity, especially vulnerable species • Lebanon's protected areas do not represent all ecosystems and habitats • Storage dams may cause the irreversible loss of rare and/or endemic species and reduce/inhibit environmental flows that sustain species and habitats downstream
Lebanon's unique archaeological heritage (Cultural Property) is threatened by anthropogenic activities	I.1, I.4	• Excavation and inundation in many parts of the country are likely to affect sites, relics and artifacts of international importance, including Roman aqueducts. • Although these should be dealt with by site-specific EIAs, it is important that critically important sites be avoided where possible and an adequate framework is in place to allow for appropriate management of cultural property during the EIA process and more importantly during future works.
Contribution to Lebanon's renewable energy output	I.3, I.6	• Lebanon has voluntarily adopted a 12% RE target in its energy mix by 2020 (declaration made at the UNFCCC summit in Copenhagen in 2009) • Proposed irrigation schemes in south Lebanon (Qaroun and Canal 800) will reduce total hydropower production thus conflicting with the 2020 target • What steps need to be taken to maximise the cost-effective net hydropower generation when the NWSS is fully implemented? • Other opportunities for RE production in the water sector (biogas, micro-hydropower, etc.)

Key Issue	*Link to NWSS*	*Rationale – Why is this a Key Issue?*
Agricultural schemes and poverty alleviation	I.6	• There is a clear correlation between irrigation and economic growth; how will irrigation water in agricultural areas affect output and farmer income? Will poor farmers and rich plantations compete for additional water resources? • The conversion of rainfed crops (e.g., tobacco) to irrigated agriculture has a profound effect on production systems and farmer income
Water awareness (including Water Demand Management) is generally very low	I.4, I.5, II.5	• Water awareness has received little attention in Lebanon; opportunities for large-scale WDM abound at central and regional level • The NWSS recognizes water conservation and awareness as one of five management initiatives
Catastrophic failure due to Natural Disasters, Sabotage or Military Action. How will the NWSS respond to other emergencies (e.g., influx of 1+million displaced Syrians)?	I.3, II.3, II.4	• Open water bodies (man-made lakes) are vulnerable to pollution from deliberate contamination and/or poor catchment management • Despite on-going water reform process, MEW still does not have a dedicated unit/department to manage and operate dams • Lack of emergency response protocols in case of a catastrophic failure and other emergencies

*Legend: **I.1** Optimization of surface water resources, **I.2** Artificial recharge of groundwater aquifers, **I.3** Surface storage, **I.4** Water supply transmission, **I.5** Water supply distribution, **I.6** Irrigation rehabilitation and expansion, **I.7** Wastewater collection, **II.1** Institutional and organizational, **II.2** Financial and commercial, **II.3** Legal and regulatory, **II.4** Environmental concerns, **II.5** Water conservation and awareness*

Source: Adapted from NWSS Scoping Report, dated December 17, 2013.

3. DESCRIPTION OF THE PROPOSED STRATEGIC ACTION

This chapter describes the proposed National Water Sector Strategy including its implementation status. Although the NWSS was endorsed in 2012, many of the listed interventions have been in the planning and/or construction phase long before that date.

3.1 NWSS OBJECTIVES

The NWSS has crafted a *vision*:

"Water is a right for every citizen and a resource for the whole country"

A *mission:*

"Ensure water supply, irrigation and sanitation services over all the Lebanese territory on continuous basis and at optimal service levels, with a commitment to environmental, economic and social sustainability"

It has also articulated seven objectives:

(1) Maximizing the potential and improving the quality of surface water resources,

(2) Improving the management and protection of groundwater resources (construction of wastewater networks and treatment plants; 26 STP by 2020),

(3) Fulfilling deficits through groundwater (artificial recharge of up to 200 million m^3 by 2020) and/or surface water (construction of remaining dams, surface storage up to 650 million m^3 by 2020),

(4) Ensuring proper and continuous access to high quality water supply (reduce extraction from private wells and increase extraction from public wells; upgrade and /or extend water networks),

(5) Providing adequate quantities and quality of water for irrigation (reuse of treated wastewater: up to 101 million m^3 in 2020; implementation of water-saving irrigation techniques),

(6) Increasing coverage of wastewater collection networks and treatment capacities, and

(7) Optimizing current wastewater treatment processes and sludge disposal.

As summary of the interventions is presented next.

3.2 NWSS INTERVENTIONS AND PLANNED INVESTMENTS

The NWSS presents 12 initiatives, including 7 infrastructure initiatives that can be grouped into three headings, consistent with the analysis presented in the Strategy:

(1) Additional Water Resources --production
(2) Water Supply Transmission and Distribution – conveyance
(3) Wastewater Collection and Treatment --wastewater

The water sector objectives can also be categorized into five (5) headings:

(1) Tariffs
(2) Water and wastewater quality
(3) Research and monitoring
(4) Demand management, and
(5) Water conservation

The water sector "management" initiatives are institutional and organizational, financial and commercial, legal and regulatory, environmental, and awareness and conservation. The Strategy presents a Strategic Roadmap that extends from 2010 to 2020, with at least three initiatives extending through 2035 (dams, irrigation schemes, and water awareness). NWSS's key components and related expenditures are summarized in Table 2 and 3.

Table 2. NWSS Key "Infrastructure" Components and Projected Cost Estimates

Strategy Initiatives	***Summary Description***	***Cost Estimate ($ million)***
1. Optimizing surface water storage	• 64 million CM of additional water	$2,206 (29% of total CAPEX)
2. Artificial recharge of groundwater aquifer	• Up to 200 million CM of additional water by artificial recharge (during the wet season / excess flow)	
3. Surface storage: dams and hill lakes	• Up to 670/880 million CM of water storage (static/dynamic) at identified sites) • 46 sites identified as suitable for surface storage incl. dams and hill lakes (<1 million CM)	
4. Water supply transmission	• 2800 km of transmission pipes • 191000 m^3 of storage in 561 tanks	$1,790 (23%)
5. Water supply distribution	• 9600 km of distribution pipes • About 1 million water meters	
6. Irrigation rehabilitation and expansion	• Up to 30,000 ha irrigated by 2020 • Additional 60,000 ha irrigated by 2035	$577 (7%)
7. Wastewater collection and treatment	• 12 coastal STPs planned (secondary treatment level) to serve 5,597,000 people-equivalent • 42 inland STPs planned to serve 1,977,750 people-equivalent	$3,104 (40%)

Table 3. NWSS Key "Management" Components and Projected Cost Estimate

Strategy Initiatives	*Summary Description*	*Cost Estimate ($ million)*
Institutional and organizational	• Priority actions to complete the restructuring of WEs • Improve operating model between MEW and WEs (to ensure integrated water resources management) • Improve performance of WEs (including monitoring and evaluation) • Improve coordination among the various players in the water sector (MEW, WEs, LRA, CDR, etc.) with a clear delineation of authorities • Create formal Water Users Associations (WUAs) and define their roles and responsibilities with respect to water management	
Financial and commercial	• Implement consumption-based tariff • Apply wastewater tariff to customers connected to network and STP at a first stage (to cover, at a minimum, O&M costs); Apply wastewater tariffs based on water consumption at a second stage • Adjust irrigation water tariffs based on the specificities of existing and anticipated irrigation schemes • Promote Private Sector Participation (PSP)	
Legal and regulatory	• Ratification of the Water Code • Complete implementation of Law 221/2000 and its amendments • Develop wastewater collection and disposal regulations • Improve irrigation regulations • Review and update standards for wastewater discharge • Develop standards for wastewater reuse in agriculture and sludge reuse • Provide adequate legal environment to promote private sector participation	$63
Environmental concerns	• **Conduct an SEA of the NWSS** • Refine Climate Change knowledge • Develop and implement a concept for protecting recharge zones • Develop and implement a comprehensive water quality monitoring network (surface water, groundwater and irrigation water) to improve water quality; centralize data and ensure communications with consumers • Implement pollution control programs • Develop an integrated flood management plan and assess the potential use of flood water in groundwater recharge • Develop and implement water conservation initiatives on domestic, industrial and irrigation demands	

3.3 NWSS IMPLEMENTATION STATUS

The NWSS assembled a patchwork of initiatives and investments that were developed in response to immediate local needs and build them into a coherent strategy to serve the national interest over a period of 20 years or more. Therefore, although the NWSS was formally endorsed in 2012, it includes many investments (dams, conveyance systems, irrigation schemes, and wastewater treatment plants) that CDR, MEW and LRA started planning and building years before. The following tables present the status of planned dams (Table 4), irrigation schemes (Table 5) and wastewater treatment plants (Table 6) with corresponding details. There is, as yet, no formal mechanism in place to monitor the implementation status of the NWSS or to track overall progress towards achieving NWSS objectives. The following update is only partial and was prepared and compiled by the SEA team for this SEA Report, in coordination with MEW, LRA, and the four WEs.

Table 4. Status of Planned NWSS Storage Dams (updated April 2014)

Name	*Caza*	*Consultant Name*	*Contractor Name*	*Capacity (MCM) Static – Dynamic*	*CAPEX (MUSD)*	*OPEX (MUSD/yr)*
1. Balaa	Batroun	Khatib & Alami	Moawad Eddeh	1.20 – 2.20	26	0.43
2. Bisri	Jezzine	DAH N.Taleb-Novec	-	120 – 120	300	26.4
3. Boqaata	Kesrwan	Stucky-Gicome	Rocad – Khoury	6 – 12	59	2.25
4. Brissa	Dannieh	DAH N. Taleb	Batco	0.8 – 0.8	15	0.05
5. El Manzoul	Jbeil	ACE	-	0.35 – 0.35	13	0.08
6. Janneh	Jbeil	K&A	Andrade Gutierrez	30 – 90	300	13.2
7. Kouachra	Akkar	RELK&P	Antar	0.35 – 0.35	3	0.04
8. Mseilha	Batroun	Coyne & Bellier – LC	Maltauro - Batco	6 – 12	55	1.95
9. Qaysamani	Baabda	Libanconsult (LC)	Moawad Eddeh	1 – 1	21	0.3

Source: Mr. Ziad Zakhour, Advisor to the Minister on Surface Storage (MEW)

The "Janneh Dam and Lake Project" is the only dam that is being proposed in conjunction with a hydropower generation station (40MW). The Janneh dam is also the only dam that is directly financed by a water establishment (BMLWE) and being implemented by the MEW in coordination with the establishment. All the other dams are built by the MEW consistent with its mandate to capture and manage the resource, in coordination with the CDR.

Table 5. Status of NWSS Irrigation Schemes (updated April 2014)

Irrigation Scheme/Project	*Irrigated Area (ha)*	*CAPEX (MUSD)*	*OPEX (MUSD/yr)*	*Status***
1. Noura Et Tahta	5,000	58	1.2	Planned
2. El Bared	750	6	0.2	Planned
3. Assi River Basin	5,400	170	208	Planned
4. Younine Scheme	1,550	28	0.6	Planned
5. Southern Qaraoun Irrigation Project	500	8	0.25	Under study
6. South Bekaa (Phase 2) Left Bank	6,700	60	1.25	Under study
7. South Bekaa, Right Bank & North	12,800	35	0.7	Planned
8. South Lebanon Conveyor 800	14,700	255+255	5.2	Under study
9. Conveyor Anane – Nabatiyeh	3,500	145	2.6	Planned

10. Saida – Jezzine Project	1,200	8	0.25	Completed
11. Qasmieh – Ras El Ain (Phase 2)	2,100	22	0.5	Completed
12. Khardale	9,000	220	3.8	Under study
Total	**63,200**	**1,040**	**18.35**	

Source: CDR Progress Reports, *Pers. Comm.* with WWEs and Mr. Ghassan Joubran, Director of Projects in LRA

Table 6. Status of NWSS Wastewater Works (updated April 2014 and listed from north to south)

Location (RWE)	***Population-Equivalent***	***Status***
12 Main Coastal STPs		
(1) Abdeh (north)	185,000	Planned
(2) Tripoli (north)	1,000,000	Complete and operating at 10% (pre-treatment)
(3) Chekka (north)	15,600	Complete - Expected operation in 2015
(4) Batroun (north)	30,000	Complete - Expected operation in 2015
(5) Jbail (BML)	50,000	Complete – Expected operation in 2015
(6) Tabarja / Kessrwan (BML)	505,000	Planned
(7) Bourj Hammoud (BML)	2,200,000	Planned
(8) Ghadir (BML)	250,000	Operating
(9) Jieh / Ras Nabi Younes (BML)	88,000	Complete - Expected operation in 2015
(10) Saida (south)	390,000	Operating
(11) Sarafand (south)	325,000	No funding available
(12) Sour (south)	200,000	Under construction – Expected operation in 2015
7 Main Inland STPs		
(13) Mechmech (north)	68,000	Planned
(14) Barouk & Fraidis (BML)	8,000	Under construction
(15) Nabeh al Safa & Ain Zhalta (BML)	20,000	Under construction
(16) Hrajel (BML)	40,000	Planned
(17) Nabatieh (south)	100,000	Operating
(18) Tibnine & Chakra	100,000	Under construction
10 Litani Basin (Bekaa)		
(19) Baalbeck	100,000	Operating
(20) Yammouneh	6,000	Operating
(21) Zahleh	150,000	Under construction
(22) West Bekaa (Joub Janine & Saghbine)	100,000	Complete and operating at 10%
(23) Anjar	300,000	Planned
(24) Laboua	47,000	Planned
(25) Timnin el Tahta	100,000	Planned
(26) Aitanit	35,700	Operating
(27) Forzol	7,500	Operating
(28) Ablah	15,000	Under construction

Source: Based on MEW Wastewater Sector Strategy and *pers. comm*. Ms. Randa Nemr, Advisor on Wastewater Issues
AS Activated Sludge, **PT** Pre Treatment, **B** Biofiltration, **EAAS** Extended Aeration Activated Sludge, **TF** Trickling Filter

Reform of the water sector is still ongoing and although much remains to be done, some progress has been made since the release of the draft NWSS in 2010 including the following:

(1) ***Draft Water Code***. The draft Water Code is currently under review by a ministerial committee appointed by the Council of Ministers. The SEA team was not able to consult the draft water code which remains confidential until the review process is complete.

(2) ***Treated Sewage Effluent and sludge reuse standards.*** With the assistance of the FAO, the MEW has prepared draft guidelines for TSE reuse and sludge treatment and reuse.[5]

(3) ***Pollution Control Programs.*** The MOE has made noteworthy strides in pollution abatement regulation and in promoting pollution abatement technologies for industries through the completed Environmental Fund for Lebanon (EFL) and the on-going Lebanon Environmental Pollution Abatement Project (LEPAP).

(4) **At the watershed basin level,** a "Business Plan for Combating Pollution of the Upper Litani and Qaroun Lake" was prepared and debated, and implementation is slated to kick-start in 2015-2016 when initial funding becomes available (see more details in Section 4.1.3).

For an overview of water infrastructure and resources by WE, please see **Map 1 to Map 6.**

[5] UN FAO Project UTF/LEB/019/LEB , Wastewater Reuse and Sludge Valorisation and Reuse (2010)

4. ASSESSMENT OF BASELINE CONDITIONS

This chapter describes relevant baseline conditions which may be affected by the NWSS. The baseline includes environmental receptors as well as social and economic parameters.

4.1 PHYSICAL ENVIRONMENT

This section describes the physical environment that may affect or be affected by the NWSS including climate change, topography and landforms, surface and groundwater resources, and water quality. Although climate change knowledge is limited and at times circumstantial, we know enough to begin to understand some of the implications of climate change on Lebanon's water resources.

4.1.1 Climate Change

Lebanon is signatory of the United Nations Framework Convention on Climate Change (UNFCCC) (Ratification: Law 359 dated 11/08/1994). Non-Annex I countries including Lebanon submit National Communications (NC) on implementation of the Convention to the Conference of the Parties (COP). NC includes information related to national greenhouse gas (GHG) emissions and removals, mitigation options analysis, vulnerability to climate change, adaptation options, gaps and constraints in implementing the provisions of the Convention, and any other relevant information the country wishes to communicate. Since 1994, Lebanon has submitted two NCs:

What is Climate Change?

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that *persists for an extended period*, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Source: IPCC definition

(1) In 1999, a national team of experts, working under the UNEP/GEF funded Project "Climate Change Enabling Activity" at MOE, prepared and submitted to the COP Lebanon's First / Initial National Communication (INC) to the UNFCCC. Lebanon's INC included an inventory of GHGs from various sectors in Lebanon for the baseline year **1994**. The report also provided an assessment of Lebanon's vulnerability to climate change including impacts, adaptation measures, constraints and recommendations for future work.

(2) In 2011, Saint Joseph University and ELARD provided support to the UNDP/GEF funded project "Enabling Activities for the Preparation of Lebanon's Second National Communication (SNC) to the UNFCCC" at MOE to prepare the SNC and submit it to the COP. The SNC research team prepared the national GHG inventory by sectors for the baseline year 2000, and assessed Lebanon's vulnerability and adaptation to climate change including constraints, gaps and related financial, technical and capacity needs.

Lebanon is currently preparing its Third National Communication (TNC) to the UNFCCC to be submitted to the COP in 2015. The TNC will include an updated GHG national inventory for the year 2005 and time-series covering the period from 1994 to 2012, an updated analysis of potential GHG mitigation measures to key categories and progress achieved so far, an updated assessment of potential impacts of climate change on food security, social development, and poverty as well as adequate adaptation measures.

4.1.2 Topography and Landforms

Lebanon is divided into five geo-morphological areas which influence its mountains, valleys and plains. The five regions are described below and illustrated in Figure 2:

(1) The Coastal Zone, including the shoreline and continental shelf, the coastal plain, and the foothills of Mount Lebanon rises to 250 meters; it represents 13 percent of the territory.

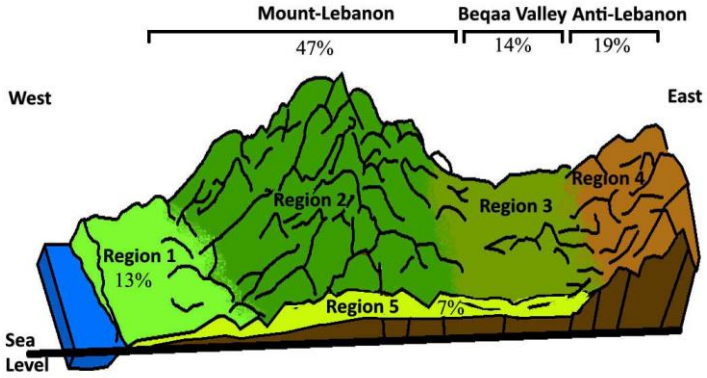
(2) The Mount Lebanon Range (or chain), including middle-and high-elevation zones, rises from Akkar in the north and extends south to the hills of Jabal Amel. The highest peak is Qornet el-Sawda (3,087 meters). It represents 47 percent of the territory.

(3) The Bekaa Valley, a fertile land corridor separating the Mount Lebanon and Anti- Lebanon ranges, is drained to the north by the Aassi River and to the South by the Litani River. It represents 14 percent of the territory.

(4) The Anti-Lebanon Range, which extends across the Lebanese-Syrian borders along the eastern part of the country and includes, at its Southern terminus, Jabal el Cheikh (Mt. Hermon, 2,814 meters), which distributes rainfall and snowmelt into at least three main watersheds across Lebanon, Syria and Palestine; it represents 19 percent of the territory.

(5) South Lebanon, an elevated plateau that extends a short distance inland from the western shores of South Lebanon to the Mount Hermon foothills in the East. Seasonal streams flowing from east to west into the Mediterranean Sea intersect this region; it represents 7 percent of the territory.

Figure 2. Five geo-morphological regions of Lebanon



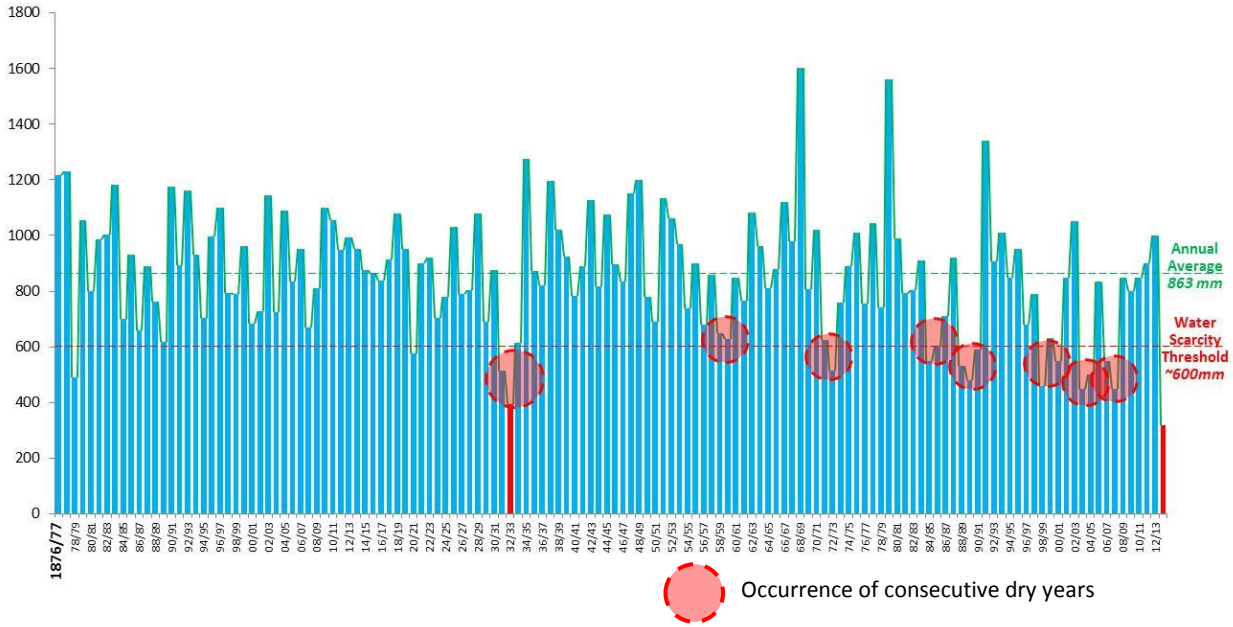
A major feature of the Lebanese topography is the formation of valleys that dissect the Mount Lebanon range in the east-west direction. Water flows through these valleys and discharges into the sea all along the Lebanese coastline. The NWSS aims to intercept and capture some of that water before reaching the sea.

*See **Map 7** on topography and surface and underground water resources*

4.1.3 Surface and Groundwater Resources

Lebanon is in a relatively fortunate hydrological position. It is estimated from isohyetal maps that the yearly precipitation results in an average yearly flow of 8,600 MCM, giving rise to 40 major streams and rivers (17 of which are perennial) and more than 2,000 springs. These maps were published in 1972 and derived based on weather data from 143 stations in Lebanon and 23 foreign stations. A recent compilation of precipitation data in Beirut by the American University of Beirut (1876 – 2014) shows significant fluctuations in annual rainfall as well as recurring dry years. In fact, the occurrence of consecutive dry years (amounting to a drought) is increasing as evidenced by at least five such incidents in the last 30 years, compared to only three such incidents in the 100-year period from 1876 to 1975.

Figure 3. Precipitation in Beirut and the Occurrence of Consecutive Dry Years (1876 – 2014)



Source: American University of Beirut (1876-2014)

The water balance developed in the 1970s does not take into consideration the impact of cumulative changes in land use and deforestation on aquifer recharge and surface runoff. Nor do those data account for the reduction in spring and river base flows and in borehole yields due to irrigation and other water uses.[6]

Lebanon's water data confidence is critically low. Data confidence will improve when new records are aggregated and analyzed in relation to changing land use and land cover to account for evapotranspiration, infiltration and runoff. At least three institutions today generate continuous rainfall and/or water data:

1977 Atlas Climatique du Liban
It is important to remember the original source of climatic data in Lebanon. The Directorate General of Civil Aviation (subsequently the Lebanese Civil Aviation Authority) published in 1977 the single-most important compendium "Atlas Climatique du Liban." This atlas was based on data collected from 87 weather stations in Lebanon plus 1 station in Damascus, Syria. Mean annual precipitation was based on 1931-1960 records, in line with the World Meteorological Organization.

(1) Lebanese Civil Aviation Authority (LCAA). Formerly the Directorate General of Civil Aviation, the LCAA was established in 2002 (Law 481/2002). The LCAA's Directorate of Environment

[6] SOER 2001.

and Meteorology established and maintains a network of weather stations and collects the data. The Directorate has today 38 automatic weather stations distributed all over the country and recording data on temperature, precipitation and humidity. The weather data is available for the public on a fee-basis.

(2) Lebanese Agricultural Research Institute (LARI). Formerly the Department of Agricultural and Scientific Research, LARI was established in 1964. Today it has eight research stations (Tel Amara, Tourbol, Kfardan, Kfarchakhna, Abdeh, Sour, Fanar and Lebaa). In 2009, LARI installed 50 additional weather stations spread all over the Lebanese territory to develop agricultural weather maps and notify concerned stakeholders (including farmers) as needed.

(3) Litani River Authority (LRA). The LRA was established in 1954 with the responsibility of managing the Litani River Basin and also measure all surface flows in the country. The authority operates 66 fixed monitoring stations covering all the rivers in Lebanon (15 mobile stations are operated jointly with Beirut International Airport). The monitoring cycle is from September to September of the following year.

More research and analysis are needed to correlate weather data with land use and land cover, and to update Lebanon's obsolescent water balance. Lebanon's groundwater data started improving in 2011 with the launch of the €1.8 million "Groundwater Assessment and Database Project". Funded by the Italian Government and completed in May 2014, the project aimed to assess the national groundwater resources through data collection and field assessment, and identify sites for potential artificial recharge in line with the recommendations of the NWSS. The previous groundwater assessment had been conducted by UNDP in 1970 over a nine-year period.

Water Balance

Total Annual Rainfall and Snow (TARS) in Lebanon is estimated at 8,600 MCM per year of which 2,700 MCM are considered net exploitable water resources. In other words, net exploitable resources represent about 30% of total annual rainfall and snow. See summary of annual available resources in Table 7.

Table 7. Annual available resources (Million cubic metres Mm^3)

Source	*MCM(1)*	*MCM (2)*	*MCM (3)*	*MCM(4)*
Precipitation (TARS)*	8,600	8,600	8,200	9,300
Evapo-transpiration	(4,500)	(4,300)	(4,100)	(4,500)
Losses	**(1,400)**	**(1,700)**	**(1,333)**	**(2,400)**
-Rivers to neighbours	(700)	(670)	(648)	
-Groundwater	(700)	(1030)	(685)	
Total Renewable Resources	**2,700**	**2,600**	**2,767**	**2,400**
-Surface Water	2,200		2,200	2,000
-Ground Water	500		567	400
Net Exploitable Resources	**2,700**	**2,600**	**2,767**	**2,400**

Sources: 1) MEW, 2010b, 2) MOE/ECODIT, 2002, 3) MEW, 2010c and 4) Fawaz, 1992
Note: Rain occurs for 90 to 100 days between October and April

Currently, water as defined by "present renewable resources per capita" in Lebanon is just over 1,100m^3/capita/year, dangerously near the international benchmark of 1,000m^3/capita/year, below which indicates water resources stress (WB, 2010). The MEW puts the total renewable resources

(drinking, industrial and irrigation) per capita per year at 926m^3 and predicts it will drop to 839m^3 by 2015 (MEW 2010b).

Snow cover

Lebanon's two mountain ranges (Mount Lebanon and Anti-Lebanon) receive a lot of snow starting at 1,500m. Above this elevation, the mountains are covered in snow several months each year, with an average yearly precipitation of around 2,787 million m^3 in the form of snow. The average annual snow cover exceeds 2,500km^2, which is equivalent to 25 % of the territory (Shaban et al., 2013).

Water from melting snow contributes 40% to 50% of the replenishment of rivers (Shaban et al., 2004 and Hreiche et al., 2006), springs and groundwater reservoirs (Shaban et al., 2013). Eight major aquifers in Lebanon carry around 1,360 million m^3 of underground water of which 400 to 1 000 million m^3 are exploitable (FAO/Aquastat Survey, 2008). It is widely recognized that water from the **melting snow is the primary water supply to many water sources** in Lebanon (Shaban et al., 2013).

Rivers

The NWSS plans to build 18 dams, of which at least 10 will capture river flows and affect perennial river systems including Al Kabir, Damour, and Nahr Ibrahim.

Lebanon has 17 perennial rivers and 23 seasonal rivers with a total annual river flow of about 3,900 million m^3. Seventy five percent of the flows occur between January and May, 16 percent between June and July and nine percent between August and October (Comair 2010). Although the LRA is responsible for monitoring river flow data, the data are incomplete, fragmented, and/or inaccurate. Not only did the 1975-1990 Civil War degrade the country's river hydrometric river systems but, equally important, the stations are obsolete and the LRA lacks the technical skills and manpower to effectively monitor river data.[7] Lebanon's highest river flows are Litani River, Ibrahim River, and El Assi River. Only two rivers do not discharge into the Mediterranean Sea (El Assi and Hasbani). Total surface water outflow is estimated at 735 million m^3/year, of which 160 million m^3 to the sea, 415 million m^3 to the Syrian Arab Republic through the Assi (Orontes) River and 160 million m^3/year to northern Israel through the Hasbani/Wazani complex (FAO/Aquastat Survey, 2008).

Many rivers receive (1) raw sewage discharged from homes and industries, (2) leachate from nearby municipal solid waste dump sites as well as (3) agricultural runoff. In terms of pollution load, the most highly polluted river system is the Litani River (and Qaraoun Lake) which has been the focus of many water quality sampling programs. In an effort to develop a master plan for mitigating pollution into the Litani River, the MOE and UNDP sponsored the preparation of a Business Plan for Combating Pollution of the Qaraoun Lake (MOE/UNDP/ELARD, 2011). The business plan presents a series of pollution abatement measures including wastewater networks and treatment, pre-treatment of industrial discharges, and land expropriations to protect the watershed. The COM tasked in May 2014 an inter-agency committee to follow-up on the $733 million plan. Meanwhile, parliament drafted a law-proposal to secure the necessary funding which was approved by the relevant parliamentarian committee.

See ***Map 7*** on topography and surface and underground water resources

The Business Plan will complement the NWSS in many ways (see Box 1).

[7] Per. Com: Dr. Salim Catafago, LRA Chairman (May 12, 2015)

Box 1. Combating Pollution of the Litani River and Qaraoun Lake

In an effort to develop a sound business model for mitigating pollution into the Litani River, the MOE and UNDP commissioned, in 2011, the preparation of a Business Plan for Combating Pollution of the Upper Litani and the Qaraoun Lake (MOE/UNDP/ELARD, 2011). The business plan examined the various sources of pressure and determined the measures and costs needed to alleviate pollution including engineering and infrastructure solutions to mitigate environmental stressors (e.g., solid waste, municipal wastewater and industrial wastewater) and to provide BMP training in the agricultural sector.

In 2012, PM Mikati mandated an inter-ministerial committee (Environment, Energy and Water, Industry, Agriculture, Public Health and Interior and Municipalities) that also include CDR, the Bekaa WE and the LRA to review the Business Plan. The committee vetted it and prepared a 5-year road map that was discussed with Parliamentarian committees in early 2013 who amended and expanded the road map to include the Lower Litani. The road map has developed into a draft law that awaits Parliament approval. Pollution abatement measures will be coordinated by the ministries of Agriculture (agricultural runoff), Energy and Water (wastewater), Environment and Industry (industrial effluent). The total cost for combating pollution of the Litani River from "source to sink" including land expropriations is estimated at L.L. 1,100 Billion. Funding to implement the business plan will come from several sources including the national budget, donations, loans and credits (including a $50 million loan from the World Bank to fund initial pollution abatement measures in the Qaraoun Lake).

In May 2014, the MOE requested the Prime Minister's Office to establish a special committee to supervise the implementation of the road map. Coordinated by the Litani River Authority, the committee includes line ministries, as well as the National Council for Scientific Research and affected municipalities.

Springs

Springs are common in Lebanon because of the highly fractured geologic rocks, and because of the existing inter-bed rock formation of differing permeability. Lebanon has an estimated 2,000 springs. Their total yearly yield exceeds 1,200 million m^3 (MEW, 2010b) however, less than 200 million m^3 is available during summer. The total annual exploited volume is 637 million m^3 (MEW, 2010b). Increased temperatures and reduced precipitations due to climate change will have significant impacts on groundwater including springs (MOE/UNDP, 2011).

Under a USAID-funded water awareness program, the Lebanon Mountain Trail Association (LMTA) in 2013 analyzed 53 springs located on the LMT, out of 72 springs on the trail. The samples were tested at the North Lebanon WWE lab in Tripoli and the Industrial Research Institute in Hadath. The results showed that 38% of the springs have no bacteriological contamination, 30% have low to moderate contamination, 15% have moderate to high contamination, and 17% are highly contaminated. Some of the highly contaminated springs are located at higher elevations (e.g., Ain Bahr in Qehmez, Mount Lebanon, 1604m), an indication that the pollution is also occurring at higher elevations. Under NWSS's source improvement program, the MEW intends to mobilize an additional 65 MCM of water by optimizing spring capture including storage and diversion.

Table 8. Water Quality of 53 springs on the Lebanon Mountain Trail (elev. 700-1800m)

Region	*Number of Samples Tested*	*Bacteriological Contamination*			
		No	*Low*	*Moderate*	*High*
North	24	13	5	2	4
Mount Lebanon	22	4	9	4	5
South	7	3	2	2	0

Source: LMT Association (samples were tested by North Lebanon WE and Industrial Research Institute) 2013

Wells

Water resources are affected by point and non-point sources of pollution. For example, aquifers that are over extracted can suffer increasing salinity, as evidenced by increased concentrations of sodium and chloride (MOE/UNDP/ECODIT, 2011). Salinity buildup can occur inland and more importantly in the coastal zone. Test results in 2006 from 20 wells and springs in West Bekaa showed that only three samples had chloride concentrations less than the MOE standard (Fidawi 2010). Seawater intrusion is severe along the coastline and near major population centers and is prompting the WEs and CDR to either find alternative sources or solutions. For example, the BML WE started mixing water from deep wells that supply Beirut's southern suburbs with water from wells located at higher elevations (Delbe) to reduce total salts.[8]

4.1.4 Water Quality

Unchecked wastewater discharges into the Mediterranean Sea, from agglomerations and industry, is affecting coastal water quality. Lebanon's coastline receives around 162 million m^3/ year (equivalent to 276,000 m^3/day) of untreated or partially treated sewage from at least 53 outfalls spread along Lebanon's 240 km coastline, of which 16 lie within the Beirut area (MOE/UNDP/ECODIT, 2011). In addition to outfalls, rivers also carry upstream pollutants from various activities and sectors to the sea including agricultural runoff, and sewage. Coastal waters are also affected by large seafront dumpsites (e.g., Tripoli, Bourj Hammoud, and Saida).

The National Centre for Marine Sciences (NCMS) runs several seawater monitoring programs. With the support of the World Health Organization, the NCMS profiled five public beaches in Lebanon over a three-year sampling period (January 2008-Decemebr 2010). The research team collected 136 samples from fixed sampling locations on five beaches: Heri in North Lebanon, Byblos in Mount Lebanon, Ramlet el Bayda in Beirut, Saida and Sour in South Lebanon. The analysis covered physical, chemical, hydrological and microbiological parameters. Expectedly, the test results showed very high bacteriological contamination in Beirut and Saida. See summary of test results in Table 9.

Table 9. Coastal Water Quality on Five Beaches

Public Beaches	*Heri Beach*	*Byblos Bahsa Beach*	*Ramlet-el-Bayda Beach*	*Saida Beach*	*Tyr Beach*
Length (m)	700	250	1065	673	2030
Depth (m)	20	30	20-60	90	210
Sewage outfalls	None	None	2 outfalls	2 outfalls	None
River discharge	Yes	No	No	No	Yes
Number of Samples	36	36	36	14	14
Fecal coliform 95th percentile 90th percentile	 19 11	 13 9	 55,742 22,182	 19,455 10,475	 78 41
Fecal streptococci 95th percentile 90th percentile	 137 77	 132 73	 45,123 19,342	 3,525 2,189	 194 109
Bacteriological Water Qua.	Good	Good	**Poor**	**Poor**	Good
Phosphate (PO_4)*	0.13-0.46-0.89	0.10-0.19-0.30	0.39-1.52-3.93	0.17-0.52-1.27	0.12-0.20-0.28
Nitrate (NO_3)*	0.14-0.31-0.97	0.24-1.32-3.72	0.73-3.58-14.15	0.96-2.66-6.05	0.52-4.72-21.21
Algae	No	No	-	Yes	No

*min-avg-max (µM/l). Source: National Center for Marine Sciences, 2011

[8] *Per com.* George El Kadi, Director of Programs, BML WE.

4.1.5 Karst Features

Karst is a terrain with distinctive landforms and hydrology created from the dissolution of soluble rocks, principally limestone. Karst features are characterized by springs, caves, sinkholes, and a unique hydrogeology system that results in aquifers which are highly productive but extremely vulnerable to water contamination. It is estimated that karst covers more than 65 percent of Lebanon's surface. Some have spectacular scenery and some are less significant in terms of beauty and biodiversity, however all are important in terms of groundwater resource.

There are three major categories of karst in Lebanon:

1. Surface karst including cockpit karst, sinkholes entries, natural bridges, pinnacle and broad tower karst, karren and lapiaz, scallops, ripples pans, flutes and rills, and dolines
2. Underground karst are caves that developed horizontally and vertically
3. Underwater karst which is submerged caves under the sea.

The widest exposed karst is the Sannine-Maameltein Formation of the Cenomanien epoch from the Cretaceous period. It covers approximately 43 percent of the Lebanese territory, extending from the coast to the highest peak in the north and present along the coast in the south and covering most of the western mountain range. They are less spectacular than their Jurassic counterpart in surface features but as impressive in underground karst elements. These two formations form the backbone of the groundwater resource in Lebanon. They are recognized for their water basin, caves and springs, such as Ain El Zarka, Jeita spring and Aanjar spring.

On the contrary, the Kesrouan Formation of the Jurassic Period is the most impressive in terms of surface and underground karst. It is widely seen in central Mount Lebanon between the rivers of Nahr Beirut and Nahr el Jaouz. Less spectacular, but still important in terms of hydrogeology, are the ones in Jabal el Cheikh, Niha and Barouk ranges. They cover around 12 percent of the surface area of Lebanon. Other karstified formations are the Eocene and the Miocene aged rocks which cover eight percent and 1.25 percent, respectively. The Eocene is present mainly in the south and southern Bekaa and the Miocene in Beirut and Tripoli areas. The Bekaa Valley is covered with extensive non-karstic Quaternary aged deposits beneath which lie karstic formations belonging to the Eocene, Miocene and Cretaceous periods. Moreover, karst areas beneath the sea are less exposed but also important; examples include Chekka, Batroun, and Jounieh in Mount Lebanon and Naqoura in the south.

Karst is very vulnerable to pollution and is affected by many anthropogenic activities. The most significant stressors include quarrying (mainly blasting), construction, substandard sewage infrastructure, waste dumping, the reckless disposal of construction waste in ravines and along riverbeds, and poorly planned road construction. Vandalism is not uncommon and can cause significant and irreversible damage to karst formations (including stalactites and stalagmites).

See ***Map 7*** on topography and surface and underground water resources and ***Map 8*** on geology and tectonic risk of surface water infrastructure.

Photo: Underground Karst Formations in Jeita Cave (Red Hall)

4.2 BIOLOGICAL AND NATURAL ENVIRONMENT

The NWSS may impact the biological environment in many ways (impoundments, STP, etc.). This section therefore describes the baseline biological and natural environment that may be affected by infrastructure works foreseen in the NWSS.

4.2.1 Riparian Habitats

Riparian zones are ecosystems located along the banks of rivers, streams, creeks, or any other water networks. Usually riparian zones are narrow strips of land that line the borders of a water source. Riparian flora and fauna are often distinctly different from those found in adjacent communities because of the water-rich soils found in the riparian zone. Healthy riparian zones provide a variety of important ecosystem services including (1) sediment filtering, (2) bank stabilization, (3) water storage and release, and (4) aquifer recharge. Riparian habitat can be defined as transitional areas regularly influenced by fresh water. They extend from the edge of a water body to the edge of the upland community, and constitute important habitats for wildlife.[9]

The importance of riparian habitat to wildlife in general and birds in particular is a well-documented phenomenon. A study by Stevens and others (1977) showed that riparian habitats contained up to 10 times as many migrant passerines (songbirds) per hectare compared to adjacent, non-riparian habitats. Riparian habitat is especially important to insectivores because flowing water is required for many insects' life cycles.[10] Riparian habitat is also critical to breeding birds. Riparian vegetation provides habitat for many more breeding birds than do surrounding uplands (Knopf et al. 1988). **In Lebanon, about 80% of the breeding WBDS nest in riparian habitats.**

Riparian habitats are important because:

- The flow of water through riparian soils regenerates ground water
- The riparian vegetation can remove excess nutrients and sediment from surface runoff and shallow ground water
- The riparian vegetation shades streams to optimize light and temperature conditions for aquatic plants, fish, and other animals
- The riparian areas provide important habitat for many endangered and threatened species and other wildlife and plants

Riparian habitats are very diverse but offer similar ecological features including energy flow, nutrient cycling, water cycling, hydrologic function, and plant and animal population. Despite their ecological importance, riparian habitats in Lebanon are not listed among the country's known biological hotspots. In fact, there has not been a systematic survey of biological hotspots in Lebanon to date. Some references have determined that the Cedar corridor in Mount Lebanon and the Orontes Valley, including the upper Litani River and its watershed, are biological hotspots.[11] Lebanon offers many more biological hotspots but those have not been sufficiently assessed.

Water bodies constitute a target for the hunters of waterfowls (also called wildfowling). They use their swimming dogs to collect any game that may fall in water. In Lebanon there are more than 300,000 hunters, of them only one third (100,000) are interested in waterfowl. Hunting may cause reduction in abundance of game, disturbance, poisoning of other predators with lead and pollution of the ground with empty cartridges. Hunting however can also contribute to improving socio-

[9] Naiman et al. 2005
[10] Stevens et al. 1977
[11] Quezel et al. (1999) & BirdLife International (2008)

economic conditions of the local communities through sale of hunting equipment, meals, beverage, rental of overnight accommodation, purchase of souvenirs, petrol and home processed food.

4.2.2 Bird Species

Lebanon is home to 399 bird species that are present along one year cycle and in considerable numbers. Of those 399 species, 47% are passage migrants or winter visitors (or both), 18% are vagrants, 16.5% summer breeders and 16.5% breeding residents. The remaining birds are of uncertain status (Leach's Storm Petrel *Oceanodroma leucorhoa*, and Namaqua Dove *Oena capensis*), have originated from escapes (Red Turtle Dove *Streptopelia tranquebarica* and Indian Silverbill *Lonchura malabarica*) or formerly bred, but no longer appear in Lebanon (Lesser Crested Tern *Sterna bengalensis* and Blue-cheeked Bee-eater *Merops persicus*).[12] The same study states that 187 species (47%) are water body dependent bird species (WBDS). They are listed in ***Annex 11.2.*** Most of the WBDS use the riparian vegetation as a corridor during the altitudinal migration or as a nesting habitat during the breeding season. Overall, at least 10 birds seen in Lebanon are threatened and 15 are near-threatened, as determined in accordance with the IUCN's 2013 Red List.[13]

Table 10. Threatened Birds Species Observed in Lebanon

Arabic name	*English name*	*Scientific name*	*Degree of threat*
شرشير مخطط	Marbled Teal	*Marmaronetta angustirostris*	VU
عقاب أسفع (أرقط) كبير	Greater Spotted Eagle	*Aquila clanga*	VU
ملك العقبان	Eastern Imperial Eagle	*Aquila heliaca*	VU
قطقاط اجتماعي	Sociable Lapwing	*Vanellus gregarius*	CR
بجع دلماشيا (أشعث)	Dalmatian Pelican	*Pelecanus crispus*	VU
نعار سوري	Syrian Serin	*Serinus syriacus*	VU
الرخمة المصرية	Egyptian Vulture	*Neophron percnopterus*	EN
صقر الغزال	Saker Falcon	*Falco cherrug*	EN
حبرو	Great Bustard	*Otis tarda*	VU
حبارى ماكويني	Macqueen's Bustard	*Chlamydotis macqueenii*	VU
شحرور الماء	Dipper of Lebanon	*Cinclus cinclus rufiventris*	Endemic

Legend (BirdLife International 2012): **CR** Critically Endangered, **VU** Vulnerable, **EN** Endangered

4.2.3 Protected Areas

Lebanon has 16 legally established nature reserves covering approximately 2.2 percent of the territory (see Table 11). The management and operation of nature reserves is a shared responsibility between the Ministry of Environment, the Appointed Protected Areas Committee and the Management Team of the Nature Reserve.

Several nature reserves have earned other designations such as Biosphere Reserves and Important Bird Areas. In total, Lebanon offers 3 Biosphere Reserves (Shouf Biosphere Reserve, Jabal Moussa and Jabal El Rihane), 13 protected forests, 16 protected sites, 4 Ramsar Sites, 5 World Heritage Sites, and 15 Important Bird Areas. Some of those nature reserves and sites may be affected by the initiatives foreseen in the NWSS. Additionally, there are other on-going efforts to establish "micro-reserves" in Lebanon. For example, the Critical Ecosystem Partnership Fund (CEPF)[14] recently

[12] Ramadan-Jaradi et al. 2009

[13] Adapted from Ramadan-Jaradi et al. 2008

[14] CEPF is a joint initiative of The Global Environment Facility, The John D. and Catherine T. MacArthur Foundation, Agence Française de Développement, Government of Japan, the European Union, Conservation International and The World Bank.

approved a grant to setup three “micro-reserves” to conserve rare or endemic species in Lebanon. Located in Baskinta, Ehmej and Sarada, these micro-reserves will help protect important species such as the *Iris sofarana*.

Table 11. Lebanon’s 16 Nature Reserves

Nature Reserve	*Legal Instrument*	*Date*	*Approximate Area (ha)**	*Elevation Zone (m)*
Horsh Ehden	Law 121	9/3/1992	1,740	1200-1900
Palm Islands	Law 121	9/3/1992	26	Sea Level
Karm Chbat	Decision 14/1	6/10/1995	513	1400-1900
Shouf Cedars	Law 532	24/7/1996	16,000	900-2000
Tyre Coast	Law 708	5/11/1998	3,889	Sea Level
Bentael	Law 11	20/2/1999	75	250-800
Yammouni	Law 10	20/2/1999	2,100	1400-2000
Tannourine Cedars	Law 9	20/2/1999	195	1300-1800
Wadi Al Houjair	Law 121	23/7/2010	3,595	250-400
Mashaa Chnaniir	Law 122	29/7/2010	27	500-530
Kafra	Law 198	18/11/2011	40	400-600
Ramiya	Law 199	18/11/2011	20	400-600
Debel	Law 200	18/11/2011	25	400-600
Bayt Lif	Law 201	18/11/2011	20	500-600
Jaij Cedars	Law 257	15/4/2014	20	1650-1750
Lazzab Dannieh	Decree 92**	9/7/2014	23,000	1400-2000

** Areas are estimated by ECODIT using Google Earth Imagery*
***Await approval by Parliament to become law*

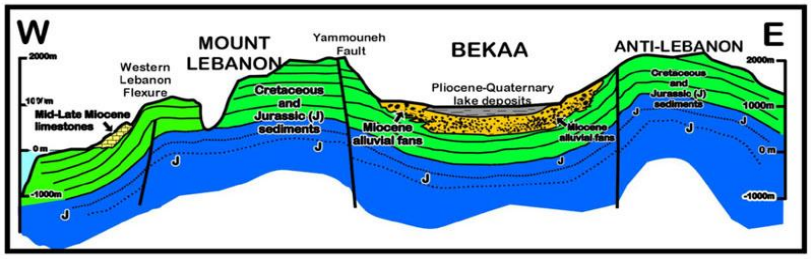
See ***Map 9*** on the location of environmental sensitive areas and large water infrastructure in Lebanon

List of forests and natural sites

4.2.4 Natural Risks

Lebanon faces different types of natural risks from large-scale disasters such as earthquakes, tsunamis, storms and droughts to smaller scale events including landslides, floods, fires and torrential rain periods. These risks may cause physical damage or destruction, loss of life, or drastic change to the environment. Some of them are interrelated (i.e. storms and floods, torrential rain and landslides, droughts and fires) while others can have catastrophic consequences (i.e. earthquakes and tsunamis). Lebanon's mountainous morphology is transected by many faults including three major faults (Yammouneh, Roum and Serghaya). There are dozens of other minor faults (see Figure 4). The National Land Use Master Plan identified areas prone to flooding, landslide, desertification and seismic hazards, as summarized in Table 12. **It is important that all large scale infrastructure works proposed in the NWSS, especially dams, are designed to withstand natural risks estimated using the Maximum Credible Earthquake (MCE), if any.**

Figure 4. Schematic East-West Cross Section of Lebanon



Source: adapted from Walley, C.D., The Geology of Lebanon, DDC-AUB

Table 12. Areas prone to natural disasters

Natural Disaster	*Areas*
Flood	Plains of Aassi in central Beqaa, Wadi Khaled in Akkar, Koura, coastal plains of Sour, Qasmiyeh plains, Saida and Damour, coastal zone of Chekka, Batroun and Khaldeh.
Landslide	High risk zones are those with steep stream basins of Nahr Abou Moussa, Nahr Qadisha, Nahr El Jaouz, Nahr Ibrahim, Nahr El Kalb. High risk zones also include places with steep slopes often located along faults, especially those of Yammounneh (Jbab el-Homr, Yammounneh and west side of West Beqaa), Wadi El Taym, Ras El Shaqaa in the caza of Batroun. The same degree of risk characterizes areas of less steeper slopes, such as the plain of Boqayaa at Wadi Khaled or west side of Koura.
Desertification	The arid regions of the Northeast (Hermel and Aassi regions)
Seismic activity	Seismic hazard is present in every region of Lebanon as a result of its geographical position over two tectonic plates. Hazards are maximal around active faults, but more or less strong tremors can occur all over the territory.

Source: Adapted from the Final Report of the NLUMP (December 2005)

See ***Map 8*** on geology and tectonic risk of surface water infrastructure.

4.3 SOCIAL AND SOCIO-ECONOMIC ENVIRONMENT

Consumers include households, farmers and industries. This section presents a baseline description of the social and socio-economic environment including population, refugees, agricultural and industrial activities, poverty areas, and water consumption patterns.

4.3.1 Population

Lebanon's last official population data was published in 1997 (Living Conditions by the Central Administration of Statistics), and 2004 (Ministry of Social Affairs); see Table 13. All other population data are based on projections.

Table 13. Lebanese Population Data (1997 and 2004)

	LC-1997				MPS-2004			
	Distr. Pop		Distr. HH		Distr. Pop		Distr. HH	
Beirut	403,337	10.07%	93,090	11.06%	389,661	10.38%	101,695	11.56%
Mount Lebanon	1,507,559	37.64%	336,427	39.97%	1,501,282	39.99%	371,289	42.20%
Northern Lebanon	807,204	20.15%	147,088	17.48%	768,709	20.48%	162,344	18.45%
Bekaa	539,448	13.47%	106,843	12.69%	471,137	12.55%	102,797	11.68%
Southern Lebanon	472,105	11.79%	95,120	11.30%	401,075	10.68%	89,423	10.16%
Nabatieh	275,372	6.88%	63,109	7.50%	221,920	5.91%	52,306	5.94%
Lebanon	**4,005,025**	**100.00%**	**841,677**	**100.00%**	**3,753,785**	**100.00%**	**879,854**	**100.00%**

Additionally, Lebanon's population also includes an estimated 400,000 Palestinian refugees (some displaced since 1948) as well as 1.5 million Syrian refugees (displaced people since 2010). Refugees whether living in host communities or in settlements also need water and sanitation services and therefore strain existing infrastructure.

4.3.2 Farmers and Agricultural Activity

There are two principal sources of information on Lebanon's agricultural profile: (1) The Living Conditions survey conducted by the Central Administration of Statistics in 2004 and published in 2006; and (2) the agricultural census conducted by the Ministry of Agriculture conducted in 2010.

According to the 2004 CAS survey, the total resident population in Lebanon at the time was estimated at 3.8 million. The national activity rate (total active population as a percentage of total population) that year was 30 percent. Around 86,000 persons worked in the agricultural sector which constitutes almost 8 percent of the total active population. The agricultural clusters may be classified into three distinct groups (Group 4 are non-agricultural clusters):

Group 1: includes clusters with a high share and high concentration of persons working in the agricultural sector. Includes clusters with a share of agricultural workers that exceeds 20% (out of total active population). Includes more than 60% of the total number of agricultural workers.	Akkar/Minieh-Dennieh, Sour, Bent-Jbeil/ Marjaayoun/ Hasbayya and Hermel/ Baalbeck.
Group 2: includes clusters with a significant share of agricultural workers. Represents around 12% of total workers in the agricultural sector.	Baalbeck city, Zahle, and West Bekaa/Rachaya
Group 3: includes clusters with significant potential in terms of agricultural activity. Represents around 9% of the total agricultural active population.	Koura/Zgharta/Batroun/Bsharre and Jezzine/Saida clusters

Group 1 constitutes the heartbeat of Lebanon's agricultural activity.

Table 14: Resident population, activity rate and share of actives in the agricultural sector

Cluster	*Population*		*Activity rate*	*Total actives in agr. sector*	*Distribution of actives in agricultural sector*	*Share of active in agricultural sector out of total actives*	*Group*
	Total	Active					
Akkar/Minieh-Donnieh	370312	81085	22%	18268	21%	23%	1
Tripoli city	226225	64198	28%	1322	2%	2%	4
Koura/Zgharta/ Batroun/Bsharre	172168	50697	29%	4401	5%	9%	3
Keserwan/Jbeil	208060	76998	37%	4827	6%	6%	4
Metn	353292	131718	37%	2621	3%	2%	4
Beirut city	390504	146135	37%	0	0%	0%	4
Baabda	535082	162808	30%	685	1%	0%	4
Shouf/Aley	405136	118853	29%	3721	4%	3%	4
Jezzine/Saida (city excl.)	172705	44012	25%	3796	4%	9%	3
Nabatieh	100044	23438	23%	1339	2%	6%	4
Sour	149128	39604	27%	7944	9%	20%	1
Bent Jbeil/ Marjaayoun/ Hasbayya	121797	33268	27%	10598	12%	32%	1
West Bekaa/Rashayya	88867	23031	26%	4463	5%	19%	2
Zahle (city excluded)	85448	25900	30%	4402	5%	17%	2
Hermel/Baalbek (city excluded)	213877	46775	22%	15499	18%	33%	1
Saida city	79365	19536	25%	430	0%	2%	4
city of Zahle	36536	13362	37%	313	0%	2%	4
Baalbek city	46473	12521	27%	1379	2%	11%	2
Total-Lebanon	**3755019**	**1113939**	**30%**	**86008**	**100%**	**8%**	**4**

Source: Adapted from Living Conditions of Households, MoSA-CAS-UNDP 2004 (calculations by CRI)

The 2010 agricultural census conducted by the Ministry of Agriculture provides valuable information on the "usable agricultural area" (UAA).[15] Table 15 shows that Akkar and Baalbeck represent 36% of total UAA and 27% of total farmers. Moreover, Cazas belonging to Group 1 (as defined previously) represent 52% of the total number of farmers, 57% of the total UAA, and 55% of the total irrigated UAA. The MOA census was conducted at the Caza level.

[15] a.k.a. Utilized Agricultural Area and, in French: Surface Agricole Utile (SAU)

Table 15: Number of farmers, agriculture areas and irrigated areas by Caza

Caza	*Number of farmers*	*Farmer's distribution*	*Total UAA*		*Irrigated UAA*	
			Dunum	*% of Total*	*% of Caza*	*% of Total*
Aakkar	28,120	17%	353,519	15%	44%	14%
Baalbek	16,850	10%	483,428	21%	55%	23%
Chouf	13,522	8%	73,618	3%	32%	2%
Sour	10,869	6%	125,608	5%	42%	5%
Danniye	10,536	6%	70,084	3%	73%	5%
Nabatiye	8,367	5%	62,047	3%	26%	1%
Saida	7,418	4%	98,138	4%	64%	6%
Bent Jbayl	7,301	4%	62,429	3%	6%	0%
Koura	5,874	3%	62,946	3%	4%	0%
Marjaayoun	5,818	3%	83,422	4%	21%	2%
Hasbaya	4,896	3%	53,051	2%	23%	1%
Beqaa El Gharbi	4,818	3%	168,184	7%	75%	11%
El Hermel	4,719	3%	92,821	4%	56%	5%
Aaley	4,634	3%	27,906	1%	41%	1%
Zahle	4,575	3%	189,258	8%	86%	14%
Batroun	4,484	3%	31,603	1%	31%	1%
Jbayl	4,426	3%	33,881	1%	63%	2%
Zgharta	4,008	2%	57,425	2%	23%	1%
Jezzine	3,824	2%	32,465	1%	23%	1%
Baabda	3,758	2%	36,752	2%	31%	1%
Kesrouan	3,286	2%	19,459	1%	87%	2%
Rachaya	3,123	2%	59,047	3%	16%	1%
Bcharre	2,282	1%	15,905	1%	91%	1%
Metn	1,552	1%	14,264	1%	64%	1%
Tripoli	452	0%	2,684	0%	31%	0%
Lebanon	**169,512**	**100%**	**2,309,943**	**100%**	**49%**	**100%**

Source: Ministry of Agriculture, Census of Agricultural Activities (2010)

The conclusions derived from the 2004 CAS survey and the 2010 MOA census converge. Indeed, in terms of UAA distribution, farmers' distribution, and number of actives in the agricultural sector, the following 8 Cazas show predominance in agricultural activity: Akkar, Baalbeck, Hermel, Sour, Bint-Jbeil, Marjaayoun, Hasbaya and Minieh-Donnieh. It is also noteworthy that in terms of irrigated UAA, the bottom three Cazas are located in the South: **Bint-Jbeil**, **Marjaayoun**, and **Hasbaya**. The Cazas of West Bekaa, Saida and Zahle rank second in terms of agricultural activity.

4.3.3 Poverty Areas

The most recent study conducted on Poverty in Lebanon was published in 2008 and was based on data gathered in 2004. The poverty results, per region (Caza or cluster) in terms of lower and upper poverty headcounts are presented in Table 16. Except Tripoli city, as well as a few other urban pockets in Saida and surrounding Beirut, which are characterized by an urban poverty dimension, the highest poverty headcounts are observed in the following areas:

i. Akkar/Minnieh-Donnieh,
ii. Baalbeck/Hermel,
iii. West Bekaa/Rashayya, and
iv. Sour.

Table 16. Lower and upper poverty headcounts in 2004

Cluster	*Lower Poverty Headcount*	*Upper Poverty Headcount*
Tripoli city	23.17%	56.72%
Akkar/Minnieh-Donnieh	20.61%	62.98%
Hermel/Baalbeck	13.40%	32.54%
Jezzine/Saida	13.17%	45.54%
West Bekaa/Rashayya	9.32%	29.95%
Sour	8.96%	36.41%
Zahle	6.20%	21.88%
Shouf/Aley	5.52%	22.77%
Baabda	4.90%	24.50%
Koura/Zgharta/Batroun/Bsharre	4.46%	24.74%
Bent Jbeil/Marjeoun/Hasbayya	3.09%	25.51%
Maten	1.63%	11.18%
Keserwan/Jbeil	1.31%	15.24%
Nabatieh	1.05%	11.37%
Beirut	0.67%	5.85%
Lebanon	**7.97%**	**28.55%**

Source: Poverty, Growth and Income Distribution, UNDP 2008 (data for 2004)

Interestingly, most of these regions belong to Group 1 (very high agricultural activity). Stated differently, three regions are characterized by both high poverty levels and significant agricultural activities. They are: Akkar/Minnieh-Donnieh, Baalbeck/Hermel, and Sour. To a lesser extent, the West Bekaa/Rashayya cluster, which belongs to Group 2 (significant agricultural activity), may also be added. The Jezzine/Saida cluster, which belongs to Group 3 (significant potential in agricultural activity) also, shows a very elevated Upper Poverty Headcount.

Previous poverty studies, such as the Unsatisfied Basic Needs studies (in 1995 and 2004), the Poverty Targeting Mechanism (ESFD 2002) and the Rapid Social Assessment (CDP-CDR, 2006) have generated similar results: agriculture and poverty maps “overlap” significantly.

See ***Map 10*** on irrigation perimeters and poverty linkages.

4.3.4 Industries and Industrial Activity

Industries in Lebanon are spread all over the territory. The majority are located outside so called "industrial zones" and inside residential areas including towns and cities. Effective zoning regulations for industries are either lacking or are not adequately enforced. According to a 2008-2010 study conducted by the Ministry of Industry (MOI) and the Association of Lebanese Industrialists (ALI), there are 4,033 "large establishments" in Lebanon (MOI/UNIDO/ALI, 2010). About half of these establishments are located in Mount Lebanon (49.8%) followed by the Bekaa (18.4%).

About 86.2% of the industrial establishments operate in 10 major industrial sectors:

(1) food products and beverages (see box 2),
(2) furniture and other manufactured goods,
(3) other non-metallic mineral products,
(4) fabricated metal products,
(5) printed matter and recorded media,
(6) chemicals & man-made fibers,
(7) rubber and plastic products,
(8) machinery and equipment,
(9) electrical machinery and apparatus,
(10) pulp, paper and paper products.

The food and beverage industries lead the Lebanese industry sector representing around 19% of total industrial establishments in the country.

Box 2. Lebanon's Water Bottling Industry

Lebanon has a thriving water bottling industry. Consumer confidence in the public water services has been historically low and the majority of consumers therefore resort to bottled water. In principle, water bottling industries must be licensed by the Ministry of Public Health (MoPH). In practice however, many bottling plants remain unlicensed and therefore avoid inspection. According to MoPH's website, there are 38 licensed water bottling plants, many of which are located in mountain areas, near (within 1km) proposed NWSS interventions.

Source: MOPH (March 2014)

Little is known about the quantity of water used by the industrial sector in Lebanon, but sources estimate that the **industrial water demand in Lebanon ranges between 150 and 163 MCM per year**, equivalent to around 11% of the total annual water demand (MEW, 2010a). Industrial water demand is generally calculated based on registered industrial establishments in public water institutions (MOE/EFL/ECODIT, 2012). Decrees 14597, 14599, 14601 and 14603 (dated 14/06/2005) related to Lebanon's Water Establishments defined daily water allocations to different subscribers including industries. In practice, industries consume more water than they receive from the public grid. They can either request more water (the utilities may or may not be able to accommodate such requests) or cover their water deficit by diverting surface water and/or tapping groundwater. Many wells are unlicensed (MOE/EFL/ECODIT, 2012). Large industrial water consumers include the food industry, pulp and paper industry, and chemical industries. Most industries continue to discharge their effluents into the municipal wastewater system (if any) or directly into the environment with no prior treatment (MOE/EFL/ECODIT, 2012).

4.3.5 Household Water Consumption and Expenditure

This section starts with a brief overview of the current water network system in Lebanon, then assesses the available data regarding household water consumption patterns, and finally presents the results based on two references, namely CAS[16] and World Bank[17] (WB). Although CAS data seems to underestimate water expenditures, it provides interesting results in terms of the water expenditure structure. The WB study presents cross-tabulated results in terms of household expenditures and income quintiles.

[16] Central Administration for Statistics, Household Expenditures Surveys (1997, 2004 and 2012)
[17] Lebanon, Social Impact Analysis – Electricity and Water Sectors; CRI – WB 2009

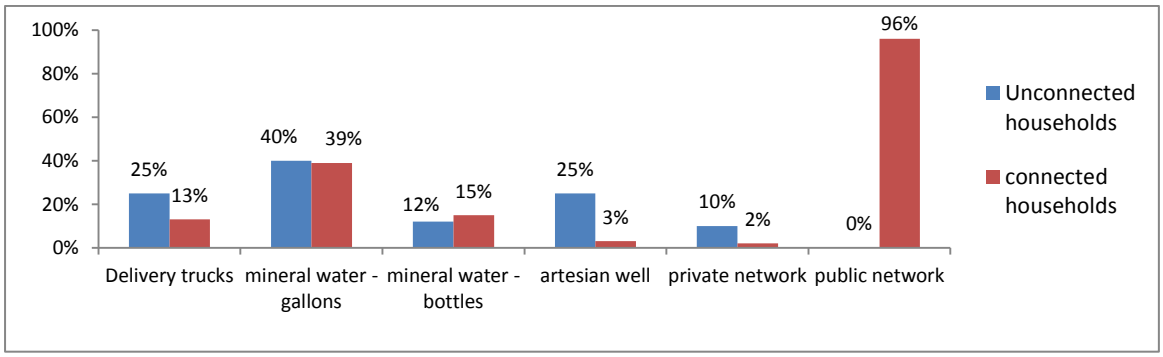
In Lebanon, public water is supplied to connected households on a subscription basis. Unconnected households have other sources of water. A fixed annual fee is charged to each connected household. With very few exceptions on pilot scale, there are no meters and the amount of water delivered is regulated by a gauge system. The vast majority of households have a one-cubic-meter-gauge connection. The amount delivered depends both on the amount of time water flows through the pipes and on water pressure. Billing is based on a contractual fixed consumption regardless of the amount of water actually delivered. Most households do not receive water on daily basis. Inadequate and unreliable water supply pushes households to purchase water from alternate sources, such as artesian wells and delivery trucks for service water or water in gallons or bottles for drinking water.

In practice, most households pay for the water provided by the public network in addition to other sources of service water and drinking water. Most households therefore pay the following:

- Public network annual fee
- Other sources of service water (e.g. water trucks, private wells)
- Other sources of drinking water (e.g. water gallons)
- Maintenance costs and/or investment costs

Although connection to the public network reaches 96%, mineral water (gallons and bottles) remains a significant source of drinking water for both connected and unconnected households: about 40% of households buy mineral water in gallons and 12%-15% of them buy mineral water in bottles. Artesian wells and delivery trucks are the main source of service water for unconnected households.

Figure 5. Sources of Water at the Household Level



Source: WB 2009

4.4 CULTURAL ENVIRONMENT

Lebanon offers countless tangible and intangible sites and features of archaeological, historical, cultural, and aesthetic or landscape interest. This section highlights some of those sites and monuments that may be affected by the NWSS.

4.4.1 Roman Aqueducts

Aqueducts, in addition to road systems and agriculture and food stores, were one of the most prominent Roman infrastructures recognized by historians and archeologists. Aqueducts were critical to ancient Roman civilization and its evolution from a regional power into a vast empire with trans-continental reach and influence (Assante, 2009). Aqueducts were man-made arches, channels and streams conducting water downhill from natural sources (springs) to public baths, latrines, fountains and private households.

Several similar aqueducts were built throughout the Roman Empire. In Lebanon, specifically in Beirut (Lebanese capital), known as *Be'erōt,* the city of wells in the Canaanite-Phoenician times (Encyclopaedia Britannica), the demand for water grew dramatically with the expanding urbanization during the Roman period. The solution was to draw water from one of the springs located along the Beirut River, the Daychouniyeh sources, situated 15 km from the city. To transport this water, the Roman architects built an aqueduct known as the Aqueduct of Zubaida, or "Qanater Zubaida" (Davie, M. et al., 1997). Also in South Lebanon, the remaining arches and structures (open and underground) of a Roman aqueduct are still surviving in Tyre. The Aqueduct of Tyre, drawing water from Ras el Ain springs to the city (5 Km), was previously used to supply the southern region of Lebanon, including agricultural areas, with fresh water (Haddad, 2013). In North Lebanon the ruins of a Roman aqueduct, the Aqueduct of Nahr Ibrahim, used to drawing water from Afqa spring to the city of Jbeil, are also found. However little is known about the Aqueduct of Msaylha in Batroun.

4.4.2 Nahr Ibrahim (Adonis River)

Adonis river was part of the cultural, religious and ideological life of ancient civilizations: people used to worship Adonis & Astarte marching the valley up to Afqa, and when the river water reddens by the action of natural phenomena the people reckoned that "Adonis has died", remembering the legend of the lover Adonis who adored the Goddess Astarte angering her god lover and provoking his vengeance. The river was since named Adonis River carrying its symbol in the blood-red color, and blooming anemones on its banks announcing the return of Adonis to life and of nature to early spring. (Source: Adonis River, Valley of the Dancing Shadows)

4.4.3 Stone mills and other artifacts

Lebanon's hydrological situation has attracted many water-dependent activities, especially in its mountain ranges. Steep canyons and valleys have encouraged the establishment of countless water mills (such as on Nahr el Joz and in Chebaa) which survived centuries and were for the most part still in use until recent times. Many more water-related and historical infrastructure has yet to be uncovered and documented. It is therefore highly probable that several dams and reservoirs proposed by the NWSS will infringe on and/or inundate cultural and water vestiges in rural Lebanon.

4.5 UTILITIES AND INFRASTRUCTURE

The following section describes pertinent water and wastewater infrastructure in Lebanon.

4.5.1 Wastewater Treatment Plants

As shown in Section 5.1.4, Lebanon's wastewater sector has made noteworthy strides but the majority of completed STP remains out of operation or are operating below design capacity. Causes include incomplete wastewater collectors, inadequate source of power, lack of O&M capabilities, and/or wastewater theft upstream by farmers. To remedy the lack of human and technical resources at the utilities to run those plants, the Council for Development and Reconstruction and the Ministry of Energy and Water have been merging awards for construction and O&M into one contract. For example, in Tripoli, the largest completed STP to date was built by French Degremont who is also operating the facility. This plant was completed in 2010 but currently operates at 10% of its capacity pending the completion of all the main collectors that feed into the plant. See detailed summary of STP (planned, under construction, completed) and their status in Table 5.

4.5.2 Storage Dams and Other Man-Made Water Bodies

Lebanon has two large-scale dams, and several smaller dams and reservoirs. The Qaroun Dam holds Lebanon's largest lake, covering an estimated 1190 ha, and holding 220MCM. The Chabrouh Dam is Lebanon's second largest dam and holds about 8 MCM. These open water bodies attract birds and

other water-body-dependent species. Additionally, Lebanon has dozens of natural and/or other smaller water bodies including: the natural swamps of Aammiq (280 ha), artificial marshes of Bishmezzine near Koura (200 ha), Oyoun Orghosh, Kwashra Lake, Oyoun El Samak, and Bnashai Lake. Lebanon has also built hundreds of small rainfed hill-lakes (10,000 - 100,000m^3) primarily located in Jbeil, Kesrouan and Baabda. All attract wildlife including birds for a reason or another.

Moreover, there are many agricultural puddles everywhere in Lebanon which provide essential moisture to a variety of animals, birds and insects. In addition, waste water treatment plants provide many aquatic birds with water that is used for resting, feeding and roosting, provided the treated water is free from any compound that may affect the water-repellent properties of these birds.

4.5.3 Hydropower Generation

Hydro-electricity energy supply in Lebanon represents about 3% of total electrical energy demand (see hydropower plants in Table 17).[18] This contribution may range from 1.5% (drought year like 2013-2014) to 4.5% (exceptional rainfall) of total energy demand. It is worthwhile noting here that with the completion of the 800 conveyor feeding the high lands of south Lebanon, the Litani River Authority may lose up to 75% of its electrical generating capacity thus reducing sensibly the overall contribution of hydro-electricity to the national electricity supply.

Table 17. Hydropower Electricity Current Installed Capacity in Lebanon

River Stream	Establishment	Plant Name	Year	Installed Capacity	MW	Remarks
LITANI AWALI RIVERS	LITANI WATER AUTHORITY	MARKABI	**1961**	1 x 17.9 MW + 1 x 19 MW	**199**	In Service - Will be affected by Conveyor 800 Project
		AWALI	**1964**	3 x 37.76 MW		
		JOUN	**1967**	2 x 24.65 MW		
NAHR IBRAHIM RIVER	SOCIETE PHOENICIENE DES FORCES DE NAHR IBRAHIM DES EAUX ET ELECTRECITE	CHOUANE	**1961**	2 x 7.5 MW	**32**	In Service - Needs Rehabilitation / Upgrade
		YAHCHOUCH	**1955**	2 x 4.984 MW + 1 x 2.464 MW		
		FITRI	**1951**	3 x 1.664 MW		
WADI KADISHA	LA KADISHA - SOCIETE ANONYME D'ELECTRECITE DU LIBAN NORD S.A.L. (EDL OWNED)	BECHARE	**1924**	2 x 0.82 MW	**21**	In Service - Needs Rehabilitation / Upgrade
		MAR LICHA	**1957**	3 x 1.04 MW		
		BLAOUZA II	**1961**	3 x 2.8 MW		
		ABU-ALI	**1932**	2 x 2.72 MW + 1 x 2.04 MW		
NAHR AL BARED	AL BARED CONCESSION	AL BARED 1	**1936**	3 x 4.5 MW	**17**	In Service - Needs Rehabilitation / Upgrade
		AL BARED 2	**1936**	1 x 1.2 MW + 1 x 2.5 MW		

[18] Source: MEW, 2012

SAFA SPRING	ELECTRICITÉ DU LIBAN	RICHMAYA - SAFA	**1931**	2 x 3.1 MW + 1 x 6.8 MW	**13**	In Service - Needs Rehabilitation / Upgrade
TOTAL INSTALLED CAPACITY					**282**	MW

Source: MEW, 2012 (Hydropower Electricity in Lebanon)

Note: Actual capacity may be up to 30% lower than nominal (installed capacity) because most stations are more than 50 years old and maintenance procedures experienced setbacks from 1975 to 1990 and beyond.

4.6 LEGAL, INSTITUTIONAL AND POLICY ENVIRONMENT

This section describes the baseline legal, institutional and policy environment affecting the water sector in Lebanon, in brief.

4.6.1 Multilateral Environmental Agreements

The NWSS may affect seven Multilateral Environmental Agreements (MEAs). The following crosswalk shows potential linkages between the MEAs and planned NWSS investments.

Table 18. Potential linkages between the MEAs and planned NWSS investments

Multilateral Environmental Agreement	***NWSS Component***			
	Source	Conveyance	Irrigation	Wastewater
• Decree Law 126/1977 - Convention for the Protection of the Mediterranean Sea against Pollution – Barcelona				X
• Law 292/1994 - Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources – Athens			X	X
• Law 23/1999 - Convention on Wetlands of International Importance especially as Waterfowl Habitat – Ramsar	X	X	X	X
• Law 359/1994 - United Nations Framework Convention on Climate Change (UNFCCC)			X	X
• Law 360/1994 - Convention on Biological Diversity - Rio de Janeiro (CBD)	X			
• Law 469/1995 - United Nations Convention to Combat Desertification – Paris (UNCCD)	X		X	
• Law 412/2002 - Agreement on the Conservation of African - Eurasian Migratory Water Birds (AEWA)	X		X	
• 25 May 2013 - Convention on International Trade in Endangered Species (CITES)	X	X		

Specifically, several MEAs highlight the importance of riparian habitats:

(1) The CBD Convention ratified by Lebanon in 1994 states that by improving the riparian zones, the stream bank erosion can be reduced, the water quality can be improved and the biodiversity can be supported and conserved.

(2) The AEWA calls for improving and restoring riparian woods that would benefit tree-nesting species protected by the Agreement such as Goosander *Mergus merganser* and Goldeneye *Bucephala clangula*,

(3) The RAMSAR Convention on Wetlands considers the riparian areas as part of the wetlands of international importance, and

(4) The CITES pays attention to the riparian area as a refuge to a variety of species protected by CITES (such as the Otter).

4.6.2 Relevant Laws and Regulations

Lebanon has a plethora of environmental laws and regulations. The most significant laws and regulations in relation to the NWSS are listed in Table 19.

Table 19. Relevant Selection of Existing and/or Planned Laws and Regulations

Existing	*Planned*
• Law 444/2012 – Environment Law • Decree 8735/1974 – Public Cleanliness • **Water** Sector Reform Law 221/2000 (and its amendments) • MOE Decision 52/1 – 1996 - Specifications to reduce air, **water** and soil pollution • MOE Decision 8/1-2001 - Specifications and standards for air pollutants and **liquid waste** generated by classified establishments and wastewater treatment plants • Article 20, Item 9 of Decree 8018/2002 – Class I and II industries have to be 1000m distant from **springs** • Decree 8633/2012 – Fundamentals of the Environmental Impact Assessment* • Decree 8213/2012 – Strategic Environmental Assessment* • Law 251/2014 – Establishing the Public Environmental Prosecutor	• **Finalization of Water Code** • Modernization of Ottoman irrigation laws (1913) – Development of new irrigation Laws • Developing required legislation to initiate Private Sector Participation (PSP) • **TSE reuse standards and guidelines** • MOE proposal to develop a master plan for the coastal zone, mountains, and other fragile ecosystems, and prepare a related SEA (Ref. 3461/B dated 21 August 2012); proposal has been endorsed by almost all relevant ministries including Defence, Industry, and Municipalities and Interior, and now awaits the response from the Higher Council of Urban Planning.

Based on Environment Law 444/2002, the EIA and SEA decrees have gained traction in recent years. Although MOE has been receiving EIA studies long before Decree 8633/2012, the regulatory timeframe for responses were not adhered to and EIA findings and recommendations were seldom implemented. Since 2012, the EIA sector has gained recognition from line ministries and agencies thanks to steadfast mainstreaming by the MOE. The EIA cycles continues to face important challenges which are described in **Section 8.4**.

The extent to which the EIA process has been implemented in the planning, design and construction of NWSS investments to date will be explored later in this SEA Report.

4.6.3 Water Sector Institutional Setup

The water sector has many institutional stakeholders. There are a number of ministries and government agencies building infrastructure like water supply networks, dams, sewage systems. There are also a number of ministries and government agencies operating water infrastructure. There is a high degree of duplication along with lack of effective coordination between the stakeholders. The institutional structure along with the stakeholder's roles and responsibilities is summarised in Table 20. Lebanon also has a vibrant NGO community and several pressure groups.

Table 20. Key players and responsibilities in the water and wastewater sectors

Function	*MEW*	*LRA/WEs*	*MOE*	*MOPH*	*CDR*	*Other Govt.*
Planning	X	X			X	
Licensing and permitting (inc. EIAs)	X		X			X
Capital Investment	X	X			X	X
Infrastructure construction	X	X			X	X
Operation & maintenance	X	X				
Financing (national)	X	X			X	
Financing (external funding)	X				X	
Regulations and guidelines	X		X	X		

Note: "Other Govt" includes Council for the South, Municipalities, other ministries and agencies.

Abbreviations: **MOPH** Ministry of Public Health **MEW** Ministry of Energy and Water, **WEs** Water Establishments **MOE** Ministry of Environment, **CDR** Council for Development and Reconstruction.

Ministry of Energy and Water

The Ministry of Energy and Water (MEW) is responsible for the water sector under Law 221 dated 26 May 2000. According to Article 2 of this law[19], the Ministry has the following responsibilities:

1) Monitor, control and measure water resources, and determining needs and use of water resources
2) Monitor the quality of water resources and setting relevant quality standards for water resources
3) Establish public plans for the utilization and distribution of water resources, as well as preparing the master-plan for water and wastewater to be endorsed by the COM through the MEW
4) Design, build and put into operation major water facilities such as dams, mountain lakes, underground conveyors, river stream correction works and water supply networks and the like
5) Implement artificial recharge of groundwater when required and regulate the volumes of water extracted
6) Protect water resources from pollution and waste by issuing laws, rules and regulations and their application and enforcement
7) License wells and all water extraction from rivers and public water resources according to applicable laws and regulations
8) Implement continuous hydrological, geological and hydro-geological research, study, data gathering and mapping pertaining to the water sector
9) Provide tutelage and oversight of all public institutions working in the water sector according to Law 221 and the laws governing these institutions
10) Enhance the operational performance of regional water establishments and monitor their performance according to approved benchmarks
11) Set the standards and benchmarks the RWEs will need to abide by in their design and operation of water supply, irrigation and wastewater systems

[19] Unofficial translation by Mr. Zuhier el Hassan, NWSS SEA Water Expert on the ECODIT team

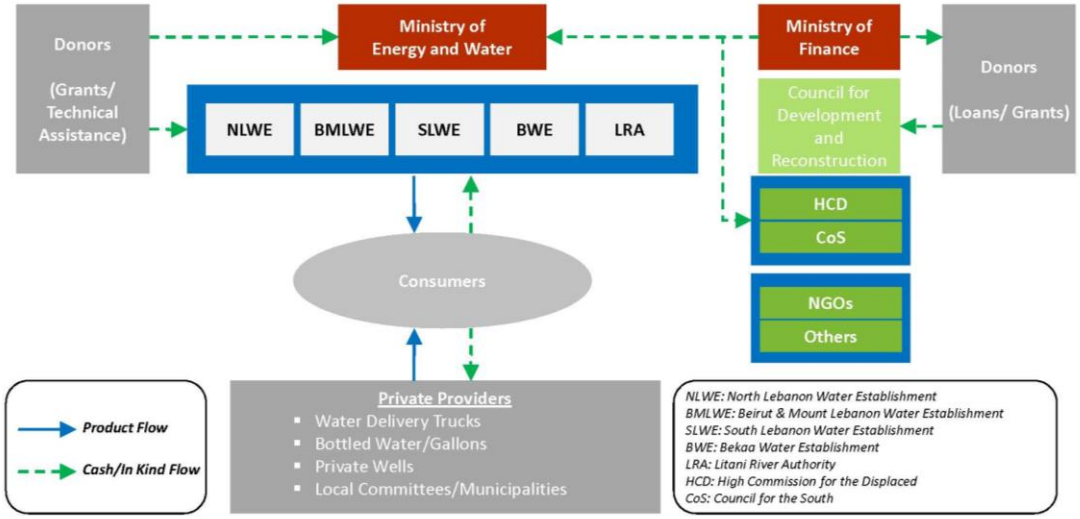
12) Conduct all land expropriations for MEW and RWEs in conformity with existing laws

13) Provide advice in the licensing of mines and quarries when such mines and quarries impact on water resources

14) Conduct outreach with citizens to inform them of water related issues and ways of conserving water.

Institutionally, the MEW is at the apex of the water sector[20].

Figure 6. Current Institutional Setting and Commercial Relations in the Lebanon Water Sector



Source: NWSS (2012)

Regional Water Establishments

Law 221/2001 and its amendments created four Regional Water Establishments (RWE): Beirut and Mount Lebanon; North Lebanon; South Lebanon; and the Bekaa. Lebanon had 21 water establishments and over 200 local water committees, mainly active in irrigation, before Law 221 was approved. Under Clause 4 of Law 221, the RWEs were given the following responsibilities:

1) Plan, build, operate and maintain potable and irrigation water transmission and distribution networks

2) Plan, build, operate and maintain sewage treatment plants (STPs) and networks

3) Ensure the quality of water supplied to their communities

4) Recommend tariffs for water, irrigation and wastewater (based on prevailing socio-economic conditions)

5) Oversee works, studies, and operation and maintenance of water installations by private service providers

[20] NWSS, 2012

The RWEs were given autonomy and control of their human resources. Financially, the RWE are subject to Government audit periodically, and their administrative activities are subject to the Government's administrative regulator (Central Inspectorate). They have the power to recommend tariff structure and rates to MEW, but not set them.

Very briefly, it is widely accepted that the performance of the RWEs has been substandard:

- Unaccounted for Water ranges from 40-52%, compared to 37% in the MENA region, and 10% international best practice
- Service is intermittent, in some parts of the country 3 hours a day during the dry season
- They do not provide wastewater services, particularly STP
- Their balance sheets, with the exception of Beirut and Mount Lebanon Water Establishment, are in a perilous state
- Collection of tariffs is low by any standard
- Customer services are rudimentary
- They are poorly resourced with technical, financial and managerial staff
- Failure to adequately maintain networks and facilities

Litani River Authority

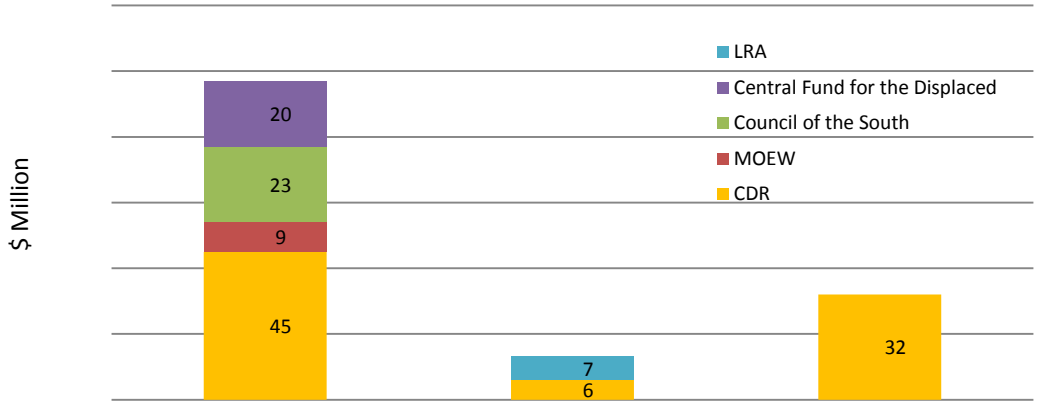
The Litani River Authority (LRA) was established in 1954 with the responsibility of managing the Litani River Basin. In particular, the LRA would (1) plan and operate all potable, irrigation and hydro-electrical schemes associated with the Litani River, (2) measure all surface flows throughout the country, (3) establish and operate all hydro-electrical generating plants.

In 1962 it was given the power to develop and operate all water systems connected to the Litani River and Awali Rivers in the area of Lebanon between the Beirut Damascus Highway and its international border in the south. Clause 7 of Law 221 affirmed that irrigation water schemes tied to the Litani River would remain under the control of the LRA. Although Law 221 should have had an impact on the LRA, it still operates as it has for the last 30 years. Its operations are within the Bekaa Water Establishment and South Lebanon Water Establishment area, yet no perceivable change has been recorded in LRA operations or those of the establishments.

Council for Development and Reconstruction

CDR has the responsibility to prepare national sector plans in coordination with the different line ministries. CDR secures international funding for these plans and then manages their execution. As different projects are completed, the ownership of facilities and assets built are handed over to the respective line ministries or establishments for management and operation. CDR has led Lebanon's capital spending in the water sector. Table 21 shows capital expenditure in the water, irrigation and wastewater sectors by several agencies.

Table 21. Yearly capital expenditure by agency



Source: WB 2009a

Other Government Agencies

The *Council for the South* is very active in building water supply systems in the south and West Bekaa regions (expenditure peaked during the period 1992-2008). These systems all rely on boreholes for the supply source. Separately, the *Central Fund for the Displaced*, which is responsible for rehabilitating and building water supply systems in the villages of Chouf, Baabda and Aley, has contributed substantially to expenditure during the last 15 years in building water supply wells. It should be noted that the Council for the South and the Central Fund for the Displaced have a lot of autonomy in terms of the decisions they take and the projects they execute. They inform MEW and the RWE, and attempts at coordination are made, but coordination remains informal.

Ministry of Environment

The Ministry, established in 1993, is responsible for controlling pollution and regulating all activities that impact the environment. Its remit is wide. The ministry has several legal avenues for controlling pollution, including prevention. For example, the EIA decree requires that all sewage treatment plants (Annex 1 projects) undergo full environmental impact assessment studies. The ministry has set standards for treated wastewater discharged into sewers (Decision 8/1 dated 30/1/2001). Although the Ministry has very limited means for law enforcement, the Ministry of Justice recently appointed environmental prosecutors pursuant to Law 251 (dated 15/4/2014)[21]. Furthermore, the MOE has been calling for establishing an environmental police force, which awaits approval by the COM. It is hoped that the presence of an environmental police and environmental prosecutors will deter, detect, report, and prosecute environmental polluters in Lebanon.

Ministry of Public Health

The Ministry of Public Health has the responsibility of maintaining health standards in the community. In relation to water resources, it monitors drinking water to ensure compliance with local and international standards. The Ministry monitors the incidence of waterborne diseases and publishes related epidemiological data.

[21] Environmental Prosecutors were appointed for all five Governorates on July 15, 2014; so far only two judges were also appointed (Beirut and Mount Lebanon, and South); so far, the prosecutors and judges appointed for environmental affairs also have other affairs to tend to.

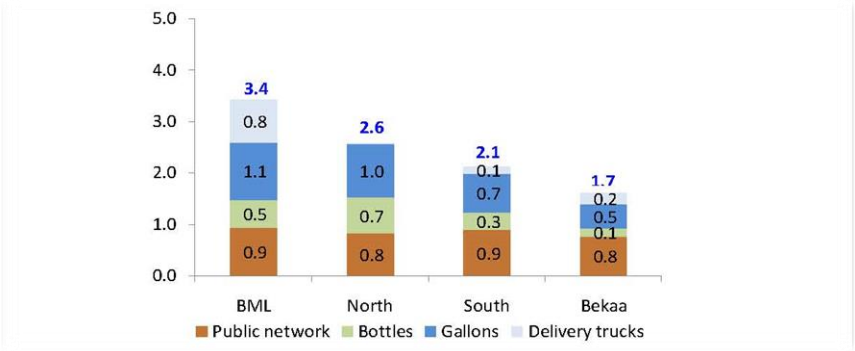
Municipalities

Traditionally, sewage networks have been the responsibility of the municipalities. Law 221/2000 is ambiguous on the issue of sewer lines, and there is a view that the rehabilitation and condition of sewer lines remains the responsibility of the municipality. Further confusion is caused by one of the provisions in the municipal law related to municipal taxes. Municipalities levy tax on the rental value of residential and commercial units, as well as a tax on sidewalks and sewers. While the RWE are not yet equipped to take possession of the STP's and other sophisticated facilities, the municipalities are totally ill equipped to operate and maintain the expanding sewage networks that are coming into operation. So while collection networks are expanding, institutionally, their operation and maintenance is uncertain. It should be noted that the municipalities continue to build or upgrade sewer lines separately from MEW, RWEs and CDR.

Private Water Suppliers

Current demand for drinking water is not being met by public resources, and the community is bearing significant additional costs with private provision of drinking water (see Figure 7). Not all the private providers of water are regulated strictly, and so the risk to public health is real. Moreover, the social and economic impact on the community, particularly the lower socio-economic groups, is quite severe. Household expenditure on water supply (public network, bottles, gallons, and delivery trucks) ranges from 1.7 percent (Bekaa) to 3.4 percent (Beirut and Mount Lebanon) of total household expenditures, of which less than 1 percent goes to the WEs (public network).

Figure 7. Household water expenditure by supply source (as % of total household expenditure)



Source: WB, 2009

At the institutional level, Lebanon's water sector reform has seen limited traction despite the promulgation of Law 221/2000 and Law 241/2000 reorganizing the country's water institutions. Subsequent application decrees related to each water establishment have likewise met considerable resistance and limited application despite noteworthy support from the donor community including USAID, GIZ and AFD. Table 22 overleaf presents a list of institutional measures in the water sector.

Lebanese Center for Water Management and Conservation

Water awareness has received little attention in Lebanon and opportunities for large-scale WDM remain untapped. The NWSS recognizes water conservation and awareness as one of five management initiatives. The MEW is hosting since 2011 a UNDP-funded project "Lebanese Center for Water Management and Conservation" –the work of LCWMC would need to be scaled up and fully integrated into the mandate and organizational structure of MEW to produce lasting results insofar as behavior change. In August 2014, UNDP funding expired and the LCWMC was suspended before it could be assimilated into the MEW.

Table 22. Targeted Selection of Existing and/or Planned Institutional Measures in Lebanon

Existing and/or Recently Completed	*Planned*
• Law establishing the Litani River Authority Law (1954) • Application Decrees for the organization of WEs based on Law 221/2000: Beirut and Mount Lebanon: Decree 14596/2005; North Lebanon: 14602/2005; South Lebanon 14600/2005; Bekaa: 14598/2005 • Establishment in 2011 of the UNDP-funded "Lebanese Centre for Water Management and Conservation" at MEW (an ad-hoc structure within MEW) • GIZ assistance (2008-2013) to the Water Sector Reform in Lebanon by (1) Strengthening the capacity of the MEW to support and regulate WEs, (2) Strengthening the technical and management capacities in all of the four WEs, and (3) improving customer relations at WEs level. • Technical assistance (through USAID funding) to WEs (2009-2015) - The Lebanon Water and Wastewater Sector Support Program (implemented by DAI) • Technical assistance to LRA (through USAID funding) – Litani River Basin Management Support program (2009-2014) (implemented by IRG/Engility)	• **Reorganize the MEW** based on Law 221/2000 and its amendments (include a unit for the operation of dams) • Restructure WEs to improve their performance in irrigation and wastewater projects, in addition to current water supply activities (including O&M) • Develop the process for the performance monitoring and evaluation of Wes; monitoring body, performance indicators and targets, and tools and procedures • Increase staffing of MEW and WEs (based on proper job descriptions) to required manpower levels according to recommended organization structures • Enforce planning and capital spending responsibilities and improve coordination among various players in the water sector (MEW, CDR, LRA and WEs) • Institutionalize of the LCWMC at the MEW

4.6.4 Urban Planning Trends and Outlook

Urban planning is important for water management and conservation. The lack of effective and "smart" urban planning in parts of the country can seriously jeopardize the efficacy of planned water investments. Haphazard urbanization has been occurring for decades in Lebanon and is potentially degrading recharge areas as well as impeding water flow in flood plains.

Urban Expansion

For decades, Lebanon has been experiencing haphazard urbanization. Urbanization can be categorized into circular, linear and leap-frog. *Circular* (or concentric) expansion is very visible around major cities and towns including Beirut, Baalbeck, Zahleh, and Marjayoun. *Linear* expansion (or ribbon construction) occurs when towns and villages expand along major roads, creating long rows of residential housing units and commercial centers on both sides of the road. Noteworthy examples include the coastal highway (from Beirut to Jounieh and from Beirut to Sarafand) and selected inland regions (from Tripoli to Halba in north Lebanon and from Zahrani to Nabatieh in south Lebanon). *Leap-frog* development occurs when developers build new residences some distance from an existing urban area, often on hilltops, bypassing vacant parcels located closer to the city, examples include Mechref Village (Mechref), Pine Hills (Chbanieh), Pine Park (Roumieh) and Beit Misk (Bhersaf). The land in between is suddenly accessible to more people and thus attractive to commercial developers and to urbanization.

Haphazard urbanization in mountain areas is a potential threat to current and future dams and reservoirs.

Mountain Resorts

In recent years, there has been an unprecedented rush to build mountain resorts, primarily in the hills overlooking Beirut, but also in other regions of Mount Lebanon. These resorts assume different forms and shapes, offer different levels of comfort and amenities, and attract both Lebanese and non-Lebanese buyers. Whereas Lebanese buyers are more likely to live in these resorts year-round

(primary dwelling), foreigners use their property less frequently and often only during summer. In some cases, Lebanese buyers seek mountain resorts to be used during winter and/or summer (secondary dwelling). The rush to build mountain resorts, especially in poorly planned and underserviced areas, poses a direct threat to Lebanon's water resources.

National Land Use Master Plan[22]

The Master Plan presents a holistic vision for national urban planning and critical recommendations for enhancing and harmonizing land uses in Lebanon while protecting the natural and cultural resource base. Key recommendations related to the environment include:

(1) Preparing legal instruments for establishing regional parks and the national park;
(2) Updating inventories of natural sites in need of protection (e.g., grottos, cliffs, fossil deposits, natural bridges, valuable geological formations, wetlands, etc.);
(3) Updating land use and land cover maps every five years;
(4) Implementing cedar and other forest corridors between 1,500m and 1,900m; and
(5) Revisiting and reforming urban planning regulations, including urban planning operations, and identifying priority sites for local urban planning.

The COM endorsed the NLUMP in June 2009 (Decree No. 2366 dated 20/6/2009). Despite limited application, the Master Plan is a valuable reference document for several administrations including the Directorate General of Urban Planning and line ministries. They should refer to the Master Plan when making decisions related to urban development, the provision of public services, and environmental heritage conservation.

The decreed Master Plan recognizes nine planning zones with servitudes for land management:

Planning Zones	Servitudes for Land Management
U Urban **R** Rural **A** Agricultural **N** Natural N1 Peaks N2 Cedars N3 Corridor **P** Vistas (view area) **S** Sites S1 500m radius around classified sites S2 500m radius around natural sites **F** Prone to flooding **G** Prone to landslides and rock fall **W** Prone to underground water pollution	(1) exploitation factors for construction, (2) construction height, (3) construction setbacks, (4) provisions for urban expansion around existing urban areas, (5) land parcelling for construction activity, (6) large scale projects, (7) quarrying, and (8) industries.

Source: Adapted from Decree 2366 dated 20 June 2009

[22] Also known as: Schéma Directeur pour l'Aménagement du Territoire au Liban (SDATL)

Specifically, the following planning zones are important to the NWSS:

Zone N are areas of national natural assets such as high mountain plateaus, cedar corridors, mountain horticulture, connection areas of forests, valleys and other natural sites;
Zone P are great landscapes; and
Zone S are archeological, historical, patrimonial and other natural sites.

The NWSS should utilize master planning tools to establish buffer zones for watershed protection, especially around impoundments and other expensive public assets.

Policies to Protect Recharge Zones

Protection of recharge zones (all lands above a certain altitude) and "dollines" was declared a national priority by:

a. National Land Use Master Plan (endorsed by the COM in 2005),
b. 2010 State and Trends of the Lebanese Environment Report (endorsed by the MOE in 2011),
c. Lebanon's Second National Communication to the UNFCCC (2011), and
d. Lebanon's National Report to the UNCSD (June 2012).

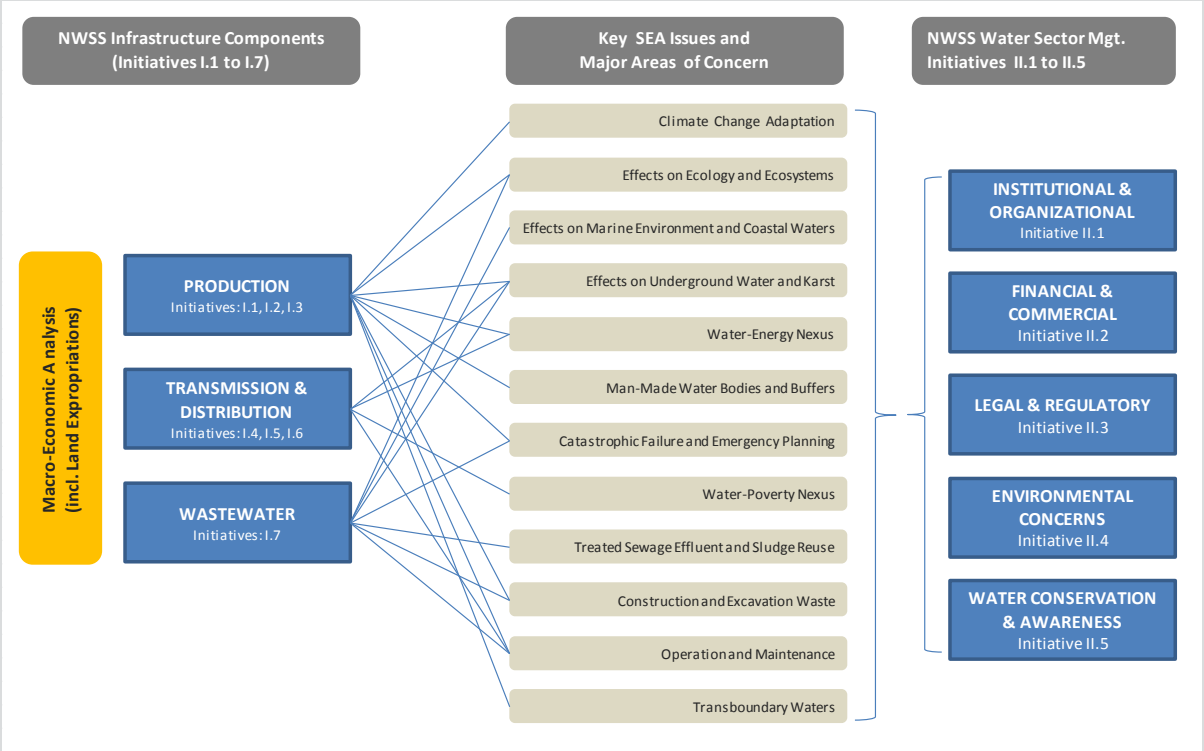
To accelerate the policy discourse on the protection of mountains and recharge zones, the MOE requested in August 2012 the COM to commission a master plan for the conservation of Lebanon's mountains. The request received positive responses from several line ministries (Interior and Municipalities, Defense, and Industry) and agencies (CDR) but awaits HCUP endorsement prior to implementation by the COM.

5. ASSESSMENT OF POTENTIAL IMPACTS RESULTING FROM THE NATIONAL WATER SECTOR STRATEGY

This chapter assesses potential impacts resulting from the NWSS on the economy, the natural environment, and the social environment. It is by no means an exhaustive list of impacts as many impacts were deemed to be localized and therefore better addressed at the project EIA level. The analysis of these impacts was based on a preliminary list of key SEA issues identified during the scoping phase, which are considered nationally and/or globally important, and therefore are major areas of concern. The preliminary list of SEA key issues was augmented and refined during the SEA analysis phase to produce 12 key SEA issues.

The major areas of concern are illustrated in Figure 8, and linked to NWSS's three components.

Figure 8. Major Areas of Concern & Key SEA Issues by NWSS Component



The figure clearly shows that Production (in particular dams) and Wastewater exert the greatest effects on key SEA issues and are linked to many areas of concern. Accordingly, the SEA has focused on those two components while also addressing Transmission and Distribution.

5.1 NWSS Effects on Key SEA Issues

This section highlights the most important effects by the NWSS (source, conveyance, irrigation, and wastewater) on key strategic areas. A more in depth analysis of each key strategic area and its response to NWSS interventions is detailed in the following sections.

5.1.1 Production

Production includes optimization of surface water resources, artificial recharge of groundwater aquifers, and surface storage (dams and hill lakes).

The NWSS aims to mobilize an additional 935 MCM of water by optimizing spring capture (65 MCM), artificial groundwater recharge (200 MCM), and the construction of 18 dams (see Box 3) and 23 hill lakes (670 MCM). The most significant effects are attributed to the construction and operation of dams and associated installations. Impoundments including dams and water reservoirs have many valuable functions, such as supplying water for domestic and irrigation purposes, particularly in drought prone areas, and providing hydroelectric power. They can also create a milder local climate for species threatened by human activities.

Box 3. Dams in Brief

A dam is a barrier that impounds water or underground streams. Dams generally serve the primary purpose of retaining water but hydropower and pumped-storage hydroelectricity are often used in conjunction with dams to generate electricity. Dams therefore are not isolated structures but may require large-scale auxiliary installations including:

- Overflow / spillway tunnels, intake and diversion works
- Access roads on steep terrain
- Hydroelectric power station (and associated transmission lines)
- Conveyance systems

Dams can have significant short and long distance impacts because of their interference with the hydrological regimes, but also with the downstream ecosystem operation. Dams can generate serious concerns for the safety and security of individuals and infrastructure downstream (risks of dam failure) and their life duration is very long, generating the need for high maintenance and rehabilitation costs, especially after several decades of operation. Dams also need to be decommissioned and dismantled at the end of their useful life. Inadequate dam design and, more specifically, lack of attention to water catchment management can lead to premature dam filling with sediments, reducing their efficiency and wasting part of the investment in lost productivity.

There are different types of dams including arch dams, gravity dams, and embankment dams.

Dams and related structures have many environmental and social effects:

- Planned dams and hill-lakes will supply much-needed water to households, farmers and the tertiary sector. According to the NWSS, the proposed dams in Beirut and Mount Lebanon will primarily supply water for domestic use (195 MCM out of 208 MCM of static storage); in the north the proportion of domestic to irrigation is almost equal (96 MCM for irrigation and 75 MCM for domestic); whereas in the Bekaa and the South, the proposed dams will primarily supply water for agriculture (86/98 MCM and 150/190 MCM respectively). Increased access to water will bring immense benefits to Lebanese society in terms of quality of life and economic output. Increased supply will also reduce abstraction and reliance on private/unlicensed wells as well as water trucks.

- Dams and impoundments are land greedy. The affected lands may be public (owned by the state) or private. In Lebanon, the private property is extensive and therefore widely impacted by the construction of dams. For example, the proposed Bisri Dam located south of Beirut will require the expropriation of hundreds of private plots covering a large area. The affected lands (needed to build the dam and for flooding) is delineated by the design consultant in coordination with the MEW and other agencies including CDR, LRA, and WEs. Compensation may not be effective at maintaining the living standards of affected people including poor people, marginalized groups and female-headed households. Proposed dams may limit access to other lands.

- Potential encroachment on protected areas and sites. Candidate sites for dams and hill lakes may infringe on existing and/or planned protected areas and sites which normally carry statutory setback and land use restrictions. An overlay of those sites and protected areas is presented in Section 5.5.

- Some dams will inundate forests. Builders will need to remove and uproot thousands of trees, clear underlying vegetation and strip the soil for base works. Whereas some dams (Chabrouh Dam) were built on bare high-altitude lands with minimal vegetation, other proposed dams are situated inside deep and steep canyons. For example, the construction of the Boqaata Dam (on-going) cleared thousands of oak trees (see more details in Section 5.4.3)[23]. Whereas oak trees may not be in short supply in Lebanon, the cumulative impact of NWSS dams on Lebanon's forest cover and vegetation warrants closer scrutiny and evaluation.

- Dams will inundate riparian ecosystems and rare species. As explained earlier, riparian ecosystems offer countless ecological benefits including habitats for water body dependent species, soil retention, and groundwater recharge. When these ecosystems are inundated, such as along riverbeds, the resulting habitat is more prone to sedimentation and is biologically poorer. Many associated species are lost or displaced. Elsewhere, inundation may affect important and rare species. For example, the Qaissamani dam is situated on a plateau that harbors an important population of the endemic *Iris sofaran*a. Unless those bulb flowers are relocated, their population will decline as a result of the dam.

- Dams and impoundments will require extensive excavation during construction. The total volume of excavation needed will depend on the size and type of the dam. Excavation occurs in connection with many earth-moving activities such as road building, the removal of sedimentation material overlaying the bedrock, and the construction of diversion tunnels. For example, the proposed Jannah Dam and Lake Project is micro-blasting a 520m diversion tunnel, 8m in diameter, producing 26,000m^3 of aggregates. The resulting aggregates are either stored on site for future use (rock-filled dam) or may require transport offsite.

- Dams will significantly alter landforms and landscapes. Dams usually require significant volumes of aggregates (especially rock-fill embankment dams) that must be extracted from elsewhere. Diversion tunnels also require excavation. Experience in Lebanon shows that excavation practices can change landforms irreversibly and create lasting eyesores unless the contractor optimizes cut-and-fill procedures. The unregulated disposal of aggregates will also affect landscapes and natural water courses.

[23] Pers. Comm. Dr. Chadi H. MOHANNA, Director of Rural Development and Natural Resources, Ministry of Agriculture

- Man-made water bodies need buffers zones. Water bodies can become important points of attractions for birds but also tourists and developers. Some of the associated activities (e.g., hunting, water sports, and tourism installations) may be unsuitable for water conservation planning. The possible lack of urban planning regulation near existing and future impoundments will lure construction and other forms of urban development that will impact the resource. Experience also shows that water bodies will increase property value and attract water activities that need to be regulated (to ensure public safety, pollution prevention, etc.).

- Dams can polarize public opinion by generating a lot of support for as well as opposition to the project. It is important to nourish a meaningful public discourse, preferably during the EIA process, to keep the public informed of the project and to address legitimate concerns.

In sum,

Production (mainly dams and reservoirs) clearly has significant environmental and social effects. Some but not all of these effects can be mitigated. The inundation of lands, and the inevitable flooding of the standing biomass in some dams, and can only be mitigated by canceling the dam altogether or by effective compensatory measures including on-site ecological restoration or off-site reforestation. The long-term protection of water reservoirs will require effective buffers and management.

5.1.2 Transmission and Distribution

Transmission and Distribution include water supply transmission and distribution, as well as irrigation rehabilitation and expansion. The NWSS aims to replace 2,800 km of existing over-aged transmission systems and associated equipment and bulk meters and improve leakage detection. This program will also expand the transmission systems to meet growing water demand by, for example completing the Awali-Beirut conveyor (domestic water) and the Canal 800 (irrigation water). It aims to increase storage capacity by 191,000 m^3 in 561 tanks. Distribution will replace existing over-aged distribution networks including house connections (about 9,600 km of pipes) and install almost 1 million water meters.

The environmental and social effects of large-scale conveyance and distribution works should be detailed and mitigated at the project EIA level. The most significant effects are linked to excavation and waste disposal, and energy intensity.

- Conveyance may require costly and extensive excavation works. Large scale conveyance projects (Awali-Beirut conveyor) will generate a lot of excavation waste that would require proper management and final disposal. Micro-blasting and tunneling may also impact underground Karst.

- Conveyance and distribution is energy demanding. Gravity networks exhibit the lowest energy intensity (most of that energy is expended during construction) versus high-lift networks are more energy intensive. The overall effectiveness of conveyance and distribution is also related to leakage. If the current extent of leakage continues (either because the systems are poorly maintained or because of poor craftsmanship), the water shortages will persist and consumers will be forced to rely on water trucks to satisfy their needs. Unacceptable leakage level also has an impact on the WEs revenues.

In sum,

The water conveyance projects for the most part do not pose significant environmental and social effects. Improved transmission and distribution will increase water delivery to end-consumers and therefore significantly improve the quality of life. Excavation waste and energy issues must be explored further and mitigated.

On the irrigation front, the NWSS proposes to rehabilitate and/or replace existing obsolescent irrigation systems and networks in the north, the Bekaa, and the south. The irrigation program will also implement 30,000 ha of irrigation schemes by 2020 and 60,000 ha by 2035 including the South Lebanon Conveyor 800. Additional irrigation water will come from planned storage dams and hill lakes (surface water). Delivering irrigation water therefore to agricultural areas will have an effect on underground water and Lebanon's hydropower capacity.

- Irrigation schemes will help reduce abstraction. When irrigation water is delivered from storage reservoirs, agricultural reliance on groundwater wells will decline. According to the NWSS, groundwater abstraction from private wells amounts to 438 MCM per year (compared with 267 MCM from public wells). Some of that abstraction will be offset by the supply of irrigation water from storage dams. At the farmer level, the effectiveness of the irrigation scheme will depend on the irrigation method.

- Large scale irrigation schemes will reduce hydropower potential. Lebanon currently produces hydropower on five river systems (Litani, Al Bared, Damour, Nahr Ibrahim, and Abu Ali). The Litani River is the largest hydro-electric producer. The completion of the South Lebanon Conveyor 800 and associated installations will significantly reduce the river's hydropower potential and undermine Lebanon's 2020 renewable energy target.

- Irrigation schemes will provide much needed irrigation water to poverty-stricken areas. Historically, Lebanon's agricultural areas are also economically the most disadvantaged. The supply of irrigation water to those areas will help farmers diversify their crops, replace rainfed crops with higher value crops, and increase agricultural activity. Irrigation water could also herald the gradual phase-out of Lebanon's tobacco industry (and Price Support Program) assuming there is political-policy consensus to replace tobacco and channel the subsidy to support new crops and irrigation practices.

In sum,

The proposed irrigation rehabilitation and expansion projects for the most part do not pose significant environmental. The related social effects are positive and will be welcomed by farmers in all affected regions, but most notably in and around poverty areas. On the energy front, the diversion of irrigation from the Litani River will significantly reduce Lebanon's hydropower production and compromise Lebanon's ability to meet its 2020 pledge of 12% renewable energy.

5.1.3 Wastewater

One of the three pillars of the NWSS is the National Wastewater Strategy.

Wastewater collection, treatment and disposal will have far-reaching effects on the natural environment and public health. Whereas inland STPs will help curb surface and groundwater pollution, coastal STPs will also reduce land-based sources of pollution into the Mediterranean Sea. Improved quality of coastal waters will stimulate the tourism industry and related economies. The

wastewater program therefore will affect many key strategic areas including ecology, underground water, treated sewage effluent and sludge reuse, operation and maintenance, and the marine environment.

- Wastewater treatment will reduce pollution loads into the Mediterranean Sea. BOD_5 reduction has been estimated by GIZ using different coverage and treatment options. Whereas secondary and tertiary treatment will reduce BOD_5 by up to 80% and 95% respectively, primary treatment will have only limited effect on pollution load. Improved coastal water quality will boost the tourism industry and thereby achieve monetary benefits.
- Wastewater treatment efficiency will depend on O&M performance. The poor performance of Lebanon regional WEs is attributable to chronic understaffing and financial constraints. Understaffing can be mitigated through Public Private Partnerships but WEs would need to improve their procurement and monitoring systems. So far, CDR has included O&M services in the STPs construction contracts. Sooner or later, the WEs will have to assume ownership of the collectors and the STPs and provide operation and management.
- STP will produce TSE (a byproduct). TSE generation and reuse (example Baalbeck and Tyre STP). Ironically, STP may not receive sufficient inflows because many farmers divert raw sewage before reaching the STP, for irrigation. Illegal industrial wastewater connections to the public sewer can overload STPs (designed for domestic sewage) and hamper wastewater treatment systems. TSE reuse can help protect water resources by reducing abstraction. TSE reuse is currently unregulated but draft guidelines were prepared in 2010 by MEW and FAO.
- STP will produce sludge (a byproduct). Sludge can be reused as a soil conditioner if adequately treated. Alternatively, it can be reused in quarry rehabilitation or land reclamation projects. The production and disposal of sludge is a solid waste management issue. Sewage sludge treatment and reuse is currently unregulated but draft guidelines were prepared in 2010 by MEW and FAO.

In sum,

The proposed wastewater program will significantly reduce ground, surface, and marine water pollution and therefore fulfill the Government's obligations under the Barcelona Convention (EMWATER, 2004). Opportunities for TSE and sludge reuse are significant but the likelihood of this happening is small considering the location of main STPs in relation to agricultural areas. Opportunities for TSE reuse must be reassessed in the future.

5.2 MACRO-ECONOMIC ANALYSIS

5.2.1 Absorptive Capacity

The NWSS shows a total capital investment of around USD 7.74 billion during the period 2011-2020, representing an average yearly amount of around USD 774 million. This projected annual CAPEX is high when compared with other macroeconomic indicators, such as public investment records in water projects, registered in Lebanon over the past two decades. The following facts clearly highlight the situation:

- The total value of CAPEX contracts awarded[24] from January 1, 1992 until December 31, 2012 in the water sector amounted to USD 1592 million - out of which 64% were provided through foreign funding - covering both Water Supply projects (882 Million) and Wastewater projects (709 Million). The water sector represented 14% of total public investment during this period.

Table 23. Total value of CDR (capital investment) contracts awarded from 31/12/1992 till 31/12/2012

Basic Services	Total contracts (in million USD)	Contracts in Progress (in million USD)	Completed contracts (in million USD)	Foreign funding (in million USD)
Water Supply	881.90	245.52	636.38	616.24
Wastewater	709.17	364.00	345.17	407.14
Total water sector	**1591.07**	**609.52**	**981.55**	**1023.38**
	100%	**38%**	**62%**	**64%**

- This means that the annual capital investment in the Lebanese water sector effectively was only about USD 80 million during the years 1993-2012, which actually represents less than 10% of NWSS's yearly capital investment projected for the period 2011-2020 (about USD 774 million per year). Moreover, only 62% of previous/on-going project has been completed.
- It should be also noted in the prevailing conditions the limited capacity of the Lebanese Government to mobilize the future required funds for capital investment purposes, including investment in the water sector. In fact, due to political and economic local and external shocks, Lebanon is facing a growing overall budget deficit and a primary budget deficit**.** In addition public capital investment has for years been an almost insignificant proportion of total investment, compared to private capital investment, as a percentage of GDP.

Table 24. Total Water Investment by the Public and Private Sectors (as % of GDP)

	2009 (actual)	2010 (actual)	2011 (preliminary)	2012 (estimates)
Nominal GDP (in billion LBP)	52'236	55'965	60'442	64'740
Public Investment	1.6%	1.8%	1.8%	1.6%
Private Investment	33.1%	32.1%	28.0%	27.8%
Gross Capital Formation[25]	**34.7%**	**33.9%**	**29.8%**	**29.4%**

[24] CDR progress report, November 2013. These figures do not include budget expenses of the Ministry.

[25] Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation (The World Bank National Accounts).

In sum,

The endorsed NWSS investment plan exceeds by at least 10-folds the historic (or past) Government of Lebanon's absorptive capacity in the water sector, as determined based on 1992-2012 spending records. Public expenditure figures are far below what has been designed for the water sector investment only:

- Total annual public investment represents 1.6% to 1.8% of GDP.
- Total annual public investment reaches, on average, around USD 660 million (in the period 2009-2012) and around USD 571 million (in the period 1992-2012, which included the reconstruction phase). Hence, the annual public investment seems to be relatively stable over the short and longer term periods.
- The water sector (water supply and wastewater) represents about 14% of total public investment, i.e. around USD 80 million on yearly basis.
- The Lebanese public administration faces structural and institutional bottlenecks which hinder effective public investment planning and procurement.
- The NWSS is suggesting an annual investment plan of around USD 774 million, i.e. almost 10 times the actual figures of the period 1992-2012.

It is important to contextualize the NWSS investment plan. Table 25 presents other sector programs and expenditures which help benchmark the NWSS's total cost. Incidentally, the World Bank has estimated that the loss in economic activity due to the Syrian conflict is approximately $7.5 billion over the period 2012-2014, which is very close to the NWSS Capex (the Syrian conflict however is not an investment program and therefore not listed in Table 25).[26]

Table 25. Benchmarking the NWSS with other investment programs

Sector/Program	*Amount (in USD)*		*Source*
Total public investment expenditure[27]	Yearly average (1997-2006)	USD 280 million	Public Finance official report for the period 1993-2006 (MoF)
Public investment in water sector (MEW and RWEs, excl. CDR)	Yearly average (1997-2006)	USD 33 million	Public Finance official report for the period 1993-2006 (MoF)
Post-2006 reconstruction effort		USD 2.8 billion (of which 61% for housing)	The Direct Cost of the War - CDR, Government of Lebanon, 2006
Litani River Pollution Abatement	2015-2020	255 million	Business Plan for Combating Pollution of the Qaroun Lake

5.2.2 Land Expropriations

This section reviews current compensation procedures related to land expropriation and assesses their social impacts. The process of expropriation and compensation is illustrated in Figure 9. This figure was developed based on the outcome of the analysis of the Expropriation Law 91/58 and a series of in-depth interviews with key informants[28].

[26] Lebanon: Economic and Social Impact Assessment of the Syrian Conflict – The World Bank 2013

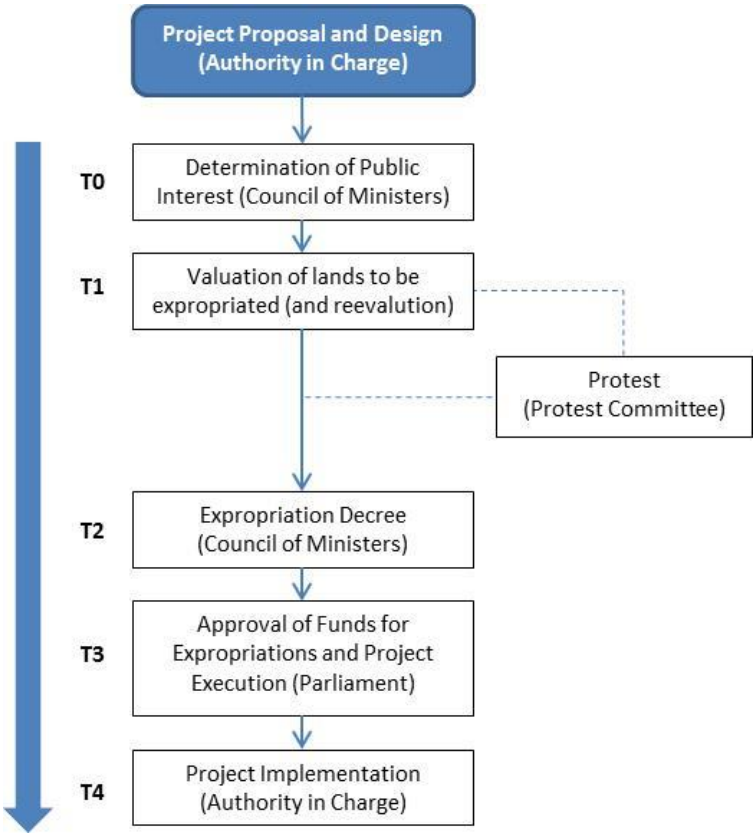
[27] Excluding public investment contributions in funds (CDR, Council for the South, Displaced fund), estimated on yearly average for the period 1997-2006 at around USD 306 million.

[28] Charbel Nahas, Former minister and senior economist; Ibrahim Chahrour (CDR)

Land Expropriation Procedures

The Expropriation process is launched when a "public investment" project is declared to serve the public interest by a Council of Ministers decision. This decision normally specifies the land parcels that would need to be expropriated for the project. The next step in the process is the valuation of the parcel(s) in question by a judiciary expropriation committee. The valuation outcome can be appealed by a protest committee. Once the valuation is completed, the government will issue an expropriation decree which is approved and signed by MEW (owner), the design engineer, the Prime Minister, and the President of the Republic. The approved expropriation is then gazetted. Once the funds for the implementation of the project have been appropriated by the Parliament, compensation is disbursed to the affected land owners and project implementation can proceed. In sum, **land expropriation for the common good involves the executive, the judiciary, and the legislative** as illustrated in Figure 9. Current expropriations systems and procedures may result in several dysfunctions, as explained next.

Figure 9. Land Expropriation Process in Lebanon



Potential Dysfunctions

History shows that the expropriation process (from determining the public interest to actually compensating the affected people whose lands have been expropriated) is a protracted process which can in some cases extend for many years. Delays occur at different junctures in the process which have important repercussions for land owners:

- Land owners essentially lose the right to dispose of their property as soon as the "public interest" has been decreed by the Council of Ministers. The period from a declaration of public interest until effective compensation can extend for up to 20 years. Hence, a land

owner will incur an opportunity cost equivalent to the potential profit that would have accrued to him/her by the development of that property.

- Delays between the valuation and actual disbursement of compensation may cause a land owner to lose the actual appreciation in the value of the property. Delays therefore can result in socio-economic impacts.
- Long delays may occur between disbursing the compensation to the land owner and the implementation of the project, translating into a misplacement of public funds. Indeed, there have been many cases in Lebanon whereby a public interest project was decreed, compensation was disbursed to affected individuals, but the project was subsequently suspended and/or never implemented.

The delays outlined above may lead to additional dysfunctions in the process:

- Evaluations may be over- or under-evaluated: There may be cases when the land may be over- or under-evaluated depending on the parties involved and commercial interests. When lands are over-valuated (or just handsomely valuated), this tends to expedite the process by minimizing protests.
- Land delimitations may be inflated: The project consultant may have incentives to vary the boundaries of the land parcels affected by the project.
- Land speculation: Insider trading may occur whereby certain land owners sell the land without informing the buyer that it had been earmarked for expropriation. Alternatively, a potential investor with insider information decides to purchase adjacent parcels from their owners who may be unaware of the "public interest" project and/or its impact on land appreciation.

Based on the above, it is important to follow a set of guiding policies on expropriation and involuntary and/or economic resettlement. Economic settlement occurs where a proposed dam reservoir will inundate farmed lands and orchards (this has occurred in connection with the NWSS Balaa Dam in north Lebanon, an area with standing orchards).

In addition to the Protest Committee, it is important that Lebanese individuals and landowners understand their rights vis-à-vis expropriations and the recourse options at their disposal, whether funding is local or through loans. For example, if the project is funded by the World Bank, individuals or communities who have been disfavored or fear being disfavored can bring the issue to the World Bank's Inspection Panel. Other funding / lending institutions such as the European Investment Bank have similar recourse mechanisms.

For more information and policy guidance on expropriation and involuntary resettlement by International Financial Institutions (IFIs), please refer to ***Annex 4.***

5.2.3 The Value of Selected NWSS Benefits

The benefits from water supply and wastewater treatment programs can range from potential improvements to public health, savings in water purchase costs, increased personal amenity from having more reliable supplies and better quality water, through to improvements in water and coastal resources. Implementing the NWSS, specifically, is also expected to result in a reduction in groundwater abstraction and provide new surface water bodies/dams; these should help curb the water level drop of aquifers and help prevent salinization, while new reservoirs can provide recreational and amenity benefits. The purpose of this section of the SEA is to provide an estimate

of the potential monetary, or dollar, value of some of the benefits associated with implementing the NWSS.

Table 26 summarizes these estimates, giving ranges that cover two time periods. The estimates are built on the results of previous valuation studies (namely, World Bank 2004), which put noteworthy efforts into estimating the monetary value of items that can be readily associated with, and adapted to the NWSS. Like the World Bank and others, potential ranges of the estimates are provided in light of uncertainty (associated with data, complex physical relationships, inherent issues in placing monetary values on such benefits, etc.), and to give a broad indication of the orders of magnitude involved. ***Annex 11.3*** provides the detailed calculations, the sources of information, and explains the methodologies used to: estimate the physical changes which could be expected to result from implementing the NWSS over time; and then to adapt values from past studies and apply them to each of the physical changes.

The estimates of the identified benefits include:

1. The value of coastal water quality improvements from wastewater treatment, looking at:
   - potential gains in international tourism revenues
   - the intrinsic value Lebanese people associate with the coast (e.g., ecological and existence value); and
   - travel costs incurred by domestic tourists going to further, cleaner beaches for recreation.
2. The value of reduced salinity/saline intrusion of coastal aquifers expected to come about from reduced groundwater abstractions.
3. The potential savings by households in domestic water purchases from private providers (e.g., mineral water, tankers, and other private supplies).
4. The potential recreational benefits associated with increased bird watching opportunities as a result of the new surface water bodies / reservoirs.
5. We also provide an estimate of the potential savings to the country, by implementing dams/reservoirs versus sea water desalination to meet the same water supply objectives (the potential water saving incurred through efficient Water Demand Management was not valued or assessed as part of this cost/benefit analysis).

The values presented in Table 26 show the present value (i.e., includes the stream of future values, but in one number, in today's terms) calculated over two periods: from the year 2013 through 2020; and from the year 2013 through 2030. Some of the benefits increase more notably than others the further into the future they are considered.

Table 26. Range of Estimated Future Values ($US Million) of Selected NWSS Benefits

Present Value of Benefits ($US Million), from 2013 through…	… through 2020	… through 2030
1. Value of Coastal Water Quality Improvements from WW Treatment	$233 to $699	$608 to $1,825
2. Value of Reduced Salinity of Coastal Aquifers from Reduced Abstractions	$98 to $406	$197 to $811
3. Increase in Bird Watching Recreational Value with Reservoirs	$3.7 to $5.5	$9.8 to $14.7
4. Averted Expenditure in Household Private Water Purchases	$98 to $294	$501 to $1,504
Total for the Above Items	**$433 to $1,404**	**$1,316 to $4,155**
5. Savings from Implementing Dams versus Sea Water Desalination	$603 to $2,874	$1,286 to $5,558

The values shown are in 2013 prices (i.e., do not take into account inflation). Future values discounted to place more importance on values/money today, versus those which are far off into the future. A "social" discount rate of 3% is used, which places more value on future generations than if a higher rate were used (e.g., 5% - 10%) typical of say, what banks or investors would use. A smaller discount rate should be considered more appropriate for looking at such environmental and social benefits.

It should be noted that the above estimates do not include all possible benefits associated with each item (e.g., potential ecological benefits from additional water bodies or from less saline groundwater spring discharges, possible improvements to fisheries, the amenity value of improved water supplies, etc.). There are several other benefits that were also not covered (e.g., economic benefits of improved water supply to industrial users, potential improvements in public health), some of which may also be significant. The SEA focused on those which could be most reasonably estimated for the purposes of this report, without requiring extensive data or more complicated analyses that would require specific, and more-academic, studies.

Nonetheless, the estimates provide an indication of the potential value of some of the benefits associated with NWSS, which are useful, at least by providing a better picture of the types and their potential values.

5.3 CLIMATE CHANGE ADAPTATION

According to Lebanon's Second National Communication to the UNFCCC, "*the effect of climate change on water resources is expected to be significant as a result of a decrease in precipitation and projected changes in its spatial and temporal distribution in addition to increased evapo-transpiration"* (MOE/UNDP, 2011). A decline in total and active precipitation is forecasted as well as a shift in rainfall consisting of higher precipitation in November and December (in the absence of proper water storage structures, a considerable proportion of this water would be lost) and a steep reduction from January onward. A reduction of 6-8% of the total volume of water resources is expected with an increase of 1°C, and 12-16% for an increase of 2°C. A 10% decrease in average annual rainfall by 2040 would reduce:

(1) TARS from 8,600 MCM to 7,740 MCM (about 10%); and
(2) Net exploitable water resources by about 270 MCM to about 2,430 MCM.

Climate change will also significantly alter snow patterns. In particular, it is estimated that a 2°C increase in temperature will reduce snow cover by 40% and a 4°C increase will reduce snow cover by up to 70% (MOE/UNDP, 2011). This will have adverse impacts on rivers, springs and groundwater recharge. In addition, snow will fall at higher elevations, shifting from 1,500m to 1,700m by 2050 and to 1,900m by 2090, affecting the recharge of most springs. Warmer temperatures (and reduced precipitation) are expected to lead to a decrease in the intensity, residence time (from 110 days to 45 days with a warming of 2°C) and thickness of the snow cover and to an increase in the manifestation of extreme events including winter floods. The reduction in snowpack will reduce river flows and therefore pose a severe challenge to the agricultural sector during summer, when irrigation demand is highest. It is expected that summer drought conditions will occur 15 days to 1 month earlier. The already dry regions such as the Bekaa, Hermel and the South will be most affected.

See recommended and priority climate change adaptation strategies in **Section 8.2.**

5.4 EFFECTS ON ECOLOGY AND ECOSYSTEMS

This section focuses primarily on the ecological effects of dams and reservoirs.

5.4.1 Undiscovered Species and Water Dependent Species

A large dam can cause the loss of entire ecospheres, including endangered and undiscovered species in the area, and the replacement of the original environment by a new inland lake. Lebanon is a signatory to the CBD and therefore has an obligation to protect biodiversity, especially vulnerable species. Although Lebanon now boasts 16 protected areas covering 2.2% of the territory, they don't represent all possible ecosystems and habitats in the country. Many unique ecosystems remain unrepresented and without any form of regulatory protection (e.g., juniper forests, karst ecosystems). Storage dams may therefore cause the irreversible loss of rare and/or endemic species of national and/or international importance and also reduce or inhibit environmental flows that sustain downstream habitats.

Dams and their associated reservoirs impact bird biodiversity and other wildlife by:

1. Blocking movement of migratory water bird species (e.g., White throated water Dipper bird of **Lebanon** that can swim under river water) up and down rivers. Impoundments can also block altitudinal migration of mammals (e.g. Otter), and many species of fish.

Dipper

Otter

2. Changing turbidity/sediment levels to which species and ecosystems are adapted. Trapping silt in reservoirs deprives downstream deltas and estuaries of maintenance materials and nutrients that help make them productive ecosystems. In **Lebanon** several bird species of waders (plovers, stints, sandpipers, lapwings, snipes, etc.) that frequent river outfalls may be affected and subsequently desert the impacted area.

3. Flood plains provide vital habitat to diverse river biota during high-water periods in many river basins. Dam management that diminishes or stops normal river flooding of these plains will impact diversity. Regular and natural high and low river causes flooded sides of the river to host many insectivore aquatic species. In **Lebanon** the floods beyond the Qaraoun Lake are artificially created but not at the seasons during which birds do breed. This deprives many bird species from the appropriate nesting habitats and from the adequate food.

4. The importance of riparian habitat to wildlife in general and birds in particular is a well-documented phenomenon. Studies show that riparian habitats contain up to 10 times as

many migrant passerines (songbirds) per hectare compared to adjacent, non-riparian habitats. Riparian habitat is especially important to insectivores[29]. The occupation of the riparian vegetation by an impoundment and a dam could result in a loss of 63 bird species that breed in that area in Lebanon[30].

5. Modifying water quality and flow patterns downstream. In **Lebanon**, the post-dam portion of Litani River has lower richness in birds than the pre-dam portion (Ramadan-Jaradi, 2013, *unpubl.*) In addition, the Kingfisher bird that uses its beak and feet to excavate nesting tunnel in wet walls of the river's sides loses this ability when the water level is low during breeding season. Similarly, normal passing ways of territorial animals are hindered since the dam works as a barrier. Meanwhile, the upstream fish movement is prevented and thus fish population decreases significantly (Stott and Smith, 2001). Subsequently, all fish eating bird species (piscivorous) like kingfishers are fewer in number downstream compared to upstream[31].

6. Songbirds breeding in riparian habitat within valleys where hydroelectric power generation regulates water levels may suffer increased nest mortality or reduced survival if rising water levels flood active nests or reduce food availability (Green & Quinlan, 2008) or destroy riverbanks and their associated vegetation, forcing species like Lesser Whitethroat, Graceful Warbler, Cetti's Warbler, Great-read warbler, etc. to desert the area.

7. Some impoundments are built with steep slopes. This prohibits shore birds from landing and feeding on what is rejected by the water body surface to the edges. Some birds may land due to thirst but can also drown. In this case, the constructed slopes are considered a deadly trap to birds.

8. Large water bodies attract several species of waterfowl for resting, feeding and roosting; especially duck species that agglomerate in the center of the water surface area to protect themselves away from enemies and human being. In Lebanon, this phenomenon is observed in many water bodies ranging from small agricultural pools to high dams with large impoundments.

9. Fish can be damaged while passing throughout the floodgates, turbines and pumps of the high bodied dams.

5.4.2 Potential Encroachment on Protected Sites

Lebanon has a large number of protected areas including nature reserves (enacted by parliament), Biosphere Reserves (UNESCO), protected sites (Ministry of Environment and Tourism), and protected forests (Ministry of Agriculture). Some of these sites may be affected and/or inundated by proposed dams and hill lakes, as listed in Table 27. Inundation will inevitably destroy plants and displace animals, including undiscovered species. Lebanon's valleys are steep and often inaccessible which increases the likelihood that not all species have been identified and inventoried. The only way to verify the presence of new species and/or important species such as endemics and threatened species is to physically inspect and survey the valleys before project implementation, and during different seasons.

[29] Stevens et al. 1977
[30] Ramadan-Jaradi, 2013, *unpublished*
[31] Ramadan-Jaradi, *pers. obs.*

Strategically, inundation can impact the ecological heritage value of natural sites by:

- modification,
- fragmentation or destruction of habitats,
- loss of rare or endangered endemic species,
- stress on already stressed ecosystems causing irreversible damage,
- breach in ecological connectivity, or
- impacts on migratory birds

When assessing the ecological impact of a proposed water investment, it is important to consider the hierarchy of the legal instrument protecting the site (MOE decisions and laws), the NWSS (COM decision), and the expropriation (decree).

Table 27. Intersections between Proposed Dams/Hill Lakes and Protected Areas

Dam / Lake Project Name	*Protected Area or Site*	*Legal Basis*	*Proximity*
Aazzibeh L	Shouf Cedars PA	Law 532 dated 24/7/1996	Inside tentative PA boundaries
Janneh	Nahr Ibrahim PS	MOE Decision 34/1 (1997)	Within 500 m buffer zone; ca. 200 m from Jabal Moussa BR
El Msseilha	Nahr El Jaouz PS	MOE Decision 22/1 (1998)	Within 500 m buffer zone
Damour	Nahr Wadi El Damour PS	MOE Decision 129/1 (1998)	Within 500 m buffer zone
Maasser El Shouf L	Nahr El Awali PS	MOE Decision 131/1 (1998)	Within 500 m buffer zone
Bisri	Nahr El Awali PS	MOE Decision 131/1 (1998)	Within 500 m buffer zone
El Assi	Nahr El Assi PS	MOE Decision 189/1 (1998)	Within 500 m buffer zone
Yammouni L	Yammouni PA	Law 10 dated 20/2/(1999)	About 250 m from PA
Qaissamani L	Shouf BR	UNESCO BR (2005)	About 50 m from SBR limit
Kfarhouneh L	Jabal El Rihane BR	UNESCO BR (2007)	Inside tentative BR boundaries

Abbreviations: **BR** Biosphere Reserve, **PA** Protected Area, **PS** Protected Site

The loss of endangered species has local and global implications. In an effort to capture and protect rare or hitherto undiscovered species, the Critical Ecosystem Partnership Fund (CEPF)[32] approved a grant to setup three "micro-reserves" to conserve rare or endemic species in Lebanon. Located in Baskinta, Ehmej and Sarada, these micro-reserves will help protect rare or endemic species such as the *Iris sofarana*. Other initiatives are underway to promote research and facilitate the online discourse on biodiversity using interactive portals (www.lebanon-flora.org).

[32] CEPF is a joint initiative of The Global Environment Facility, The John D. and Catherine T. MacArthur Foundation, Agence Française de Développement, Government of Japan, the European Union, Conservation International and The World Bank.

5.4.3 Potential Inundation of Forests

Several dams will inundate forests especially dams located on river systems (see Section 5.6). Inundation will transform the land cover from a forested valley to an open man-made water body. It is difficult to estimate the extent of forest damage without site-specific baseline. However, recent experience shows that dam builders have had to compensate for tree losses to the Ministry of Agriculture, as part of MOA's "alternative trees" policy. The SEA team met with the Director of Rural Development and Natural Resources at MOA to assess this policy. In sum, the MOA will, prior to construction, inspect the site, assess the number of trees that will be flooded, and then request the contractor to supply young replacement trees equivalent to at least six times the number of trees lost or damaged. See for example the experience of Boqaata dam (Box 4).

Box 4 Boqaata Dam forest seedlings

Rocad-Khoury, the contractor for the Boqaata dam, approached MEW to obtain an approval to remove the trees that will be impacted by the project. MEW mobilized the MOA who visited the site and estimated that at least 9,000 trees, mostly oak, would be impacted by the project. Pursuant to MOA Decision 783/1 (dated 25/11/2010), the ministry requested the contractor to supply and deliver 40,000 seedlings (pine and cypress) to one of its forest nurseries. The estimated cost of the forest seedlings is LL300 million ($200,000), which was not explicitly included in the tender document and project Bill of Quantities. The seedlings were delivered (from an unknown source) and MOA gave its approval to proceed.

MOA currently runs nine forest nurseries in the country, listed in Table 28.

Table 28. Forest Nurseries Run by Ministry of Agriculture

Forest Nursery	*Caza*
1. Hammana	Baabda (Mount Lebanon)
2. Chweifat	Aley (Mount Lebanon)
3. Al Debiye	Chouf (Mount Lebanon)
4. Al Aabde	Akkar (North)
5. Al Charkiye	Nabatiyeh (Nabatiyeh)
6. Rmeich	Bint Jbeil (Nabatiyeh)
7. Sour	Sour (South)
8. Chtoura	Zahle (Bekaa)
9. Deir El Ahmar	Baalbeck (Bekaa)

Source: Ministry of Agriculture, 2014 (Directorate of Rural Development and Natural Resources)

MOA's policy is that all projects must obtain its approval to remove trees before project implementation. As part of that approval process, MOA will estimate the number of trees that will be lost and determine the number and type of alternative trees including:

i. Size of forest seedlings,
ii. Species (for landscaping or reforestation),
iii. Total number of replacement seedlings, and
iv. Destination nursery for new forest seedlings.

The noticeable deficiencies in the system are:[33]

[33] Pers com. Dr. Chadi Mohanna (Director of Rural Development and Natural Resources, MOA)

i. There is no control on the origin (and quality) of the forest seedlings delivered by the project contractor. They could be imported from Syria (traditionally Lebanon's greatest supplier) – no quarantine or hardening required,

ii. Normally, the most common replacement seedlings are pine and cypress trees because those are readily available; the notion of riparian habitat restoration is absent,

iii. The replacement seedlings may not benefit the region that was affected by the project, and

iv. Mortality during storage and transplanting can be high (people can collect forest seedlings from MOA but there is no control over the location and method of planting).

From a management perspective, Lebanon has two options with regards to the standing biomass: either clearing for timber use, or flooding. Experience in Lebanon shows that felling is usually the preferred option in light of the scarcity of local wood and timber, used mostly for heating but also to a lesser extent furniture manufacturing. From an environmental perspective, climate change mitigation also favors clearing over flooding because flooding the standing biomass will eventually lead to decomposition and methane emission; the global warming potential of methane (CH_4) is 25 times greater than that of carbon dioxide (CO_2), calculated over a 100-year period.

5.5 Marine Environment and Coastal Waters

Wastewater treatment will significantly reduce pollution into the Mediterranean Sea. The National Wastewater Sector Strategy (part of the NWSS) was initially conceived in the mid-1990s as part of the National Emergency Reconstruction Program (NERP 1, 2 and 3). The revised NERP (2009) proposed the construction of:

- 12 priority STPs along the coast (to treat 65% of the wastewater discharges in Lebanon)
- 16 inland STPs (to treat 15% of the wastewater discharges in Lebanon)
- About 77 small- to medium-scale STPs (to treat the remaining 20%).

The current strategy has not changed much but the number of coastal STPs has been revised down to 11 (see revised list in Table 5 Section 3.3). In terms of pollution reduction, it is important to highlight the following:

i. Preliminary Treatment (PT) achieves no BOD_5 reduction –Saida and Ghadir STP (about 640,000 population equivalent). On-going proposals and feasibility studies to upgrade those two plants to secondary level remaining inconclusive.

ii. Inland STPs will help reduce pollution load into the Mediterranean Sea if their discharges lead to the sea. The environmental benefits of inland STPs will be more pronounced locally (reduced pollution of groundwater and surface water resources).

iii. BOD_5 reduction is 80% for secondary treatment and 95% for tertiary treatment. Reduction is contingent on adequate O&M services and on the completion of associated sewage networks and collectors. Many completed STPs are still offline because the networks are incomplete.

In terms of BOD_5 reduction, GIZ did some analysis to determine the incremental investment cost needed to reduce the municipal pollution load of 165,563 tons of BOD_5 by 2030. They developed four options plus the on-going option of 16 STPs operating at full capacity by 2030 serving 4.3 million population equivalent (see Table 29).

Table 29. Marginal BOD_5 Reduction by 2030 based on Different Options

Option	*Description*	*Residual BOD_5*		*Pop. Equiv. 2030 (million)*
		x000 tons	% reduction	
No intervention	No treatment (or only PT)	166	0	**7.6**
Ongoing - baseline	16 plants 2030 full capacity*	89	46%	4.3
Option 1	2030 Ghadir and Saida Second. Treat.	79	52%	1.2
Option 2	2030 Gap Secondary Treatment	33	80%	2.1

*Note: Ghadir, Hamana, Amatour, Bater, Saida, Barte and Deir Mimas, Qobeyat, Baalbeck, Aitanit, Fourzol, Jabboule and Ain Archa, Tripoli, Batroun, Chekka, Ras Nabi Younes, and Nabatiyeh. Options 3 and 4 related to upgrading STPs to tertiary treatment are not shown here.

Stated differently, and according to the GIZ analysis, Option 2 which involves operating 16 STPs at full capacity, plus upgrading Ghadir and Saida to secondary treatment, plus building additional STPs to cover the remaining 2.1 million population equivalent would achieve 80% BOD_5 reduction by 2030.

5.6 Effects on Underground Water and Karst

The NWSS dams will intercept and affect water flows in several river systems including two Transboundary Rivers (see Table 30). The impact of surface storage on hydrology is site-specific and will depend on local geology, fault lines, topography, and reservoir permeability.

Table 30. Lebanese Rivers Impacted by Proposed Dams

Dam	*Perennial River*	*Capacity (MCM) Static/dynamic*
Noura El Tahta	Nahr el Kabir *(transboundary)*	35-50
El Bared	Nahr el Bared	37-90
El Msseilha	Nahr el Jawz	6-12
Janneh	Nahr Ibrahim	30-90
Damour	Nahr el Damour	42-106
Azzounieh	Nahr el Damour	4.1-5.0
Bisri	Nahr el Awali	120-120
Kfarsir	Nahr el Qasmieh	15
Khardaleh	Nahr el Litani	120
Assi 1 and 2	Nahr el Assi *(transboundary)*	78

Impoundments have substantial effects on the hydrologic regime of affected rivers, both upstream, and more extensively downstream from the impoundment. The reservoirs also affect the underground water by inhibiting the natural replenishment of aquifers including caves. Conversely, reservoir leakage can help maintain water flows in springs located downstream (see Box 4).

Assessing the impact of a proposed impoundment on hydrology was equally difficult in Nahr Ibrahim where the proposed Jannah Dam and Lake Project (under construction) has generated extensive and contradictory assessments of its impact on the local hydrology. An investigation by a German firm had determined that the proposed dam would adversely affect the Jeita water source located approximately 23 km (straight line distance) to the south west; a subsequent study by the design consultant refuted the earlier finding by showing using modern dyeing techniques and tracers that

the two systems (Nahr Ibrahim and Nahr El Kalb) are hydraulically not connected. Although the latter investigation appears conclusive, it does illustrate the complexity of karst formations and impacts on hydrogeology. The EIA study for Boqaata Dam addresses impacts on hydrology very succinctly; perhaps due to lack of data, insufficient field investigations, and/or lack of impact modeling. **The importance of integrating hydrogeological assessments (based on field investigations) in the EIA cycle cannot be sufficiently emphasized.**

Box 5. Lessons learned from Chabrouh Dam

Located in Faraya, the Chabrouh Dam was completed in 2007 with a storage capacity of 8-15 million m^3 and is expected to meet drinking water demand in Kesrouan through 2025. The Chabrouh Dam captures surface water from a 12 km^2 basin located on the eastern flank of the Qana Plateau which extends from approximately 1600m to 1945m a.s.l. The crest height of the Chabrouh dam is 63m, its length is 470m and width is 100m.

Examination of Chabrouh Dam site started in the 1970's; Majdaleni (1977) argued that the presence of karst rocks in Chabrouh valley will make building such a structure and retaining the water in the basin quite difficult. In 2006, Bou Jaoude showed that the nature of the karstic terrain in the Qana plateau and the height of the water in the basin might lead to channeling of the water from the Chabrouh basin into the surrounding springs (Bou Jaoude, 2006). Leaks of up to 200 l/s were observed around the western abutments of the dam on the Qana Plateau side due to the geological formation of the area. In 2009, detailed surface geology of the Qana plateau revealed that the area is dissected by NW-SE dip-slip faults. Hydrographs of three major springs (Hadid, Qana and Terrache) show clear karstic characteristics. A major increase in the flow of the studied springs has been documented suggesting that leaking from the Chabrouh dam basin is occurring towards those springs (Bou Jaoude et al. 2009).

Source: adapted from (Comair 2010), (Majdaleni 1977) and (Bou Jaoude et al. 2006, 2009)

5.7 WATER-ENERGY NEXUS

5.7.1 Energy Consumption

The water sector consumes energy. The analysis objective was originally to estimate power use in kWh/m^3 of water supplies and then determine whether the projected use after completing all NWSS capital investments will require more power than is currently available. The SEA team requested power consumption data from each water utility but received instead energy *billing* data from two utilities. The focus therefore then shifted to describing the energy flow and corresponding GHG emissions in the water life cycle in Lebanon, broken down into four phases:

1. Production (extraction and treatment)
2. Conveyance and distribution (municipal, private)
3. Use and consumption (agriculture, residential, tertiary sector)
4. Wastewater collection, treatment and discharge (including reuse)

Water Phase	***Energy Intensity***
	LOW ←---------- → HIGH
Production	Natural Spring - River In-Stream - Artificial Reservoirs - Well Water
Conveyance	Gravity Networks – Low Life Networks – High Lift Networks – Water Trucks
Consumption and Use	Agriculture – Tertiary & Domestic – Industrial
Discharge and Reuse	Gravity Sewer Networks – Lift Sewer Networks – Wastewater Treatment

Every stage involves energy expenditure. The emissions related to energy flows originate from the electricity production plants (whether utility or private) because practically all energy expenditure for handling water is in the form of electrical energy. The SEA has prepared two flowcharts: the first flowchart explains the energy flow in the water life cycle, and the second estimates related

emissions. Both flowcharts show specific values per unit water volume handled along the value chain.

It is important to differentiate between water use and water consumption especially in the context of a mindset that contemplates water recycling. In the energy flowcharts, ***arrows pointing downward*** represent water use, that is water that stays within the water catchment system of Lebanon even if actually "used and of low quality". ***Bent arrows*** indicate water consumption; water that is irreversibly lost to the system through evapotranspiration, evaporation or export in products. The ***arrow width*** provides a relative indication of the importance of each flow.

The next paragraphs explain some of the underlying assumptions linked to production, conveyance, consumption, and discharge and Box 5 attempts to calculate the energy payback period for one completed dam, Chabrouh.

Production

In Lebanon, available water sources include: springs, wells, dams, and rivers. The extraction and processing stages have been merged into one phase for ease of reference. Generally, water treatment at the municipal level is usually near the extraction point.

Box 6. Chabrouh Dam Energy Payback

To build Chabrouh dam, its ancillary treatment plant and associated water network, some 1 million m³ of earth were excavated, 5 million tonnes of earth and other materials were moved around, 20,000 m³ of concrete poured, 60 km of potholes plugged with shotcrete, 30 km of pipes laid down as well as a plethora of other construction activities ranging from tunneling to landscaping.

It is estimated that the capital primary energy consumption (CAPEC) of this project amounts to around 200 GWhr, equivalent to some 18 million liters of diesel oil. This is the estimated amount of energy that was required for all local activities related to the execution of this project namely manufacturing of local construction materials (i.e., cement, block work, paint, etc.), trucking, site works, pipe laying, etc.

On the operational side, Chabrouh dam is not energy intensive; the operations energy consumption (OPEC) restricts itself mainly to the electrical energy required to run the treatment plant and the de-silting of the reservoir every few years, unless major repairs occur. It is estimated that OPEC does not exceed 1.1 GWHr/year.

The project is designed to supply some 15 million m³ of water per year and therefore displaces some 7 million m³ of pumped and trucked water, thus saving around 30 GWhr/year of primary energy. Chabrouh dam will require if all is well some 8 years to make good its energy bill and redeem the resulting GHG emissions sent into the atmosphere. This is a conservative estimate, if drought years are more frequent or the dam requires frequent maintenance or repairs then the payback period may be considerably longer. For example, in 2014 Chabrouh dam hardly supplied any water to the network.

Source: All energy data are from author, activity data are estimates from author or from articles on the internet.

Springs and wells make up the bulk of the water supply in Lebanon while dams are currently a small percentage that could significantly increase if dam projects are undertaken. Moreover, some dams could use water for electricity production (and underground seepage), but all dams consume water because of evaporation. Dam evaporation in the case of Lebanon for an average rainfall year may reach 0.02 m³ per m³ of water delivered per year (i.e., 2% losses). The larger the water body, the greater the total evaporation (as m^3/m^2). The shallower the water body, the greater the evaporation due to radiation and temperature buildup.

Springs, river intakes and dams are low energy intensity sources. Even though the civil works of dams may appear impressive, the allocation of the energy expenditure to build the dam over its lifetime throughput results in low specific energy expenditure. Water wells exhibit high energy intensity, especially if they are deep (> 200 m).

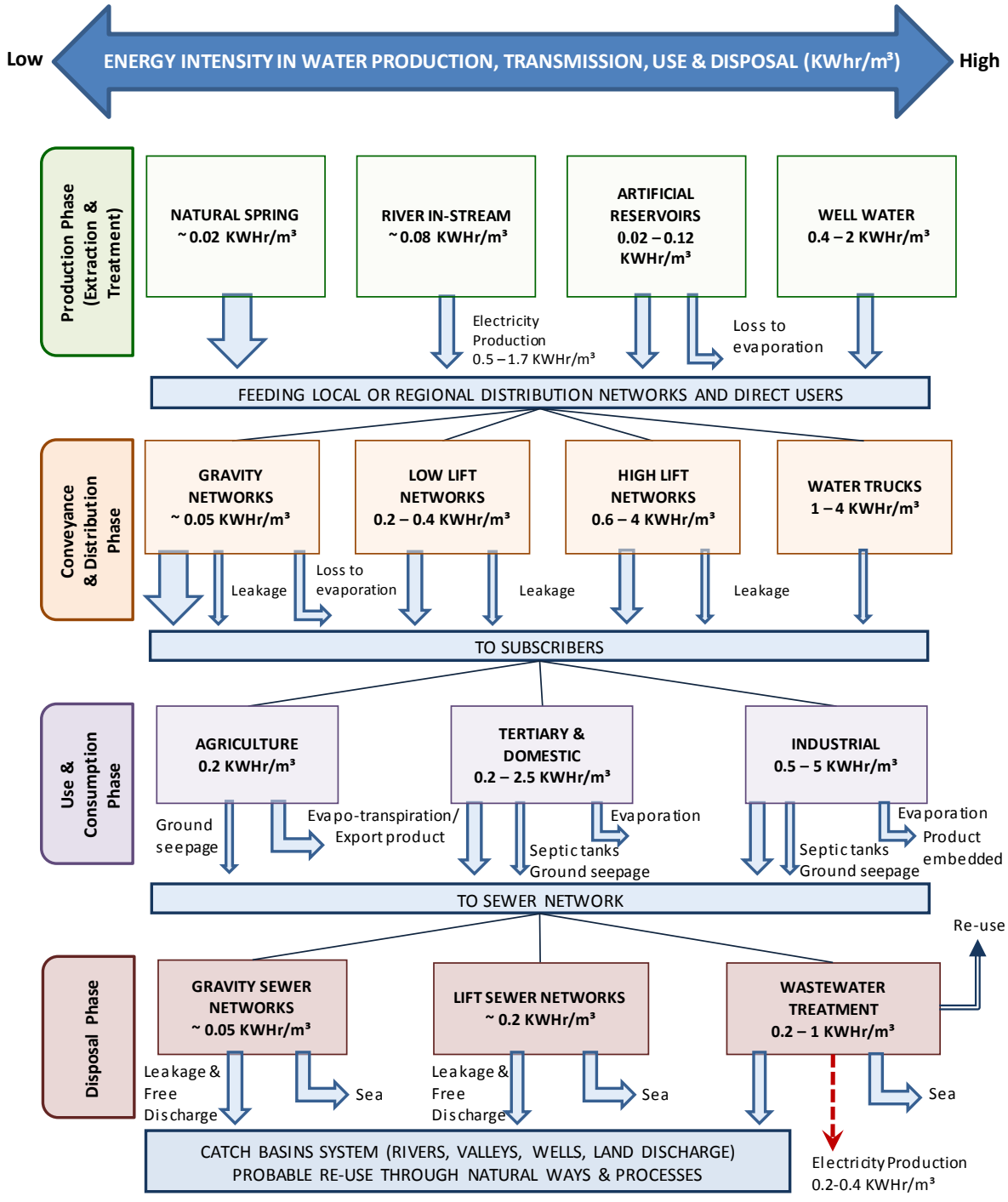
In Lebanon, most municipal water undergoes filtration and chlorination sterilization which are relatively low energy intensity processes. Reverse osmosis or other desalination processes, which are relatively high energy intensity processes, are not needed at the municipal level.

In Figure 10, the values for the energy intensity of natural springs are CAPEC (CAPital Energy Consumption) values only as it is assumed that flow is purely gravity therefore no pumping is required. The value was obtained by taking as example the civil works of *Nabeh Al-Assal* source in *Ouyoun el Simane*. The energy expenditure required for the civil works of the catchment were computed and divided over the yield of the source assuming an infrastructure life span of 70 years.

The values for river catchment include CAPEC and OPEC (**Op**erations **E**nergy **C**onsumption) because withdrawing from rivers usually needs pumping. In this case the same procedure as above is followed and a low lift pumping energy consumption is added.

Artificial reservoirs are similar to natural springs. For this SEA, we used the Qaraoun dam as model while well sources are similar to river catchment. In the same line of reasoning, the values in Figure 2 for natural springs are CAPEM (CAPital EMissions) only while for the other three sources these are CAPEM and OPEM (OPerations Emissions).

Figure 10. Energy Flows in the Water Life Cycle, the Case for Lebanon



Source: Prepared by ECODIT for this SEA Report. All energy rates (KWhr/m^3) are approximate.

Water conveyance

Most users are supplied with water through networks, gravity networks are the least energy intensive because pumping is not required, however open channel gravity systems consume water through evaporation. Evaporation depends on the channel configuration and aspect ratio, it may reach 0.05 m^3/m^3 of water conveyed (5 percent). Pressurized networks are costly in energy but still are less energy intensive than water trucks which are an aberration even in developing countries.

Leakage from distribution systems is inevitable, but unacceptable levels of water loss are widespread in Lebanon. Nationally, Unaccounted for Water (UfW) represents 49% of total water supply. This water loss increases the energy intensity of the water sector because more water is supplied to make up for losses. Leaking water seeps usually to groundwater therefore it may not be counted as a loss to the natural water catchment system of Lebanon.

In the case of conveyance, CAPEC and CAPEM involve the energy consumed and resulting emissions to build the pumping station and its installations, distributed over the lifetime of the installation (70 years). OPEC and OPEM are directly related to running the pumps and auxiliary installations including maintenance and overhaul.

A similar treatment is performed for water trucks where CAPEC and CAPEM are computed using the energy required to build the truck and the water delivered over its lifetime (300,000 km travel). The OPEC and OPEM involve fuel consumption and truck maintenance (oil, tires, engine overhaul, etc.).

Water consumption and use

There are three categories of users (by rank):

(1) agriculture which is by far the biggest user (about 61%);
(2) the domestic/tertiary sectors which are second (about 30%); and
(3) industry which uses the lowest share (about 9%).

However the latter has the highest energy intensity in handling water, mainly because of stringent requirements for water treatment (RO systems, softeners and pressurization). Agriculture has the lowest energy intensity as far as water use is concerned but has the highest water consumption. Depending on irrigation method and time, up to 50 percent of agricultural water is lost to evapotranspiration. This loss can be significantly decreased if nighttime drip irrigation is used.

CAPEC, OPEC, CAPEM and OPEM for agriculture are a result of low lift pumping and operating drip irrigation. For residential and tertiary they are related to water treatment (Filtration, RO/softener), lifting to roof reservoirs and pressurizing. The same applies to industry but to higher intensities.

Water Discharge

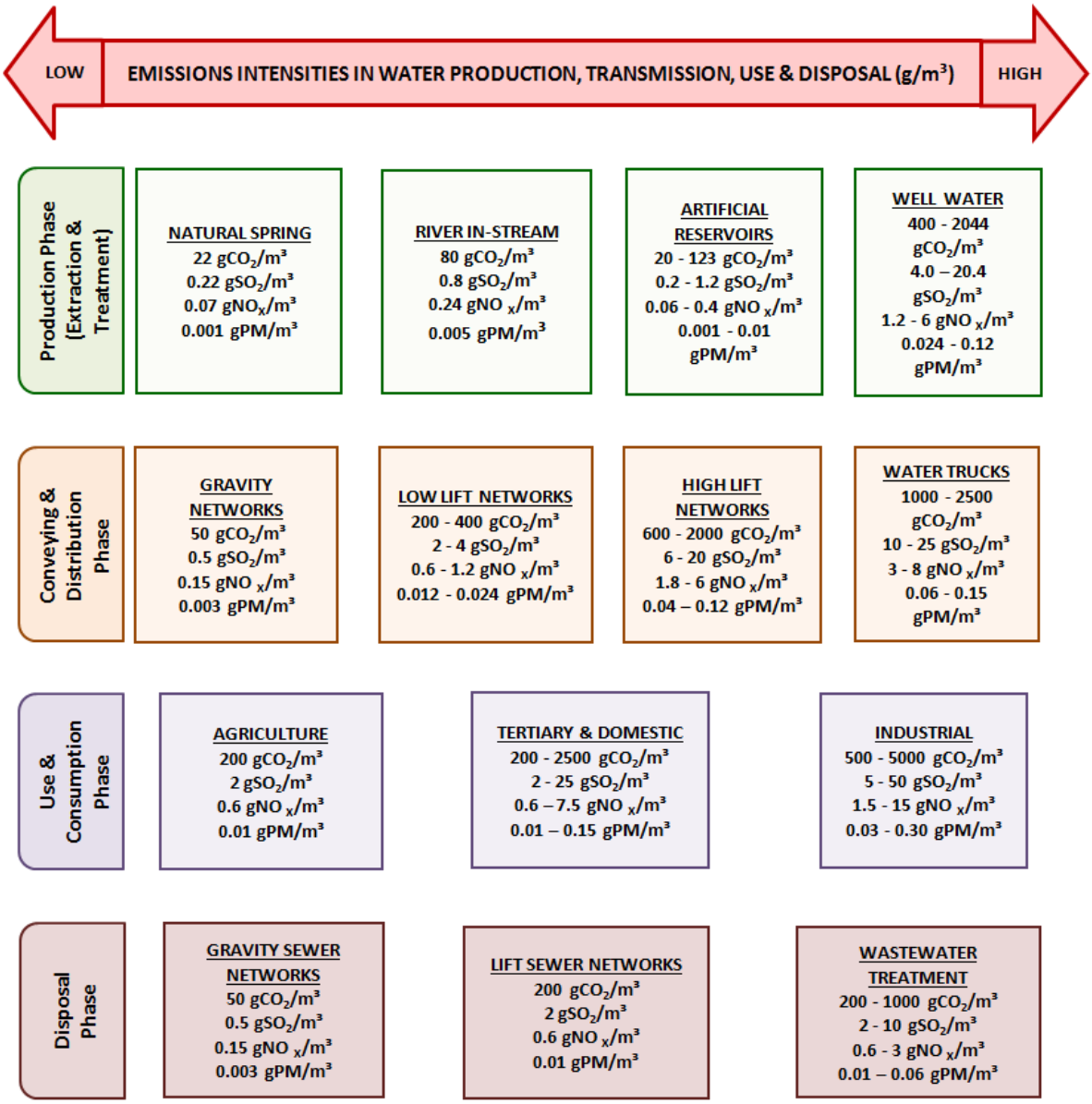
Currently, most used water in Lebanon ends up in the sea without treatment or only primary treatment (Ghadir). This water is lost to the catchment basin system, unlike the 15% or so of used water which is discharged directly to catchment basins, including through seepage into the ground.

If wastewater treatment is implemented on a larger scale, and near agricultural lands, more water (Treated Sewage Effluent) could be recovered and reused in irrigation. However, TSE reuse has an energy price as shown in the flow diagram. However, very large STPs have the design capacity to produce electricity in bio-reactors thus offsetting part of their energy requirements (e.g., Tripoli STP).

The energy and emissions intensities for gravity sewers are estimated from the energy consumed to build the sewer divided by its lifetime throughput (lifespan 70 years). For lift systems pumping installations are taken into consideration. For STP, the energy spent to build the plant and operational energy consumption was considered.

In conclusion, the emission value in the flowchart suggest that the energy cost of using water for an average person may range between 1 - 2.5 KWHr/m^3 or on a daily basis around 0.6 KWHr/person. Putting this number into perspective, a Lebanese resident will on average consume daily around 100 KWHr of energy for water and wastewater related services.

Figure 11. Selective Emissions Related to the Energy Flows in the Water Life Cycle



5.7.2 Lebanon's Potential Hydro-Power Production Capacity

The Government of Lebanon pledged at the Copenhagen CoP 15 Summit (December 2009) to meet 12% of its electricity production from renewable sources by 2020. The planned irrigation schemes and water conveyance projects will seriously compromise Lebanon's ability to meet this target as the GOL relies heavily on existing hydro-electric plants to leverage its 2020 target. The government would need to significantly bolster other sources of renewable energy.

According to MEW, Lebanon's current installed hydropower capacity is about 280MW including 180MW on the Litani River. A master plan completed in 2012 by the French consultant SOGREAH regarding untapped hydro-electric potential on Lebanese waterways showed that potential hydropower production could be increased by 263-368 MW from 31 potential sites which were divided into 3 categories:

(1) Category 1: 10 sites with a total generating capacity of 125 MW with a potential high IRR and low environmental impacts.

(2) Category 2: 13 sites with a total generating capacity of 100 MW, most of these have high potential environmental impacts and medium IRR

(3) Category 3: 6 sites with a total generating capacity of 25 MW, these have very high potential environmental impacts and low IRR

Detailed environmental, technical and financial feasibility studies need to be undertaken to assess which sites are candidate for implementation. The following conclusions can be made based on SOGREAH's report:

- Most of the proposed sites will have a direct impact on water supply (domestic, industrial and irrigation) therefore the feasibility studies should be based on the NWSS.
- Pollution of water resources will be insignificant as long as most stations do not rely on dams. They are Run-of-the-river (ROR) type without water retention facilities.
- Impacts on riparian environments are potentially significant, as water abstraction will take place and river flows will be altered.

Moreover, construction works (such as tunneling and routing of pressure pipes in valleys and river beds) may occur in fragile and topographically difficult settings, potentially resulting in additional adverse impacts. Building on SOGREAH's preliminary findings, MEW started examining the hydropower potential of four proposed dams (Jannah, Boqaata, Mseilha, and Yammouneh) all of which are being planning or under construction. The hydropower potential of each dam depends on many factors including: whether the hydroelectric installations will be exploited in peak mode or run-of-the-river, the interference with water supply for irrigation and domestic use, and financial and environmental considerations. From an environmental perspective, design options that favor hydropower production based on run of the river mode is more acceptable as they avoid ecosystems disturbance by maintaining average flow rates downstream.

Lebanon faces many institutional and administrative barriers to hydropower production. Whereas the MEW (DGRHE) has the exclusive rights on the exploitation of the hydraulic resource, EDL has the exclusive rights on the production and distribution of electrical energy. There are only four private concessions (Bared, Kadisha, Nahr-Ibrahim, and Litani) which can produce electricity but the current tariff structure and corresponding freeze on tariff hikes have rendered those facilities obsolete, bordering on non-feasible. The Power Purchasing Agreements between EDL and the private

concessions have fixed the price of hydro-electricity at LL40/KW (2.6¢/KW) which has effectively deterred any real investment beyond the provisions of basic O&M services to the existing hydro-power plants. There is simply no financial incentive to upgrade these existing hydropower plants.

Regarding non river source hydroelectricity, more commonly called micro-hydro, a study carried out by the UNDP-funded CEDRO project in collaboration with the MEW assessed the micro hydro potential of 20 sites. The study concluded that 13 sites are potentially feasible and would generate up to 5 MW of hydropower, broken down as follows:

- 55% from thermal power plants,
- **34% from irrigation networks, and**
- **12 % from drinking water networks.**

The most promising source is the thermal power plants because of their accessibility and ease of implementation (but this source is not related to the NWSS). The potable and sewage networks (related to the NWSS) are far more difficult to tap because of the state of the networks and legal barriers. It would also require detailed and accurate network maps which currently do not exist. Despite some of the inherent limitations of producing micro-hydro power, MEW has expressed interest in preparing a master plan and is currently seeking funding[34].

5.7.3 Case Study – The Litani River Basin

The following case study examines the impact of conveyance systems on Litani's hydropower production. The implementation of NWSS will impact hydro-electric power generation in Lebanon. In particular, the proposed irrigation schemes and conveyance projects on the Litani River Basin will **decrease hydroelectric output during a normal rainfall year by at least 60 percent.**

The Litani River Authority (LRA) owns and operates three hydro-electric plants. Their total nominal generation capacity is 190 MW distributed as follows:

- Markaba (Ibrahim Abdel-al plant), 34 MW, commissioned in 1962
- Awali (Paul Arcache plant), 108 MW, commissioned in 1965
- Joun (Charles Helou plant), 48 MW, commissioned in 1968

The three plants are connected in cascade and are fed from three main sources: the Litani River and Lake Qaraoun feed all three plants but mainly the Markaba plant; the Ain el Zarqa source feeds mainly the Awali plant but also Joun, and the Bisri River feeds the Joun plant. During a normal rainfall year, the three plants provide around 500 GWHr (Giga Watt-hour equivalent to 10^9 Watt-hours) of electricity that require some 400 Million Cubic Meters (MCM) of turbined water that is subsequently partly used for irrigation of coastal areas and partly discharged to sea. This output represents approximately 3% of the current total electricity production in Lebanon and about 75% of total hydro-electricity production. It should be noted that in the 1960s, the LRA hydro-electric plants supplied more than 50% of total electricity requirement in Lebanon.

Proposed irrigation schemes along the Litani River and watershed will provide irrigation water to:

(1) The South Bekaa through Canal 900 (about 10 MCM),
(2) The highlands in south Lebanon through Canal 800 (110 MCM capacity), and
(3) Other agricultural areas including Qasmieh (30 MCM) and Lebaa (10 MCM).

[34] *Pers. Comm* Mr. Karim Osseiran, Energy Consultant and Advisor to MEW (August 2014)

As well as:

(4) Potable/domestic water villages in West Bekaa/Rachaya and Greater Beirut Area (40 MCM).

These schemes and conveyance projects will tap water from different locations along the river, thereby affect the total flow and hydro-electric potential of the Litani River Basin. The LRA has estimated that these projects will divert up to 70 percent of the water flow available for hydro-electric generation. The hydro-electric power potential of the three stations will drastically decline, as summarized in Table 31 according to three rainfall scenarios (low, moderate, and high). The medium scenario is the most probable and realistic.

Table 31. Assessment of hydro-electric power production in Litani River Basin

Rainfall	Markabi		Awali		Joun		Total Output P (Gwh)	
Year	MCM/Y	P (Gwh)	MCM/Y	P (Gwh)	MCM/Y	P (Gwh)	Expected	Actual
Low	0	0	9	8	0	0	8	150
Moderate	**50**	**20**	**142**	**128**	**122**	**49**	**197**	**500**
High	350	140	440	396	422	169	705	1000

Source: LRA (resources allocations water balance is tentative and require continuous update)

Exceptionally high rainfall years usually occur once every 12 years and even then only during a maximum of three month of the rainy season. In sum, the implementation of all the planned irrigation and water conveyance projects on the Litani River Basin will decrease hydroelectric output during a normal rainfall year by at least 60 percent.

Measures Needed to Optimise/Alleviate the Potential Impacts:

The lost hydro-electric production along the Litani River Basin will need to be compensated by electricity produced either from hydrocarbon burning plants or from other sources of renewable energy. Burning plants would result in the following average yearly added emissions based on current estimated emission factors for the electricity sector in Lebanon:

CO_2	500,000 Tonnes
SO_2	5,000 Tonnes
NOx	1,500 Tonnes
PM	30 Tonnes

Source: Calculations by Mr. Naji Tannous, SEA Energy Expert

Alternatively, and if the GOL intends to offset the emissions presented above or is adamant to make good the 2020 12% renewable energy pledge, then there are two alternative technologies to replace the lost hydro-electric production: photo-voltaic (PV) and wind turbines (WT). The average load factor of the LRA hydro-electric plants is around 0.35 while for PV and WT in Lebanon they are approximately 0.20 and 0.28, respectively, not including the prime WT sites of Akkar.

Assuming a 50-50 mix of PV and WT, some 170 MW_p of PV and 120 MW of WT should be installed. Assuming financial outlays of $1.8M/MWp for PV and $1.3M/MW for WT (conservative estimates), then the overall cost to the Lebanese economy will amount to $460 million. In reality, this investment will be much higher as the three hydro-electric plants will need extensive modifications for the purpose of turning them into reactive power generators (this will help stabilize the electricity grid and ensure LRA some income). This venture would require excellent technical and administrative coordination between LRA and EDL.

5.8 MAN-MADE WATER BODIES AND BUFFERS

The NWSS has identified candidate sites to build up to 18 dams[35] and 23 hill lakes. The proposed reservoirs will hold from <1 MCM (hill lakes) to 120 MCM (Bisri Dam); collectively, up to 670 MCM of static storage can be achieved in those sites. Dams and hill lakes will create man-made water reservoirs of varying depth and area depending on the site topography. Maintaining water quality requires effective regulation of discharges in the affected water basin as well as sound urban planning. This section describes the issues and options for establishing buffer zones and Lebanon's experience to date.

5.8.1 Buffer Zones

A water course or body - such as a lake or dam should have a buffer zone, sometimes referred to as setback zone, which is that area within a defined distance (setback) from the bank of the water course or body in question. Some examples of setback from different jurisdictions[36] are shown below:

- 75 m in New Brunswick[37] (Canada)
- 100 m in Queensland[38] (Australia)
- 29 m US Forest Service[39] (USA)
- 30 m US Federal Regulatory Energy Commission[40] (USA)

For those water courses, such as rivers, that have not had the natural habitat on their banks destroyed, the immediately adjacent land constitutes a natural buffer that protects them from contamination. Roots, trees and other vegetation help to prevent soil erosion, and together the soil and vegetation absorb and filter chemicals, toxins, pesticides, etc. thus providing protection for the water body. Furthermore, it helps reduce the amount of sediment entering watercourses.

It should be noted that buffer zones alone, cannot provide complete protection for water courses if land use activities adjacent to the buffer zone are so severe to undermine their capacity to offer protection[41]. Under the Order here cited, the wider watershed or catchment area is broken into three zones:

i. 75 m setback zone
ii. remainder of the watershed, and
iii. the water course itself.

The Order defines the allowable land use and other activities within each of the zones described above. All dam applications in New Brunswick, Canada, must meet these requirements.

[35] NWSS 2012 (Pgs. 51-52): Noura El Tahta, Qarkaf, Bared, Iaal, Dar Boochtar, Mseilha, El Janneh, Booqata, Aazounieh, Damour, Bisri, Kfarsir, Khardali, Ibl Es Saqi, Massa, Younine, Assi I and II.
[36] No sources were found for experience in countries around Lebanon, such as Jordan, Syria, Cyprus, etc.
[37] "Understanding the Law, A Guide to New Brunswick's Watershed Protected Area Designation Order, Department of the Environment and Local Government, Canada
[38] Traveston Crossing Dam Stage 1, **Coordinator-General Information Sheet**, www.dip.qld.gov.au
[39] David Cornell, "Principles of planning and establishment of buffer zones", **Ecological Engineering**, 2005
[40] Bear River Hydroelectric Project.
[41] Understanding the Law, A Guide to New Brunswick's Watershed Protected Area Designation Order.

This approach was repeated in all the cases consulted. For example, in the Traveston Cross Dam case, referenced earlier, the land use and management plans submitted for approval focused on protecting the designated buffer zone by:

- restoring the native trees and vegetation in the buffer zone
- managing all land use activities in the buffer zone and in the watershed to ensure the buffer zone is protected and enhanced
- managing sedimentation throughout the watershed to ensure the protection of the buffer zone.

There are advocates of taking a wider approach by specifying buffer zones along all upstream rivers and streams feeding into water bodies:

> **"Only good management of the uplands and healthy riparian zones will completely protect the quality of receiving waters."**[42]

According to this study, most of the water entering a water body, does so through first and second order headwater streams. Cornell (2005) advises that pollutants and nutrients should be removed in these streams before entering into the watercourses that flow subsequently into water bodies[43].

An example which is given in the study is worth recounting in the context of Lebanon. If a lake is considered in a watershed, 50% of the first order streams have no riparian vegetation[44]. Cornell argues that these first order streams would be major sources of pollution, particularly in wet weather. This is pertinent to Lebanon because the dams program under NWSS aims at collecting rain runoff and snowmelt.

As a consequence, it is essential that the riparian vegetation relevant to these small streams be restored. Cornell argues that imposing buffer zones on lakes and dams is not enough, but should also be imposed on all rivers, watercourses feeding lakes and dams[45].

5.8.2 Buffer Zones: Assessment of Lebanon Experience

In Lebanon, the notion of "buffer" or setback zones is not very common. While the MOE started introducing buffers in connection with protected areas and fragile ecosystems, and MEW requires setbacks from major rivers and water courses, the application of buffer zones is still rudimentary. In the water sector, buffers are either not part of any formal regulatory regime or simply not enforced by the relevant agencies involved in the planning, approval, construction, operation and management of the proposed dams under the NWSS.

The implementing agencies that should participate in delineating and/or managing activities inside a proposed buffer zone in coordination with MEW include:

- Ministry of Environment
- Council for Development and Construction (and design engineers)
- Ministry of Health
- Ministry of Agriculture

[42] David Cornel, **loc.cit**, p434.
[43] **Ibid**, p435.
[44] Riparian vegetation is that plant life adjacent to a water body and affected by the water in the body.
[45] **Ibid**.

- Ministry of Public Works and Transport (and the DGUP)
- Litani River Authority
- Regional Water Establishments

Each dam and lake is studied and approved in isolation. They are all subject to MOE Level A EIAs, that must be reviewed and endorsed by the MOE. According to Decree 8633/2012, the MOE after reviewing an EIA study and related addendum/clarifications will issue an "opinion" on the project's environmental impact. In theory, the MOE does not reject an EIA study but will request design modifications to minimize potential adverse impacts. This may be an iterative process with the project proponent (MEW) and design engineer. If the residual environmental impacts are significant and cannot be mitigated, then MOE will request compensatory measures to offset the project's environmental footprint.

Any buffer zones defined would be set by the consulting engineer appointed to design the dam or lake in question, in coordination with the MEW and CDR. There is no national legal requirement for stakeholders to follow or meet. See case study on Janneh Dam in *Box 7* overleaf.

In conclusion, there is an urgent need to protect water reservoirs from incoming pollution sources (domestic, industrial, agricultural, and solid waste) in the catchment basin as well as watercourses feeding the lake / dam.

Box 7 Case Study: Janneh Dam and Lake Project

Technical Details:
Location: Nahr Ibrahim
Capacity: 30 MCM – 90 MCM (static – dynamic)
Lake surface area: ca. 1km^2 (4 km x 0.25 km)
Max lake depth: 105 meters
Expected seepage/loss: 70-200 l/s
Ecological flow: 500l/s (minimum flow over the year)
Estimated Cost: USD 250 million
Technical features: Roller Compacted Concrete (RCC) dam, hydropower plant and conveyor to Dbaye WTP

Project Owner: Beirut and Mount Lebanon Water Establishment
Design Consultant: Khatib & Alami (KA) and ARTELIA
Construction Supervision: JV ARTELIA/KA

Construction of this dam is ongoing. Its original location on Nahr Ibrahim was determined by the 1954 American mission to Lebanon known as "Point 4". Following detailed site investigations, the original location was contested by the Design Consultant (KA/ARTLELIA) arguing that it was vulnerable to seismic activity, which would undermine the dam's storage capacity. The consultant recommended a new location 1,100m upstream, which was accepted by MEW.

The dam is financed by the Beirut and Mount Lebanon Water Establishment (also the project beneficiary). Its involvement in the design, construction or operation and management of the dam is however minimal. The original EIA study was prepared by KA, and was later challenged by the general public, pressure groups and the Ministry of Environment. An EIA update was commissioned by MEW in coordination with MOE to further examine the potential environmental and social impacts of the project.

Some of the pertinent technical characteristics of the dam design are:

- Concrete gravity dam would be built on the bedrock, about 60m below the existing ground level
- Designed to withstand 1 / 10,000 year seismic event. Verified by a committee of experts from the International Commission on Large Dams (ICOLD)
- Minimum 500 l/s will be released to the river downstream, equal to the natural flow of the river
- Lands 20-30 m above the lake's water level were identified for expropriation

Janneh dam is a major public asset, estimated to cost of $250 million. The reservoir will supply drinking water to the upper regions of the Caza of Jbeil (about 30 MCM) as well as Beirut (about 65 MCM) through the Dbaye Water Treatment plant in the summer months. The Dbaye plant is the main water source for Beirut.

The original design did not include any buffer zone, emergency action plans or crisis management requirements. The Directorate General of Urban Planning was not consulted, and no measures are in place to reduce or prevent unwanted construction near the lake in the future. Urban development and sprawl, so widespread in Lebanon including mountain areas, could also happen in the vicinity of the proposed lake in the absence of tougher urban planning regulations and restrictions.

Without buffer zones, the dam reservoir will not be protected from point or diffuse source pollution. The resulting lake will stretch beneath two growing urban masses: Qartaba and Lassa. The potential absence of land use planning regulations around the lake may result in water pollution from uncontrolled construction and other man-made activities including agricultural and industrial. The absence of emergency action planning means any failure due to defective dam operation or pollution of the dam will render dam operators and downstream communities ill equipped to manage any future crisis.

The updated EIA must provide for adequate mandatory buffer zones. It must also prescribe an emergency action plan, the framing of which should have included consultations with the relevant authorities. Failing this, the updated EIA should set up a process that will lead to the establishment of emergency action plans.

Source: Based on a meeting with Dr. Adel Abou Joudeh, Khatib & Alami (10/2/2014), and review of media reports

5.9 CATASTROPHIC FAILURE AND EMERGENCY PLANNING

Throughout the world, the planning and approval or licensing processes applicable to the construction and operation of dams mandate environmental safeguards to ensure:

i. dams are not exposed to pollution from their environments,
ii. operation of dams do not impact adversely on their downstream environments, whether in their routine operations or in the event of dam failures, catastrophic or otherwise,

In this section we will describe these safeguards as they apply in particular to protecting dams from the adverse effects of their environments, and ensuring their operation does not have deleterious impacts on the environment. The analysis leans on Lebanon's experience to date.

5.9.1 Planning and Approval

Internationally, dam construction is subject to an extensive planning and approval process. Dam construction applications comprise the following documents which must be compliant with local regulatory requirements which may differ from country to country:

i. Design is technically compliant, and also within the acceptable standards and norms applicable in the international dam building industry.
ii. The dam design is compliant with the Environmental requirements, which means the formal approval of the regulatory agency mandated with such approvals.
iii. Land Use Plans defining buffer zones, protected waterside habitats, pollution point and non-point sources, agricultural and industrial activities, residential agglomerations in the project area, heritage sites and recreation/touristic areas[46].
iv. Land Management Plans to manage the areas identified in the Land Use Plans[47].
v. Land Restoration, enhancement and protection plans for the restoration of native habitat.
vi. Sediment Management Plan to manage and minimise sedimentation in the dams which reduces dams' storage capacities.
vii. Dam Safety Management Plan, which must include an Emergency Management or Response Plan[48].

The World Bank, under OP 4.37 Safety of Dams[49], recommends:

i. reviews by an independent panel of experts of the investigation, design, and construction of the dam and the start of operations;
ii. preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan,
iii. an emergency preparedness plan; and
iv. prequalification of bidders during procurement and bid tendering, and
v. periodic safety inspections of the dam after completion.

[46] Traveston Crossing Dam Stage 1, **Coordinator-General Information Sheet**, www.dip.qld.gov.au
[47] Bear River Hydroelectric Project, **Land Management and Buffer Zones,** Cirrus Ecological Solutions, UTAH, 2011.
[48] Refer to US Federal Emergency Management Agency (FEMA) for extensive literature on this subject. Other literature consulted includes British Columbia, Canada, and New South Wales Australia. Literature available on this topic is extensive.
[49] OP 4.37 Safety of Dams, World Bank Guidelines for Borrowers.

Dam safety, and emergency or crisis management, is fundamental to dam construction process. It is also related to the dam size; see analysis in Section 5.11.2 (on dam classification) and Box 6 (a review of the cause of dam failure).

The above list involves the interplay or coordination of a number of government agencies, beginning with the water authorities wishing to build dams, the water resource authority responsible for bulk water resources, the government environmental authority, the land use and management authority, government emergency services, law enforcement authorities, and local community groups. As will be shown below, such a schema in its entirety, cannot be observed in Lebanon, whether in relation to the planning and approval process itself, or in relation to the issues impacting the environment, which are within the remit of this assessment.

It must be acknowledged however, that the 1st point of the approval process is adhered to, as the Ministry of Energy and Water (MEW) does ensure that both the design and construction of the dams in question meet the acceptable international standards. Furthermore, both MEW and MOE are carrying out EIAs for each planned dam or lake, although several EIAs were conducted prior to the EIA Decree (2012) and therefore did not go through a proper MOE review exercise.

Yet, dam operation and safety in terms of the mutual impact of the dams and their environment and surrounding communities on each other, are not addressed in Lebanon. Crucial to the protection of dams from sources of pollution identified during the planning and approval process are creation of buffer zones around the dams and upstream water courses feeding into dams.

5.9.2 Dam Classification and Safety

Dam Classification

As the Dams and Lakes Program is the centerpiece initiative under the National Water Sector Strategy, the requirement to prepare emergency management plans for dams and lakes should be tied to world recognized classification systems.

The World Bank, by virtue of its OP 4.37[50] classifies dams as follows:

i. **Small Dams** - less than 15 meters in height such as farm ponds, local silt retention dams, and low embankment tanks.
ii. **Large Dams** - higher than 15 meters.

Dams that are between 10 and 15 meters in height are regarded as large if they have: large flood handling equipment or they are located in areas of high seismicity or they possess complex foundations or they are likely to retain toxic material.

The World Bank recommends "generic dam safety measures designed by qualified engineers are usually adequate" for small dams.[51] For Large dams, the World Bank recommends:

- reviews by an independent panel of experts of the investigation, design, and construction of the dam and the start of operations;

[50] World Bank OP 4.37, **Safety of Dams,** October 2001 (Revised April 2013)
[51] Ibid.

- preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan, and an emergency preparedness/action plan;
- prequalification of bidders during procurement and bid tendering; and
- periodic safety inspections of the dam after completion.

Under the Australian National Committee on Large Dams (ANCOLD)[52] safety requirements, the dam classification is little more nuanced. It stipulates that EMPs and safety requirements apply to dams that meet its criteria for large dams:

- Height 5 m and holding capacity of 50,000 m^3
- Height 10 m and holding capacity of 20,000 m^3
- Height of 15 m
- Is on a water way and has the ANCOLD consequence category of significant

The International Commission on Large Dams (ICOLD) includes dams on its register if they have a height of 15 m or more, measured from the lowest portion of the general foundations to the crest. Furthermore, dams between 10 to 15 m are registered if they comply with one of the following conditions:

- the length of the crest is not less than 500 m,
- the capacity of the reservoir formed by the dam is greater than 1,000,000 m^3,
- the maximum flood discharge dealt with by the dam is greater than 2 000 m^3,
- the dam has special foundations problems or is of unusual design.

Both the World Bank and ICOLD classifications are very similar.

Based on the literature that was consulted related to dam size, what determined the need for EMPs was the likelihood of loss of life or significant material or property damage if the dam in question failed. Based on the above, we recommend that Lebanon adopt the World Bank dam classification system outlined above as a guide for preparing EMPs. This means that MEW should classify the existing and proposed new dams retroactively according to WB's small dam and large dam classification, and accordingly decide on and commission the preparation of EMPs.

Dam Safety

According to the US Federal Guidelines for Dam Safety[53]:

> **"A dam safety incident is an impending or actual sudden uncontrolled release or excessive controlled release of water from an impounding structure. The release may be caused by damage to or failure of the structure, flood conditions unrelated to failure, or any condition that may affect the safe operation of the dam. The release of water may or may not endanger human life, downstream property, or the operation of the structure."**

Furthermore, an emergency is "any incident, whether natural or manmade, that requires responsive action to protect life or property."[54] Other literature sources identify that safe dam operations were

[52] www.ancold.org.au

[53] **Federal Guidelines for Dam Safety: Emergency Action Planning for Dams**, Federal Emergency Management Agency (FEMA), July 2013, pI-2.

impacted by pollution of dam water storage or upstream flows[55]. The World Commission on Dams has examined dam safety and failure around the world and has determined that dam failure is rarely linked to dam height, but more often to small, newly built dams (see summary in *Box 8*).

Box 8 A review of the causes of dam failure

The proportion of dams failing varies little with the height of the dam and so most failures involve small dams. Most failures involve newly built dams. Some 70% of failures occur in the first ten years of life of the dam and proportionately more during the first year after commissioning. Foundation problems are the most common cause of failure in concrete dams, with internal erosion and insufficient shear strength of the foundation each accounting for 21% of failures. The most common cause of failure of earth and rock fill dams is overtopping. This is followed by internal erosion in the body of the dam and in the foundation.

Where other works were the seat of the failure, the most common cause was inadequate spillway capacity. When most large dam projects are built, the assumption is that river flows in the future (total runoff and severe floods) will be much like those in the past. Climate change has introduced another level of uncertainty about changing flows within the life span of most dams. The safety of large dams is affected by changes in the magnitude or frequency of extreme precipitation events. These changes are highly uncertain, but climate change is expected to lead (and perhaps already has led) to larger and more frequent extreme precipitation events.

Source: Dams and Development: A New Framework. The Report of The World Commission On Dams. November 2000

Internationally, most dam owners are required to submit Emergency Action Plans or Dam Safety Plans or Crisis Management Plans as part of the planning and approval process[56]. As will be seen, only one dam in Lebanon, the Litani River Dam, has an Emergency Action Plan (EAP) in place. Reviewing the international literature, including the Litani River Dam EAP[57], it is clear Emergency Action Plans should include the following elements:

i. Notification flowcharts, communication procedures and contact information clearly showing who activates the EAP, who notifies whom from the beginning of the incident to its termination

ii. Response process, which will include a determination the emergency level based on the evaluation of the incident or event as it develops. Depending on the emergency level, a commensurate response process, predefined in the EAP, will be triggered.

iii. The roles and responsibilities, predefined in the EAP, depending on the response level activated, will be brought into play. Depending on the response levels, dam owners, operators, emergency services personnel, security staff, community groups, etc., will be instructed to respond in line with their EAP defined roles and responsibilities.

[54] Ibid.

[55] **British Columbia Plan Submission Requirements for Construction and Rehabilitation of Dams**, BC Dam Safety Guidelines, 13 May 2013, and **Dam Safety and Emergency Preparedness: State Water's Incident Management Framework,** NSW State Water Corporation,

[56] It should be noted, that although most of these titles are synonymous, in some instances they are not, but the approach here is to ensure there is a plan, endorsed by all affected parties, that ensures that dam failure can be managed safely. We will be dealing with Emergency Action Plans.

[57] Litani River Basin Management Support Program, **Emergency Action Plan for Qaroun Dam,** USAID, September 2012.

iv. Preparedness activities will be put into effect. These are actions triggered before the incident or emergency eventuates in order to alleviate the effects of the emergency. Again the preparedness activities will be determined by the evaluation of the level of emergency. If dam failure is imminent, then these activities would wide ranging.

v. Inundation Maps which would define those areas most affected by dam failure to facilitate speedy notification, and if required, evacuation of downstream activities.

vi. Any requisite additional information.

The response process of an EAP in its general form must include the following 4 steps:

- Incident or dam conditions detection, evaluation and emergency level determination
- Notification and communication of procedures to be followed by stakeholders according to the type of incident or level of emergency
- Emergency actions
- Termination and follow up.

The response process embodies the actions taken under the EAP during an emergency situation. In some jurisdiction, this is called the Crisis Management Plan, and is a subset of the EAP. Before dealing with the salient elements described above, the stakeholders involved in the planning and operation of dam EAPs should be accounted for. Typically they would include:

- the dam owner and operator
- the design consultant
- emergency services
- police and security authorities
- environmental agencies
- downstream community groups and representatives
- volunteer groups

This has been observed in all the international literature we have reviewed and referenced. The Litani River Dam EAP is the only case in Lebanon where an EAP has been prepared. This has been done not in response to statutory requirements, but on the initiative of the Litani River Authority and USAID. The organisationally unified approach required under an EAP is absent in Lebanon. There is no evidence even in the Litani River EAP that any of the typical stakeholders identified above have been included in the consultations during the preparation of the EAP. There is no signoff of stakeholders; no clear assignment of roles and responsibilities of stakeholders.

Response Process Step 1 Emergency Levels

Absolutely fundamental to any EAP and its implementation is the setting of the emergency level. This will determine the response required, the notification protocols and all subsequent actions.

To be able to carry out this activity adequately, the EAP should either include or reference the following:

- Measures for detecting existing or potential failures
- Operating information, such as normal and abnormal reservoir level data

- Description of monitoring equipment, such as water level sensors and early warning systems
- Monitoring and instrumentation plans
- Inspection procedures
- Process for analyzing and confirming incoming data

Although the international literature is mainly in agreement on the emergency levels categorisation, we will use the Litani River Dam EAP[58] categorisation because it is line with the international approaches. Four levels are identified:

i. Level 0, normal situation. No action required.

ii. Level 1, unusual situation, but no immediate danger. This will usually mean something has been observed in the dam such as failure in spillway, or level of water at crest level or some cracking or seepage in the dam face or abnormal readings from dam monitoring equipment. It could also mean some significant occurrence in the vicinity of the dam such as an earthquake or upstream flooding. Finally it could include a bomb or sabotage threat.

iii. Level 2, possible emergency situation or dam is potentially failing. Again there are clear technical criteria that help in determining this emergency level. This could be a result in an inoperable spillway or water is more than 0.5 m above dam crest or there is significant seepage through the dam face caused by a bomb detonation or earthquake.

iv. Level 3, emergency situation, dam is failing.

Usually the level assessment and determination is made by the dam owner or the person assigned this responsibility in the EAP.

Response Process Step 2 Emergency Notifications

Once the emergency level has been established, the EAP subsequent actions are initiated. The processes and procedures governing this step should be clearly defined in the EAP.

The Litani River Dam EAP is clear in this respect. It details the notification actions based on the emergency level determined by the Engineer responsible for the Dam's operations. They are:

i. Level 0. No action.

ii. Level 1. Notification immediately issued to LRA General Director and to LRA Head of Hydro-electric Production. Dam staff to visually monitor the dam to update the Engineer, who will in turn update LRA General Director and to LRA Head of Hydro-electric Production twice daily or if situation deteriorates.

iii. Level 2. Notification issued immediately to LRA General Director and to LRA Head of Hydro-electric Production, General Director of Exploitation in MEW, Civil Defence, downstream municipalities. All the above will be issued with updates every 2 hours or immediately if situation deteriorates. Dam and situation monitored on continuous basis.

iv. Level 3. Same notification protocol as Level 2. The LRA EAP stipulates that downstream communities would be "informed" to evacuate flood prone areas. Updates of the situation will be issued on hourly basis.

[58] Litani River EAP, p 5.

Response Process Step 3 Emergency Actions

As soon as the emergency level has been set and notification set, the emergency actions stipulated under the EAP should be initiated.

> **"After the initial notifications have been made, the dam owner will act to save the dam and minimize impacts to life, property, and the environment. During this step, there is a continuous process of taking actions, assessing the status of the situation, and keeping others informed through communication channels established during the initial notifications."**[59]

The LRA EAP divides this into emergency measures at the dam, and emergency measures downstream.

At the dam, LRA propose:

- If the threat to dam is rising level, the low level outlet will be opened provided downstream communities have been forewarned and are prepared for this action.
- If the dam emergency is due to cracking in dam face, emergency repairs should be undertaken immediately and longer term repairs scheduled as a priority.
- If the dam has settled due to an earthquake, and water is overflowing, they propose immediate dumping of rockfill, and scheduling long terms repairs as a priority.

For the downstream municipalities they propose:

- Immediate notification of affected communities.
- closure of all road and bridges in the identified inundation zones.
- mobilizing boats for rescue purposes.
- maintain communications amongst the stakeholders.

It is worth noting that the several iterations of steps 2 and 3 may be performed as the situation develops, either improving or deteriorating.

Response Process Step 4 Emergency Termination

The EAP should, as with the other steps, clearly detail the criteria that determine emergency resolution and process and the procedures to follow to formally end the emergency situation.

This will trigger a post emergency review which should describe:

- Events or conditions leading up to, during, and following the incident
- The actions taken by each of the EAP stakeholders and improvements for future emergencies
- The strengths and deficiencies encountered during the implementation of the EAP, materials, equipment, staffing levels, and leadership
- Corrective actions proposed and action plan implement proposed actions

[59] (FEMA), July 2013, pII-9

5.9.3 Dam Safety: Assessment of Lebanon Experience

A brief assessment of the LRA EAP will be provided below in order to encourage EAP's for all the dams built or under construction or planned in the future. This assessment will be made against the 5 basic elements identified at the beginning of Section 5.9.2.

Element 1 - Notifications

The LRA EAP provides a very brief "Contact List"[60]. It is deficient in a number of ways, namely:

- It does not include all the contact details of the people in the emergency notification chart provided in the LRA EAP, and which is summarized in section 2.4.2 above.
- No contact information of Civil Defense
- No contact information for local downstream communities

The FEMA guidelines require a flowchart that provides any sequencing or prioritization of actual contacts. However, it is sufficient under this section to have a "contact list", provided it is comprehensive and covers all the stakeholders, and their roles in the EAP or during the response process[61].

Element 2 - Response Process

As the Response Process encapsulates all the actions under the EAP, it has been described above in detail. However, fundamental to the effectiveness of the response process, and ultimately of the entire EAP, particularly in an emergency situation, is the quality of the other elements in the EAP.

Once the emergency level has been determined, if the contact list does not correctly identify and include the contact details of the right people, the emergency will not be effectively notified or communicated. If then the roles and responsibilities are not clearly defined, the ensuing actions will again be uncoordinated and ineffectual. Equally important, the emergency actions need to be clearly defined in the EAP, and practiced or rehearsed periodically by the EAP stakeholders, to ensure they are activated as required. Finally, if the inundation maps of the flood prone downstream are not current and correct, the emergency actions would potentially fail to evacuate the right people in the right areas.

The LRA EAP does include the essential steps discussed above as part of the response process. It does not deal with the final step: termination of emergency. It describes the steps and actions required under the response process very briefly. However, as the response process relies on the quality of the other EAP elements described above, once the LRA successfully determines the emergency level, the deficiencies in the Contact List, as reviewed, will mean the downstream communities and civil defence authorities will not be notified speedily.

[60] LRA EAP, pIV.
[61] Cradle Mountain Water Dam Safety Emergency Plan, Tasmania, 2011, pp 15-24. Contact List attached to report.

Element 3 - Roles and Responsibilities

Under the Emergency Notifications section of the LRA EAP[62], the only role given to any of the stakeholders is to the Engineer in charge of the dam in question. All the other stakeholders receive the emergency notifications and updates as the emergency develops.

Responsibilities under a typical EAP can be divided as follows:

- Dam owner responsibilities
- Notification and communication
- Evacuation
- Monitoring
- Termination and Follow Up
- EAP coordination
- Awareness raising

The LRA EAP assigns the preparation, and more importantly the implementation directly with the LRA Head of Hydropower Production Department. The LRA is to:

- Hold orientation meetings with LRA staff annually,
- Hold orientation meeting with Civil Defense and community representatives assigned "disaster management duties",
- Circulate the EAP, including inundation maps to Civil Defense and downstream communities.

Regarding other stakeholders roles and responsibilities, "the final decision about evacuating flood prone areas rests with Civil Defense and local municipalities"[63].

It is clear that in terms of defining the roles and responsibilities of the LRA and its staff, the EAP is adequate. However, the roles and responsibilities of the other stakeholders, and how and when they will interact, are not described with anything of the detail required. Most of the responsibilities listed above as part of a typical EAP are not dealt with adequately.

In the LRA EAP, there is emphasis that the Qaroun Dam is an "essential infrastructure" for Lebanon[64]. Yet, there is no contingency for setting up an emergency core team or a temporary emergency management or crisis center to manage and coordinate all activities during a level 2 or 3 emergency. Such centers were observed in all the literature reviewed. Crisis Centre should always be kept in a state of complete readiness to host predefined emergency or crisis teams to manage major emergencies.

Unfortunately, this level of emergency preparedness is lacking in the dams program, and in all the other capital investment programs of the NWSS.

[62] LRA EAP, p7.
[63] Ibid, p11.
[64] Ibid, p10.

Element 4 - Preparedness

> **"Preparedness activities attempt to facilitate response to an incident as well as prevent, moderate, or alleviate the effects of the incident."[65]**

FEMA recommends, at a minimum, the EAP should address the following categories related to preparedness:

i. Surveillance and monitoring
ii. Evaluation of detection and response timing
iii. Access to the site
iv. Response during periods of darkness
v. Response during weekends and holidays
vi. Response during periods of adverse weather
vii. Alternative sources of power
viii. Emergency supplies and information
ix. Training and exercising
x. Alternative systems of communication
xi. Public awareness and communication

The LRA EAP only addresses adequately points i, ii, iii, x and xi.

Element 5 - Inundation Maps

Inundation maps in the EAP should include:

- the flood prone areas downstream from the dam
- travel times of waters if the dam fails completely
- the critical locations
- the critical roads and bridges that could be used in evacuation in case of dam failure

The inundation maps should be prepared in full coordination with the Civil Defence, the urban planning authorities, roads authorities, downstream authorities, and the police. There is nothing to indicate that the inundation maps included in the LRA EAP were derived based on the level of coordination described above.

In this section, we have shown that an essential part of planning and approval process for dams, is the preparation of an Emergency Action Plan. As of the writing of this assessment, despite the extensive dam construction program ongoing under the NWSS, we had access to only one EAP covering the Litani River or Qaroun Dam. This EAP, although deficient in a number of areas, is a start that should be extended to the entire dams program. These are vital capital assets that should be protected, while at the same time, the authorities should provide the downstream communities the protection they are entitled to in the event these dams fail. Comprehensive EAP's, as is best international practice, should be mandated as part of the dams program.

[65] FEMA, p II-13.

5.10 WATER-POVERTY NEXUS

The NWSS plans to increase static surface storage by up to 670 MCM (Initiative I.3), and increase irrigated areas by around 63,200 ha (Initiative I.6). The primary objective of the proposed dams and hill lakes in North Lebanon, South Lebanon and the Bekaa is to provide irrigation water, as evidenced by the percent water allocation to agriculture (Table 32).

Pre-feasibility and feasibility studies of past irrigation projects show that irrigation will generate overall additional net revenue per hectare estimated between $2,500 and $3,000 per year. According to FAO and LRA experts, the new level of revenue per hectare is four to five times the revenue level on similar but non-irrigated areas.

Table 32. NWSS planned storage infrastructure

Mohafaza	*Total Static/Dynamic (in MCM)*	*Of which irrigation (in MCM)*	*% irrigation*
Beirut and Mount-Lebanon	208-339	13-27	6%-8%
North Lebanon	171-257	96-119	**46%-56%**
South Lebanon	ca.190	150	**79%**
Bekaa	ca. 98	86	**87%**

Most of the 46 sites planned in Initiative I.3 (surface storage) and all the sites in Initiative I.6 (irrigation) are located in agricultural regions with high poverty incidence. Hence, it is expected that **proposed irrigation schemes will have potential to contribute to poverty alleviation**. According to the MDG Costing exercise for Lebanon,[66] the above initiatives will have the following effects:

- Increase access to irrigation by current farmers
- Increase area of total irrigated land (and consequently reduce rainfed agriculture)
- Increase the overall number of farmers in the affected areas
- Increase the productivity ratio per area
- Enable the diversification of crops (and reduce the dependency on heavily subsidized and labour-intensive crops such as Tobacco[67]) – see Box 9

[66] Prepared by Consultation and Research Institute for UNDP, 2005
[67] Refer to Annex 1, Tobacco cultivation in Lebanon

Box 9 Case Study - The Impact of Irrigation on Lebanon's Tobacco Industry

Lebanon's tobacco production and processing industry goes back several decades. Tobacco is one of Lebanon's major cultivated crops as evidenced by total annual output (about 11,000 tons) and the number of farmers engaged in tobacco cultivation (about 24,000 tobacco farmers). Tobacco cultivation covers about 10,000 ha and is mostly concentrated in South Lebanon. Tobacco is also very labour intensive. On average, each hectare of tobacco requires 610 labour days, compared to 25 and 242 labour days for cereals and vegetables, respectively. For every registered farmer, there are an estimated 1.4 additional family members and 0.9 seasonal laborers. It is estimated that about 45,000 people depend at least partially on tobacco cultivation for their livelihood.

To support tobacco cultivation and farmers in Lebanon, the Régie Libanaise des Tabacs et Tombacs (established in 1935) buys tobacco from farmers under a quota system at a fixed support price of around $7,500 per Metric Ton (MT) and re-sells it at a loss on the world market, at a price of around $3,500 per MT (values for 2008). This Price Support Program (PSP) is becoming increasingly expensive, estimated at $74 million per year. The Régie exports nearly all domestic tobacco production (of lower quality than the tobacco demanded by Lebanese consumers) and imports a similar quantity of higher quality to Lebanese consumers. With its tax revenues from imports, the Régie covers the trade deficit and the PSP.

Lebanon's tobacco sector faces many challenges:

1. It requires intensive workforce (usually the whole family is involved in this activity, hence depriving children from school and generating significant social negative impacts)
2. It is not cost-effective, taking into account public subsidy direct and indirect costs and especially when compared with other crops.

The gradual arrival of irrigation water to South Lebanon therefore has the potential to displace the tobacco industry. Notwithstanding the socio-political implications of a tobacco phase-out program, farmers will have the possibility to grow higher value irrigated crops. In fact, the PSP has come under international pressure from the WTO and WHO for artificially increasing demand for Lebanese tobacco. Since 2003, the Régie and the Ministry of Finance have been examining alternative ways to support farmers once the PSP is phased out. For example, instead of spending resources growing low-grade tobacco, and encouraging smoking behavior, the program could instead:

- Demonstrate and promote alternative crops adapted to the local environment;
- Invest in modern irrigation practices to diversify agricultural output; and/or
- Provide direct cash transfer to encourage investment in new and profitable activities.

If cash payments to farmers are continued after the tobacco phase-out, they can be made conditional on, for example, school attendance and medical checkup for children. Removing the PSP is an important step for Lebanon to reduce public spending in a non-productive sector while encouraging spending in more viable and environmentally-sustainable activities. The NWSS can help achieve this goal by providing much-needed irrigation water to farmers in South Lebanon.

In conclusion, the NWSS will have both direct and indirect impacts on poverty and will constitute one of the pillars of any poverty alleviation policy. The NWSS will have a significant positive impact on the household income of farmers in agricultural regions.

5.11 TREATED SEWAGE EFFLUENT AND SLUDGE REUSE

Under the NWSS, the Government proposes to build a number of sewage treatment plants (STPs) along with their associated collection networks, along the coast and inland as follows:

- About 12 coastal STPs serving 5,597,000 people equivalent (PE)
- About 42 inland STPs serving 1,977,750 PE

This section explains the potential for Treated Sewage Effluent (TSE) and sewage sludge reuse based on draft guidelines prepared with technical assistance from the FAO [68]. Despite proven benefits from reusing TSE and sewage sludge in agriculture, landscaping and land restoration, a closer examination of NWSS wastewater interventions shows that:

- Several STPs will treat the sludge by incineration, and
- Several coastline STPs are located in non-agricultural areas and are not equipped with TSE storage ponds; the resulting TSE will be discharged into the sea.

5.11.1 Treated Sewage Effluent Impact on Dams and Lakes

Discharge of TSE, that meets certain quality criteria, is commonly practiced throughout the world. Significant volumes of TSE are discharged into rivers that provide drinking water for parts of **Sydney**.[69] The **European Council** through its Directive concerning urban wastewater treatment (91/271/EEC dated 21 May 1991) sets the quality criteria TSE should meet before discharge into "sensitive water bodies". In **South Africa**: "The return of treated sewage effluent to rivers is regarded in inland areas of South Africa as an important aspect of water management, especially with regard to downstream availability of raw water for further abstraction"[70]. International practice does stipulate that TSE that is discharged into water courses or bodies should meet two conditions:

- quality criteria
- the right balance between the volume of TSE discharged and the volume of the receiving water.

If the STPs are operating to a level that produces the TSE to the right quality, the TSE can be discharged into water courses or bodies, provided the volume of receiving water is at the appropriate level. This volume of receiving water and TSE is determined on a case by case basis.

Based on the above we recommend the following actions with regards to TSE being released into Lebanon's water courses or bodies:

(1) TSE meet the minimum acceptable quality criteria set by international best practice or provided by Lebanese law and regulations (MOE Decision 8/1 of 2001). STP Environmental Management Plans set daily sampling of TSE to monitor quality. MOE and MEW must enforce it on the RWEs or STP operators.

[68] Project UTF/LEB/019/LEB, Wastewater Reuse and Sludge Valorization and Reuse (2010)
[69] Sydney Morning Herald, 25 October 2005.
[70] Ania MW Grobicki and B Cohen, "A Flow balance approach to scenarios for water reclamation", p 480 (Available at www.wrc.org.za)

(2) MEW and MOE should verify the conditions of the receiving water to ascertain if it is in a state to receive the volume of TSE to be discharged. This could be part of the EIA for the STP in question.

(3) Holding tanks be built in STPs to hold untreated sewage in case of operations shutdown or malfunction. Raw sewage bypasses should only be allowed if approved by MOE and MEW as part of the EIA process.

(4) Water courses containing TSE should be sampled immediately upstream from any lakes or dams (baseline) to ensure the quality criteria for the lake or dam in question are being met downstream. Again MOE and MEW should be empowered to enforce the RWE to conduct this sampling. Furthermore, this should be part of the Environmental Management Plan for both the STP discharging the STP or dams or lakes receiving the water.

(5) An appropriate buffer zone be established for inland STPs either through MEW/MOE/DGUP regulations or through the STP EIA process to ensure that no seepage of contaminated material during construction or untreated sewage seepage from any of the STP tank structure is allowed into nearby water bodies recourses.

5.11.2 Treated Sewage Effluent Reuse

Planned and completed STPs will begin to produce TSE when operations begin. Certainly, the selection of treatment technologies must be supported by the institutions responsible for O&M and appropriate legislation must be enacted to ensure effectiveness of Lebanon's wastewater treatment sector.

With technical assistance from the FAO, the MEW prepared in 2010 draft wastewater reuse guidelines including Best Management Practices. The guidelines were based on viral and microbiological risk factors in relation to TSE reuse in agriculture. The draft guidelines recognize three TSE categories with matching crops and irrigation methods (see Table 33).

Table 33. Draft TSE reuse guidelines for Lebanon

Parameter	***Category***		
	I	**II**	**III**
BOD_5 (mg/l)	25	100	100
COD (mg/l)	125	250	250
TSS (mg/l)	60	200	200
Cl_2 residual (mg/l)	0.5-2	0.5-2	0.5-2
$N\text{-}NO_3$ (mg/l)			
Faecal Coliforms (in 100 ml)	<200	<1000	Non required
Helminth ova (in 1 litre)	<1	<1	<1

Source: MEW-FAO Project UTF/LEB/019/LEB

Each category and the corresponding crops are listed next:

Category I

Water treatment expected to the criteria: secondary treatment + filtration + disinfection

- Fruit trees and crops that are eaten cooked
- Parks, public gardens, laws, golf courses and other areas with direct public exposure
- In case of stabilization ponds, TSS limit is 100 mg/l

Category II

Water treatment expected to the criteria: secondary treatment + filtration + disinfection OR secondary treatment + either storage or well-designed series of maturation ponds or infiltration percolation

- Fruit trees
- Laws, wooded areas, and other areas with limited public access, road sides outside urban areas
- Landscape impoundments: ponds, water bodies and ornamental streams, where public contact with water is not allowed
- Cereals and oleaginous seeds, fibre and seed crops
- Crops for canning industry

Category III

Water treatment expected to the criteria: secondary treatment + few days' storage or oxidation pond

- Fruit trees (but not sprinkler-irrigated)
- Plant nurseries, ornamental nurseries, wooden areas, green areas with no public access

The guidelines also include suggested sampling frequencies as well as protocols for influent and effluent sampling and analysis. Future STP operators would need to adhere to those guidelines.

5.11.3 Sludge Disposal

Lebanon's first sludge assessment report was prepared in 2001, when CDR's wastewater master plan was still in its infancy. The 2001 assessment report had estimated total sludge production in 2001 and 2010 respectively. Although these estimates were overstated due to delays in STP implementation, and to less-than-expected inflows, they remain pertinent over the long-term. This SEA Report did not find any other estimates or data on current and future sludge production.

Table 34. Estimated sludge production (estimates for 2001 and 2010)

Mohafaza	*2001*		*2010*	
	Mass (tons/day)	Volume (m^3/day)	Mass (tons/day)	Volume (m^3/day)
Beirut	113	283,182	136	339,607
Rest of Mount Lebanon	21	162,981	26	198,150
North Lebanon	50	141,892	61	173,389
South	14	66,811	18	83,329
Bekaa	53	297,472	69	465,552
Total	**251**	**952,338**	**310**	**1,260,028**

Source: SOER 2001 based on CDR/Tecsult-Kredo (2001)

The character and amount of solids will depend on the quality of inflowing wastewater. Sludge quality will also depend on the number and type of industries discharging into the public sewer, the degree of pre-treatment, and the primary and secondary treatment process deployed in the STP. In anticipation of this waste product (byproduct), the MEW has prepared draft guidelines and Best Management Practices for sewage sludge reuse in agriculture with the assistance of the FAO.[71] These guidelines describe sludge treatment methods (advanced and conventional) and optimal conditions for sludge drying. Four sludge classes are suggested with corresponding uses (Table 35).

[71] *Idem*

Table 35. Sludge use based on sludge classification

Class and Restriction Level	*Usage*						
	Public activities sites	*Parks and green areas*	*Agriculture**	*Forest*	*Reclama-tion land*	*Landfills*	*Surface soils***
A – Unrestricted use	●	●	●	●	●	●	●
B – Restricted (I)			●	●	●	●	●
C – Restricted (II)				●	●	●	●
D – Not suitable for use						●	●

Notes: *not applicable to vegetables eaten raw, **located within the STP premises

The guidelines stipulate maximum allowed concentrations for heavy metals in agricultural and non-agricultural soils, as well as Nitrogen limited sludge application rate. Non-compliant sludge that exceeds maximum allowable heavy metal concentration and/or pathogens must be placed in a sanitary landfill.

5.12 Construction and Excavation Waste

Dams, hill lakes, conveyance structures, irrigation canals, and wastewater networks and treatment plants involve a lot of earth moving and will, in the process, generate significant volumes of construction waste and aggregates. Lebanon does not have a national policy or guidelines for the handling and disposal of excavation waste and unutilized material. Decree 8735/1974 bans the disposal of bulky waste and construction and demolition waste along roads, in public areas, water streams, the public maritime domain, and in residential areas. **The decree does recommend the disposal of construction and demolition waste in construction sites or in natural depressions**.

In practice however, there is very little control on the fate of excavation and construction waste. These wastes often end up on roadsides and down ravines, producing trails of rubble and lasting eyesores. Illegal dumping usually happens at night, but also in broad daylight. For example, the war in July 2006 generated 3.72 - 5.75 million m^3 of rubble which prompted makeshift disposal sites along the coastline and inland. The same phenomenon was observed in connection with the fighting in the Nahr-El-Bared refugee camp in North Lebanon (May 2007) that produced an estimated 0.6 million m^3 of demolition waste.

Water installations generate a different kind of waste stream but at least one experience shows the deleterious effects of poorly executed excavation works and disposal practices. Construction works at the Brissa dam (implemented by the CDR in Dannieh) moved a lot of topsoil and unsuitable material away from the impoundment to a nearby site; works also extracted rock material to build the rockfill embankment, damaging landscapes and landforms (see Photos below). A full EIA and management plan would have recommended using the unwanted material to backfill the quarry from which rocks were used to build the dam; it would also have recommended a full site restoration plan before completion of works and final handover. The Qaroun dam, built in 1959, used better quarrying techniques and the LRA has implemented several site restoration activities to improve landscapes.

The unchecked disposal of excavation waste in future dams would create irreversible damage to mountain landscapes and ecology in Lebanon.

See photos of Brissa Dam overleaf.

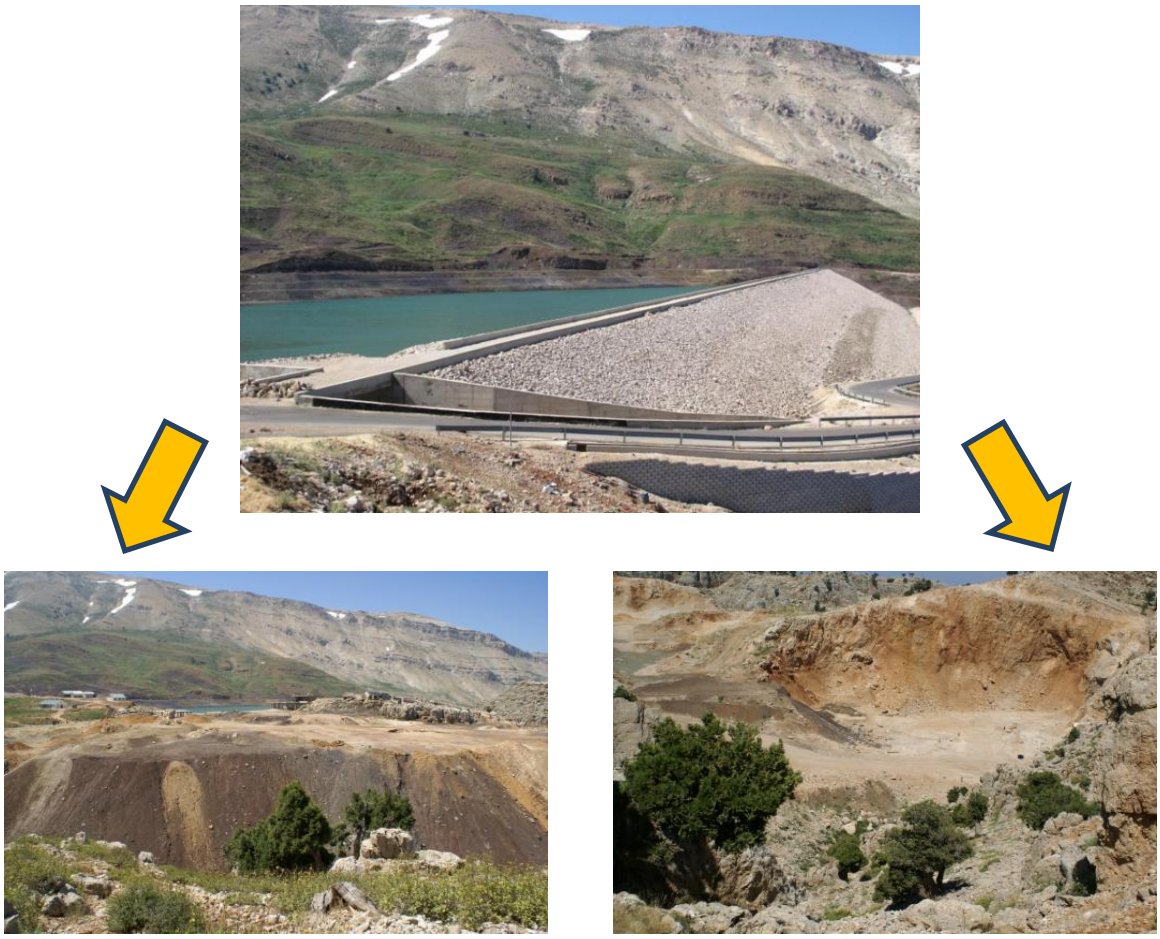
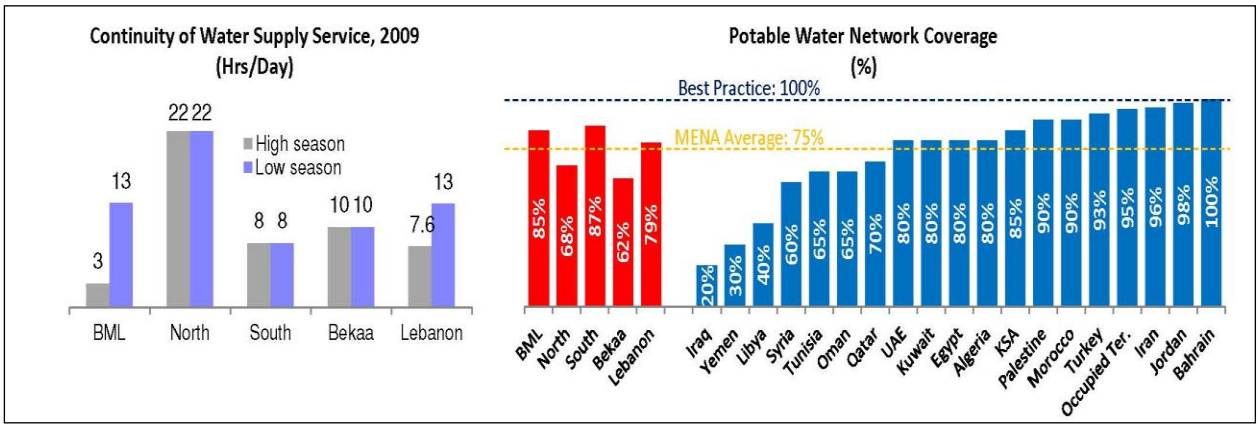


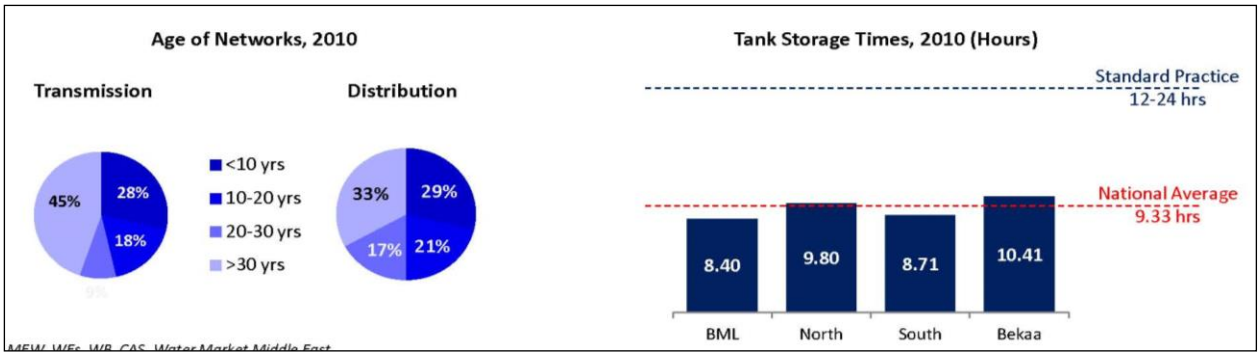
Figure 12. Photos of Brissa Dam in Dannieh and Residual Impacts on Landscapes

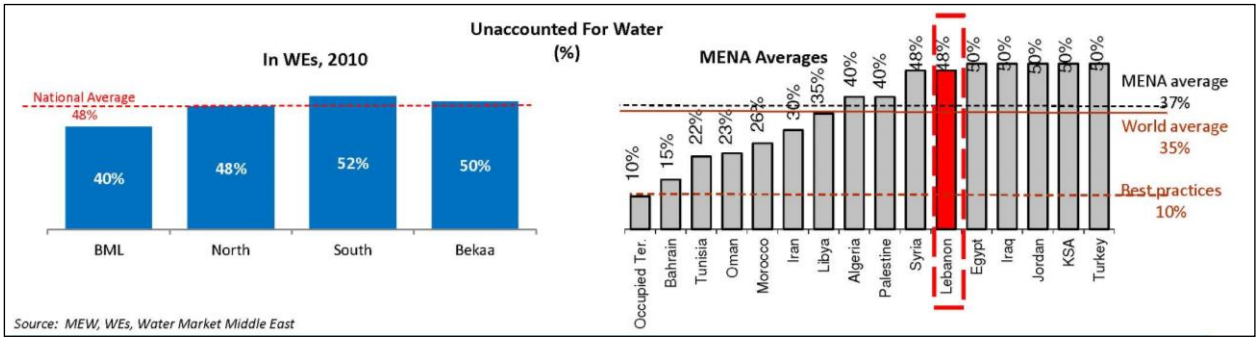
5.13 Operation and Maintenance Performance

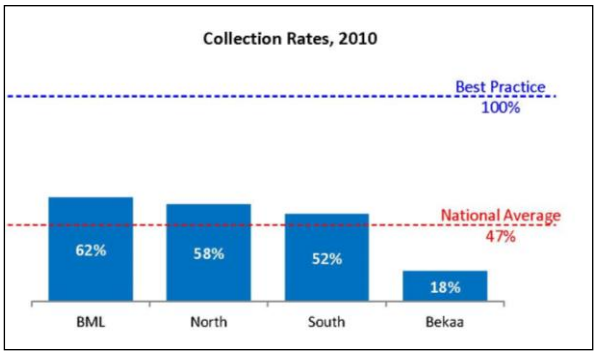
The performance of the WEs is highlighted in the following indicators[72]:



[72] NWSS, 2012







The poor performance is attributable in the main to chronic understaffing, particularly in managerial positions. As was highlighted in the Bekaa Water Establishment case, the WEs have not been able to procure their operational staff. Table 36 summarizes the staffing level and percent vacancies in each WEs. It is noteworthy that staff number is trending downwards for BML but encouragingly upwards for the Bekaa, North, and South WE's. Nationwide, the four WEs have 4,050 designated staff positions but currently have only 1,391 (34% filled). Because WEs are facing difficulties recruiting new staff, they often resort to contract workers / day laborers (known as *ghib el talab*). Contract workers can in theory be more qualified than utility staff and are often brought in for that purpose. A reported drawback is, however, that their procurement is not always in accordance with good practice and unqualified personnel may be appointed through nepotism or favoritism.

Table 36. Staffing Level in Water and Wastewater Establishments

WE	*# Decree*	*Decreed Staff #*	*Filled Positions*		*% Vacant*[/3]
			/1	*/2*	
Beirut and Mt. Lebanon	14915/2005	1120	621	550	51%
Bekaa[/4]	14916/2005	787	241	261	67%
North Lebanon	14913/2005	1271	262	317	75%
South Lebanon[/5]	14914/2005	872	218	263	70%

(1) Data from 2012 NWSS; (2) data updated with the WEs in April 2014; (3) % Vacant is based on 2014 staffing numbers; (4) Bekaa WE has 111 contract workers; (5) South WE has 500 contract workers.

In terms of staff optimization, Lebanon currently has 1.93 WE staff per 1000 connections (NWSS 2010). Assuming the WEs were able to fill all 4,050 designated positions, then the ratio would increase to about 5.79 staff per 1000 connections. The best practice average is 2.5 - 3.0 staff per 1000 connections, which is indicative only and an average of top 15 operators in the world. Applying the best practice average to Lebanon would yield 2,086 WE staff, which is about half the number of designated positions. International comparisons however may not be reliable considering Lebanon's unique geopolitical, hydrogeological situation, and demographics. Additionally, current understaffing may be preventing the detection of operational and managerial inefficiencies (see more analysis on optimum staff levels in Box 10).

Box 10 Water Utility Staffing Levels

Water utility staffing levels, expressed as a number per property served are influenced by many factors, including the size and characteristics of the area to be supplied, the level of service provided to the consumer, staff salaries, work culture, organizational structure and the extent of control and optimization. Typical staffing levels for water utilities in the United Kingdom range between 0.7 and 1.6 employees per thousand connections. These levels represent the situation where the majority of the capital program is outsourced to external designers and contractors but all other functions remain in-house. International staffing levels range between 1.5 and about 3.0 employees per thousand connections for utilities with similar characteristics to UK companies. International utilities that utilize less sophisticated technology, deliver a lower level of service or intermittent supplies, or where labor costs are low, tend to operate with higher staffing levels, typically between 2 and 20 employees per thousand connections.

Source: Adapted from Twort's Water Supply, 6th Edition, 2009 [Chapter 2.13 Organisation of a Water Utility]

Compounding the problems highlighted above, the WEs are financially constrained. The Government has been funding the gap in their balance sheets, although considering the state of the Government budget, this is not sustainable. Coupled to this, the tariff structure being applied by the WEs also limits their ability to raise the funds required to address their problems[73]. Critically, The World Bank has found that spending on operation and maintenance has been well below what was required to ensure efficient operation of networks that have come into operation the last 15 years (World Bank, ERP, 2009a). To further highlight the current inability of the WEs to operate and manage the infrastructure they are tasked with, Box 11 briefly describes the findings of the World Bank after the completion of the Baalbeck Water and Wastewater Project. These findings partially explain why during SEA consultations, the WEs expressed a lot of hesitation taking-on O&M responsibilities.

5.13.1 NWSS Institutional Remedies

The Ministry of Energy and Water through the NWSS, advocates the following initiatives[74]:

Institutional and Organizational

- Support a full implementation of the water sector reform and improve on the management model between WEs and MEW
- Improve on capital spending responsibilities, inter-agency coordination and spending efficiency
- Improve the management of the irrigation sector

In relation to the WEs, the actions proposed under this initiative can be summarized as follows:

[73] NWSS, p18. Readers are referred to NWSS for detailed exposé of state of water sector.
[74] NWSS, 2012

i. Complete the WE restructuring process initiated under Law 221
ii. Work towards granting the WEs administrative and financial autonomy vis-a-vis MEW
iii. Introduce performance based management into the WE's
iv. Improve the WEs management by introduction of modern IT systems for billing, accounting, maintenance management systems, supply chain and procurement management, human resource management.
v. MEW monitor and audit the WEs against key performance indicators, benchmarks, etc
vi. Expand and enhance the manpower base of the WEs through recruitment drives and greater training
vii. Introduce stakeholder participation by allowing water user associations to interface with WE's
viii. Introduce demand management and cost recovery in the operation of irrigation schemes.

As with these actions, and all other actions under all the initiative, unless the Government of the day provides the necessary budgets, and reform drive, for their implementation, no action will take place:

- Law 221 was enacted in 2001, and yet its implementation is partially complete
- Recruiting the appropriate technical and financial staff will be paramount as both the case of the Management Contract in Tripoli Water Authority[75] and the Service Contract in Bekaa Water Establishment, unless this staff is in place, improvements in performance will be short lived.
- The Government has been investing, with the aid of the multinational donors, in many technical capacity building programs in the MEW and WE with little effect.

It is acknowledged in the NWSS, as will be shown below, that despite the sector initiatives and actions, the WEs will not be able to efficiently and effectively operate and manage the STPs and dams coming into operation.

Financial and Commercial

- Introduce and implement new tariff strategies
- Promote private sector participation in O&M and capital projects
- Gradually achieve O&M cost recovery and then full cost recovery.

The actions proposed under this initiative are:

i. The introduction of the user-pays system based on meter usage. This will entail the installation of meters in all the WE's, and charging customers on usage. This tariff will replace the existing fixed tariff. This will only be introduced after tangible improvement of delivery of services, and will cover O&M costs
ii. Introduction of an irrigation tariff also based on metering and usage. Will cover O&M costs
iii. Introduction of sewage tariff, to ultimately cover O&M costs
iv. Introduce private sector participation in the form of management contracts, for the downstream part of the sector. This is advocated due to poor performance at the moment and levels of tariffs
v. Introduction of full Public Private Participation (PPP) for upstream activities like dams and STP's

[75] Management Contract, Tripoli Water Authority, **SOER**, 2010.

vi. Establish the statutory and institutional framework to allow effective PSP while protecting the Lebanese people and environment

Just to reiterate, MEW proposes to assign the management and operation of the dams and STP's to PPP arrangements for several reasons, namely:

i. the WEs are not equipped, and will not be in the future, to operate and manage these assets
ii. PPP will provide greater benefit due to the expertise and efficiency of private operators
iii. PPP arrangements in relation to the dams, are more in tune with MEW's responsibility for water resources planning and management.

It is not clear from the NWSS, whether MEW or CDR or some special purpose vehicle will be established to manage the PPP procurement process, and then provide regulatory oversight for the private operators. With regards to the STP's, as a stop gap measure, O&M provisions are being inserted into the STP construction contracts. This is pending the establishment of institutional setup for PPP contracts. It should be noted that the STP's now commissioned in Lebanon are run by the private sector (e.g. Baalbeck, Tripoli, Ghadir). In a policy vacuum, or in the case of continued policy fuzziness, these contracts can be extended infinitum.

Dams are more than projects, but schemes involving hydro-electric plants, water treatment plants, sophisticated operational requirements, EAP's, and extensive interfacing with water distribution utilities. They are by their very nature and size amenable to PPP arrangements. But that is not the only model that has proved successful around the world. Many of the world's dams are operated under specialized authorities or catchment authorities. Indeed, some dams are operated by public water authorities[76].

There is a local model for such authorities. The Litani River Authority is such an authority. It has operated and managed the Litani River Scheme for more than 50 years. And uniquely for a Lebanese public agency, it is recognized as operating efficiently and of being managed well. It has operated the Qaroun Dam, and all the associated irrigation networks and hydroelectric scheme without incident.

It is clear that this policy fuzziness needs to end soon, because, irrespective of the state of the WE's, the operation and management of the STP's and dams needs to be resolved. More importantly, their operation cannot be solely driven on commercial grounds, but equally on environmental grounds. Their operation impacts, more than all the other water sector assets, on the environment. Operated poorly or unsustainably, they become environmentally threatening rather than enhancing.

<u>Legal and Regulatory</u>

- Enhance and modernize the legal setup to support the implementation of the NWSS and future requirements
- Enforce a regulatory regime which would align WEs with leading utilities in the region and worldwide

The actions sanctioned under this initiative are:

[76] Warragamba Dam, one of Sydney's main water sources, was managed and operated by Sydney Water. In 1997, after a pollution incident, the Sydney Catchment Authority was established to take the dam over from Sydney Water

i. Enactment of the Water Code. This has been 10 years in the making. Modeled on the French code, it will define: the water sector actors, establish a National Water Sector where all the actors will be represented, incorporate all the laws and statutes governing the water sector
ii. Setup the legal framework for the entire sector. These will include: WE bylaws, procurement framework, performance incentives, PPP framework.

Environmental Concerns

- Achieve advanced climate change knowledge
- Improve water quality, flood mitigation and protection of recharge zones

The main actions under this initiative are:

i. Improve knowledge of impact of climate change on water data. This speaks to upgrading data such as: precipitation, snowfall and coverage, evapotranspiration, runoff, recharge rates, available water resource.
ii. Strategic Environmental Assessment.

MEW is to be commended on this initiative because the entire planning edifice for the last 30 years, including this NWSS, is based on data dating from the 1970's. All the water indices industry specialists rely on have been regressing over the last 20 years due to climate change.[77]

5.13.2 Recommendations

Water Establishments

The initiatives embodied in the NWSS are favorable in relation to the WEs. It is clear that in their present state they are unable to operate effectively. They are certainly not equipped to take over either the dams or the STPs that are being built. However, they will need to be reformed in line with the NWSS initiatives, to avoid undermining the dams and wastewater programs.

Under the above scenario, the transmission and distribution networks providing potable water to the community, will be owned, operated and managed by the WE's. If the WE are not reformed to enable them to operate these networks properly and recover their costs, including some profit for future investments, the augmented water supply facilitated by the dams program will be dissipated. The environmental costs of unaccounted for water will be inestimable. The success of the dams program, irrespective of how they are operated and managed, will depend on the effectiveness of the WE's.

Clearly, augmenting water storage, without reforming the WEs, will compound the challenges water resources are facing in Lebanon in the face of climate change.

Equally, the collectors conveying raw sewage to the STPs will be owned, operated and managed by the WEs. A number of STPs are completed in Lebanon, but are running under capacity because the collection and conveyance systems are not complete. Yet, when they are complete, if they are not maintained and repaired to ensure proper operation, the STPs will operate sub optimally. In addition, sewage leakage is a direct public health and environmental threat. The WEs are ill equipped at the moment to operate the sewage networks. Their capacity to do so should be built up as a matter of Government priority.

[77] SOER, 2010.

Dams O&M

As was shown in the sections dealing with Dam Safety, as dams are schemes, their operation and management is complex. A model worthy of Government consideration is provided by the LRA. It has over 50 years of experience of operating, including:

- Qaraoun Dam
- Three hydro-electric stations (Awali 108MW, Joun 48MW, and Markaba 36MW)
- Canal 900. A network of open channel. It will irrigate an estimated 18000ha (2000ha in Phase 1). Eutrophication of the canal is very common because water flow is slow. LRA uses copper sulfate to suppress the eutrophication.
- Canal 800. Includes two tunnels totaling 52 km. The irrigation scheme will extend from Qaraoun to Aita Chaab. It will transport 108 MCM of water per year from the Qaraoun Lake to irrigate 15000ha of agricultural lands in south Lebanon (around 50 villages). Under construction.
- Water data and monitoring. LRA monitors river flows all over the territory. The establishment currently operates 66 fixed monitoring stations covering all the rivers in Lebanon (15 mobile stations are operated by LRA and Beirut Airport).
- Dam management. LRA has acquired a wealth of experience in operating and managing impoundments. With technical support from USAID's Litani River Basin Management Project (ending in 2014), the LRA acquired advanced seepage detection equipment (which offsets the needs for deep-sea divers). In terms of emergency management, the LRA recently conducted a Dam Failure Analysis for Qaraoun lake (and prepared a draft Action Plan) which presented several scenarios. In terms of sedimentation, a recent survey revealed that sedimentation has had a very negligible impact on storage capacity (0.3% of the reservoir volume); this is partly due to surrounding topography and the Litani River slope.
- River Cleanup. In 2008, and in coordination with the Ministry of Energy and Water, LRA implemented a river cleanup campaign to remove debris and other obstruction from the riverbed (28 Km from Chtoura to Qaraoun) and along both riverbanks.

Should the Government decide, catchment authorities are not the best vehicle for the dams program, the NWSS approach for PPP is achievable provided the following conditions are met:

i. An independent regulatory authority is established to manage the preparation of the PPP contracts and the procurement of the PPP contractor
ii. The regulatory authority monitors the work of the PPP contractor on the basis water industry benchmarks and ensures they are met
iii. Government provide financial guarantees to ensure the continued operation of the dams in the event of PPP contractors default
iv. All the stakeholders involved be represented in the setting of tariffs
v. Arbitration and dispute resolution mechanisms be based on international rules
vi. Contingency planning and procedures are in place to ensure dams operations do not disrupt supply of water to dependent communities.

STP O&M

The experience of CDR with regards to the O&M contracts for STP's has been good. Furthermore, although the World Bank deemed the Baalbeck Water and Wastewater Project as unsatisfactory, it did assess the service contract as a success (see Box 9).

It should be noted that these contracts are not performance based contracts. Payment to the contractor is guaranteed by the Government. In that sense, the contractor has certainty. The Government could continue with these contracts, while introducing incentive and performance requirements. It is recommended that if the Government decides to continue with these projects, the WEs capacity to procure and manage such contracts be enhanced.

Certainly the PPP model proposed for the dams program could be applied to the STP's, with the same conditions.

5.14 TRANSBOUNDARY WATERS

Lebanon has three transboundary rivers:

(1) Nahr el Kabir (north Lebanon)
(2) Assi River (Bekaa)
(3) Hasbani/Wazani River (south)

Two of those rivers (Kabir and Assi) will be dammed. The corresponding design and storage capacity respect Lebanon's bilateral agreements with Syria. The third river system (Hasbani/Wazani) in south Lebanon which drains into the Tiberias Lake will be affected by the proposed Ibs es Saqi dam. The Government will proceed with its construction when the security situation in the south permits.

Strategically, investment projects must be declared on all trans-boundary waters to reserve / secure Lebanon's water rights.

Box 11. Baalbeck Water and Wastewater Project

In July 2003 the World Bank funded this project. The loan was provided through CDR, and the beneficiary was the Bekaa Regional Water Establishment. The objectives of the project were

1) develop and strengthen the institutional capacity of the Bekaa Regional Water Establishment
2) Improve access of customers to satisfactory to water and wastewater services
3) involve the private sector in the operations and maintenance of water and wastewater services
4) rationalize the use of water through the use of water meters

When the World Bank appraised the project on its completions, it made the following findings:

1) Objective One: Unsatisfactory
2) Objective Two: Unsatisfactory
3) Objective Three: Moderately satisfactory
4) Objective Four: Unsatisfactory

The project components and their rating at completion of the project were:

1) Institutional Development: Unsatisfactory
2) Increasing the coverage of water supply services: Unsatisfactory
3) Increasing coverage of wastewater collection and treatment: Moderately satisfactory
4) Service contract: Moderately satisfactory
5) Consulting Services (construction supervision): Satisfactory

Some indicators illustrate the lack of improvement, collection rates, meter coverage and growth in subscriptions:

	At Appraisal	As of December 31, 2011
Collection Rate	35%	32%
Installation of Water Meters*	4,000	13,873
*In the absence of tariff reform, consumers cannot be billed based on consumption despite having a meter installed.		

Project Localities	Current Population	Household Units Census*	Meters Boxes Installed	Subscriptions 12/12/2007	Subscriptions 12/12/2009	Subscriptions 12/12/2010	Subscriptions 12/12/2011
Baalbeck AimChiki/ Ain Borday	86,087	17,218	13,304	4854	4909	5182	5728
Surrounding Baalbeck	37,610	7,522	8323	1,393	1,401	1,537	1,539
Nabi Chit	14,373	2,874	4037	1812	2,197	2,351	2,526
Total Project Area	138,070	27,614	25,664	8059	8507	9070	9,793
***Residential and Commercial**							

The World Bank post completion appraisal attributed the relative failure of the project to:

- Failure of the MEW and Government to appoint a Director for the WE and technical and financial staff. For 5 years, the Technical Support Unit appointed under the loan to help the WE did not have counterparts to train and support in the execution of works.
- This also applied to the service contractor. Increase in subscriptions, collection of tariffs and installation of meters required WE staff to be with the service contractor staff to interface with the community.

The failure was mainly institutional. It should be noted, the service contract is still running, as it has been extended with a different contractor.

Source: World Bank, Implementation and Completion and Results Report, Baalbeck Water and Wastewater Project, 2012.

6. ANALYSIS OF ALTERNATIVES TO THE PROPOSED STRATEGIC ACTION

As stated earlier, the NWSS is under implementation and many interventions were planned decades ago. An SEA must review and assess proposed alternatives that have been identified and studied by MEW to provide sufficient information for proper assessment. In the absence of formal *alternatives* to the NWSS, this chapter focuses instead on highlighting potential alternatives that may not have been adequately researched or assessed, in addition to the no-action alternative.

6.1 ANALYSIS OF THE NO-ACTION ALTERNATIVE

Normally, an SEA would explore and evaluate the No-Action Alternative.

In this case, the NWSS is well underway and some of its momentum cannot be reversed. For example, the sewage program is ongoing and cannot be reversed considering the vast resources already invested in the sector since the 1990s including expropriations, and design and construction contracts. **Dealing with O&M as well as environmental issues remains an urgent priority**. Here, the Private Sector Participation option becomes almost the only option.

There is a conceivable No Action Alternative on the dams program, which would entail halting the commissioning of further dams (see list of dams under construction in Table 4). But Lebanon is facing a water shortage. It could perhaps be addressed in the short term with effective demand management and effective institutions. This would require strong political will, something that is historically lacking in a political environment that is beset by many intractable issues. But it is clear from the analysis presented in the NWSS that without effective action to increase supply, that even under conservative demand scenarios, Lebanon would be in danger of facing severe water shortages in the near future, particularly if rainfall is low.

Therefore, a realistic No-Action Alternative would entail completing the ongoing initiatives that are already in advanced planning and the construction that is already underway, but holding off on new investment. The scenario would then look like this:

1. ***Completion of all coastal and inland STPs by 2020-2025***. The extent and effectiveness of O&M responsibilities and activities remain uncertain so long as the RWE are constrained by finances and human resources. TSE and sewage sludge production increases gradually but reuse in agriculture and other sectors remains unregulated and/or poorly monitored.
2. ***Completion of at least nine dams and hill-lakes by 2020*** in Balaa, Bisri, Boqaata, Brissa, El Manzoul, Janneh, Kouachra, Mseilha and Qaysamani (listed in Section 3.3). Emergency Action Plans are missing for some, and there may be rising public opposition towards the more controversial dams, partly due to a lack of public engagement in the EIA process and/or the absence of approved EMPs.
3. ***Improved groundwater quality in response to reduced abstraction.*** Illegal abstraction (for irrigation and industry) and related salinity buildup will begin to level off in response to additional water supply from NWSS's surface storage program, provided that significant progress in UfW reduction is achieved.
4. ***Delayed and inefficient response to Syrian refugee influx***. Already facing acute pre-crisis challenges of balancing supply augmentation with demand management, the Lebanese WSS

sector must now meet an additional estimated water demand of 26 million m^3 per year.[78] This additional demand is particularly difficult to satisfy during a dry year. The government's hitherto hands-off approach to the Syrian refugee crisis raises serious concerns regarding water and sanitation services. Whereas informal camps are poorly serviced, host communities can offer better WSS to refugees but not without a concomitant decline in WSS services to local residents (see Box 12).

5. ***Delayed and/or ad-hoc response to current and future drought conditions.*** In the absence of drought management plans, Lebanon is unable to mount a coordinated response to low rainfall years. All the discussions held by the SEA team with water stakeholders confirm the absence of a coordinated response. The MEW and the utilities are being challenged to come up with short-term solutions to satisfy the water deficit including more abstraction from new deep wells and water imports by sea from neighboring water-rich countries.

Box 12. Impact of Syrian Crisis on the Water Supply and Sanitation Sector

When the NWSS was prepared in 2010, the Arab Spring had not started yet. When the NWSS was endorsed by the COM in 2012, the conflict in neighboring Syria was still contained and the number of refugees was limited. Since then, those numbers have swelled to an estimated 1.4 million refugees broken down as follows:

- 1,087,413 registered refugees
- 57,401 awaiting registration (UNHCR, May 2014),
- 230,000 unregistered Syrians,
- 52,335 Palestinian Refugees from Syria, and
- 33,569 Lebanese returnees.

This represents 30-35% of Lebanon's resident population. In terms of distribution, the largest concentration of refugees is based in the Bekaa (about 33%), followed by North Lebanon, Mount Lebanon, the South, and Beirut (only 3%). In terms of water and sanitation needs, the incremental increase in domestic water demand for refugees is estimated between 33 and 52 MCM (based on May 31, 2014 estimates) and it is expected to reach 43 to 70 MCM by the end of 2014. This corresponds to an increase between 8 and 12 percent of the national water demand. The NWSS supply and demand forecasts could not foresee this event.

UNHCR and the World Bank have estimated that between $340-375 million will be needed over the period 2012-14 for stabilization interventions required to reinstate pre-crisis levels of WSS services to host and refugee communities:

(1) humanitarian relief interventions such as distribution of bottled and tanked water, chlorination kits and storage tanks to the most vulnerable populations;

(2) additional capital and operation and maintenance costs associated with the restoration of access to water supply and sanitation including short-term infrastructure/equipment and restoration of services in schools and urgent sanitation interventions; and

(3) medium-term planning activities for the acceleration of infrastructure investments and institutional reforms such as storage and transfer infrastructure, distribution network rehabilitation and replacement, water and wastewater treatment and irrigation expansion and improvement.

Source: MOE/EU/UNDP 2014, UNHCR 2014, and WB 2013

[78] WB, 2013

6.2 OTHER OPTIONS AND COMPLEMENTARY MEASURES FOR ACHIEVING STRATEGIC GOALS

Strategically, it is important to assess and accelerate the water reform process, eventually by facilitating Private Sector Participation, to augment water resources, and to reduce losses *concomitantly*. The following paragraphs present some complementary actions that could support the NWSS in achieving its strategic goals.

6.2.1 Blue Gold

Blue Gold is the brainchild of Civic Influence Hub (CIH), a Lebanese non-political NGO established in 2012 to (1) promote federative economy, (2) promote state/citizen partnership, and (3) create true civic public opinion. CIH selected water as their first socio-economic project because "*water is the most strategic commodity for the future, has been incompetently managed for a long time, and offers many value facets to the Lebanese population."* Supported by a growing number of "councillors", prominent figures from Lebanon's business community, CIH launched a water program dubbed "Blue Gold" which went viral in the media in 2013. Blue Gold is a 5-year plan that challenges the GOL's National Water Sector Strategy on several levels. Specifically, Blue Gold aims to:

(1) Transform water from a commodity into wealth and raise awareness
(2) Enhance the government plan so that sustainable approaches to water sector management are adopted
(3) Create the proper platform for the private sector and entire Lebanese population to participate in the development of the water sector
(4) Federate the Lebanese population around common interests.

The Plan lays out 40 initiatives over the 2030 horizon including 15 short-term initiatives by 2020:

Increase Water Supply (13 initiatives):	1. Increase surface storage and interconnectivity between basins
	2. Rehabilitate irrigation and domestic networks
	3. Optimize river flows through canalization
	4. Increase forestation for groundwater recharge
	5. Artificial recharge of underground aquifers
	6. Capture water from sea springs
	7. Harvest rainwater from rooftops
	8. Treat and reuse grey water
Optimize Water Demand (7 initiatives):	9. Implement drip irrigation schemes
	10. Promote high-value crops
	11. Install household efficient appliances
Improve Water Quality (6 initiatives):	12. Develop wastewater treatment solutions and expand sewage networks
Improve Water Management (14 initiatives):	13. Create monitoring and information center on water
	14. Establish a national training center on water
	15. Setup legal administration

The NWSS and Blue Gold have many commonalities. Blue Gold however distances itself from the NWSS on a number of counts. For example, on surface water storage, Blue Gold recognizes the need for storage dams but proposes 14 dams compared to NWSS's 18. However, its views depart from the NWSS in terms of the size and the location of several dams. In particular, Blue Gold believes that the proposed Jannah Dam is a high risk dam that will require prohibitively expensive engineering works. And because Nahr Ibrahim is a dynamic river (different from Chabrouh), the potential for replenishing the reservoir is very high. Therefore, Blue Gold proposes to build a series of small cascading dams rather than one large dam. Equally important, Blue Gold places a premium on

private sector participation (yet it does not provide a conclusive model for PSP), and transparency to create an enabling environment for the state and citizens to work together for a better water sector.

Blue Gold, like NWSS presents many cost estimates but the basis for these estimates remains unclear. But although the numbers remain speculative, it is important to recognize the contribution of Blue Gold to Lebanon's national water discourse. Blue Gold is currently running a media campaign to solicit "votes" and "likes" by SMS, on its Facebook page, and its website (60,000 votes and likes as of April 2014). Clearly, the water discourse is important for Lebanon's water sector.

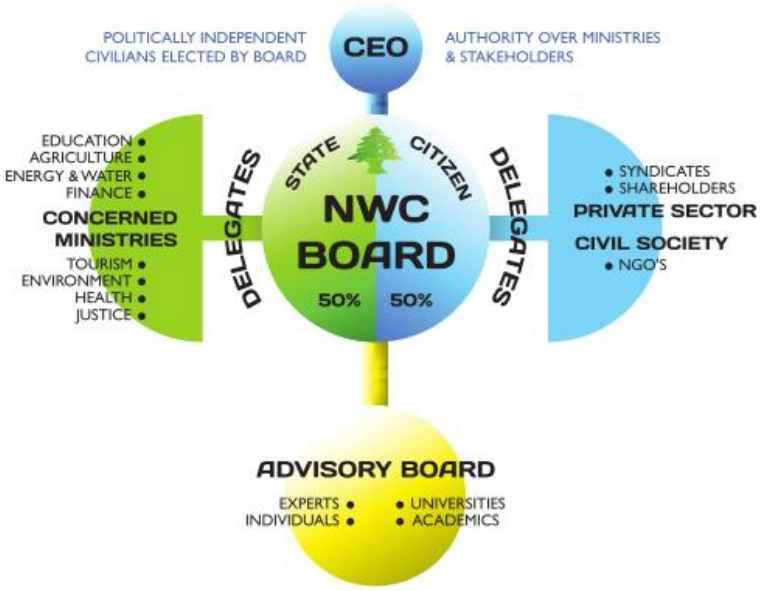
6.2.2 Water Reform

The National Water Council (NWC) of Lebanon was proposed many years ago, as an umbrella organization that would oversee all water planning and implementation programs. The proposed entity is reportedly also mentioned in the draft Water Code (which is still under review the Council of Ministers). The team therefore relied on Blue Gold to assess the proposed structure and purpose of the NWC. Blue Gold depicts the NWC as a supervisory authority that is expected to:

(1) Prioritize the general objectives in the water sector
(2) Approve the general master plan
(3) Agree on all national and regional projects related to organizing and distributing water
(4) Follow-up on the implementation of related conventions and protocols
(5) Coordinate between different ministries.

Also according to Blue Gold, the NWC delegates would be 50% state (ministries) and 50% citizen (private sector and civil society). The council would have a politically independent CEO elected by an advisory board that includes experts, individuals, universities, and academics. The proposed NWC would interact with other organizations including (see diagram):

(1) Water Regulatory Authority (analogy, the nascent Lebanese Petroleum Authority)
(2) Water Users Association
(3) Watchdog organizations



Source: Blue Gold (CIH)

6.2.3 Private Sector Participation

Private Sector Participation and Public-Private-Partnership have been treated and discussed in Lebanon since 1992. Former PM Hariri, a champion of PSP at the height of his powers during the 1990s wasn't able to advance it much more than the Ondeo management contract in Tripoli with the North WE and the service contract in Baalbeck with the Bekaa WE. The Ondeo management contract was not continued; the utility managers accepted the labor and expertise, but purely in a client contractor relationship. Clearly, the NWSS (and the Blue Gold) advocate PSP as a mechanism for increased transparency and efficiency but the modalities for real PSP remain elusive.

Politically speaking, there is only appetite for O&M (service) contracts on a case by case basis, and perhaps for Sewage Treatment Plants as stand-alone installations. Although there is wide recognition that RWEs performance is substandard, and that further improving their capabilities will only generate limited gains, the basic question that needs addressing is the cost. Will PSP ensure affordability of the service?

The most important reasons to include the private sector in public services provisions, the so-called 'drivers' for PSP, can be summarized as follows:

- Increased access to (private) capital investments, and effective use of capital;
- Increased technical and managerial capabilities in the water sector;
- Increased operating efficiency;
- Increased customer focus;
- Reduced need for, but, more transparent subsidies.

We have summarized in ***Annex 11.4*** different types of PSP including service contracts, management contracts, lease contracts, BOT type contracts, concession, and divestiture/full privatization.

Determine clear PSP / PPP policy

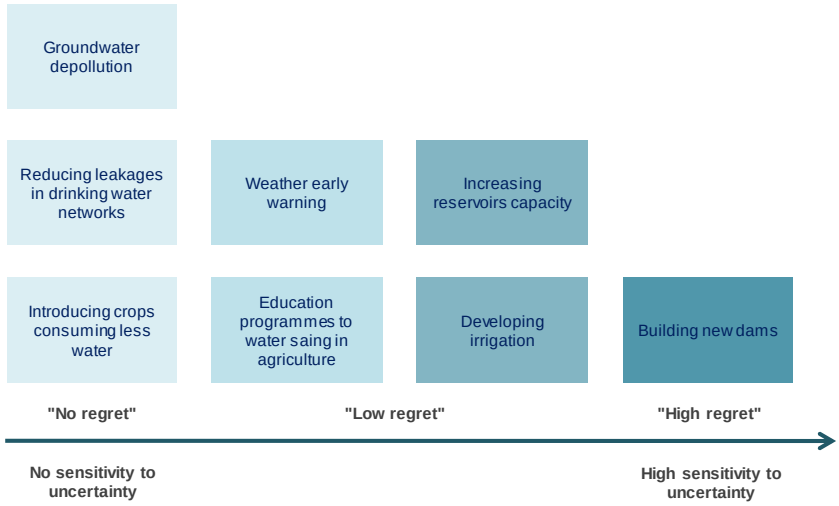
A very first step towards PSP is the development of a policy framework. This policy should be a clear statement regarding a government's commitment to implementing a PPP policy in a professional and sustainable manner. The policy should demonstrate a "partnering friendly" culture, and provide a systematic approach to conducting PPP for different market segments or services. It should complement existing policies with regard to planning, procurement and other areas, and ensure that the PSP / PPP contracting and execution process is fair, transparent and in the public interest.
The goals of a PSP policy are the following:

- Define PPP / PSP as seen by the host country, and identifies potential partners;
- Ensure that PSP is explored as an option for service delivery or attracting investments;
- Ensure PSP is used only if and when appropriate;
- Communicate the approach to PSP to all stakeholders and potential stakeholders;
- Define codes of conduct;
- Indicate the various possibilities of tendering, ranging from unsolicited bids to international competitive bidding;
- Identify risk, concerns, and responses to these risks and concerns.

6.2.4 Resource Augmentation

On the supply side, the NWSS has considered the most readily available options including optimizing surface water storage (spring capture), artificial recharge of groundwater aquifer, and storage dams and hill-lakes. The effectiveness of storage dams is highly sensitive to uncertainty. For example, how will one dry year affect actual storage? How will a prolonged drought affect storage? More generally, how will climate change affect the capacity of dams? Uncertainty also relates to hydrogeological conditions. Lebanon's intricate geology and hydrogeology increases the risks related to permeability and water "losses" by seepage. Some of this uncertainty is addressed in the design and location of the dam, but some risk is inevitable and dams are typically regarded as "high-regrets" measures on the sensitivity-to-uncertainty scale (see Figure 13).

Figure 13. Impact of uncertainty on the effectiveness of management and adaptation measures



Source: Plan Bleu, 2011

Stated differently, and in anticipation of rising uncertainty due to climate change, it becomes important that the NWSS remains flexible and adaptive to accommodate future and sometimes urgent revisions. Plan Bleu's 2011 "Climate Change Adaption in the Water Sector in the Mediterranean Region" presents the following recommendation:

> **"Giving priority to flexible, reversible strategies and measures in order to minimize the risk and cost of maladapation. This could, for example, imply investing in infrastructure with a shorter lifespan (construction of several low cost hillside dams rather than one very large structure) or factoring greater security margins into their design."**

The other conceivable options to increase water supply include submarine freshwater springs, and desalination. The current drought has accelerated the discourse on the submarine springs including technical feasibility, cost, and potential water availability.

<u>Submarine springs</u>

Lebanon also has a number of freshwater submarine springs. In the Chekka region (North Lebanon), researchers have identified six permanent and six seasonal freshwater submarine springs. The Karstic features of the Chekka region facilitate the occurrence of submarine springs. Water from

some permanent springs was assessed quantitatively and qualitatively. An average yield of about 450 l/s was recorded from the largest permanent spring. Electrical conductivity, as well as the concentrations of chlorides, sulfates, and magnesium was found to be relatively high as compared to values normally found in fresh water. Although previous analysis indicated that capturing freshwater submarine springs was at the time technically and financially not feasible, onshore exploitation of submarine springs through inland wells of differing depths was found to be economically feasible for several tested scenarios (different flows and depths). The accelerated discourse on capturing freshwater submarine springs to reduce the water deficit appears to be gaining traction (see Box 13). **The NWSS should prioritize R&D work related to identifying and capturing submarine springs in accessible waters and update the supply forecasts accordingly.**

Box 13 Exploring the viability of capturing submarine freshwater springs

The proximity of the western mountain range to the sea is conducive to the formation of submarine freshwater springs. Such springs have been reported by scientists (CNRS) and divers alike for quite some time. These springs enjoy so much pressure that the water usually rises to the surface before mixing with seawater (lower density). This phenomenon however is influenced by anthropogenic activities on land, as well as climate. To achieve commercial viability, the MEW would need to assess the following parameters:

a) Location of the most important freshwater submarine springs (Tripoli, Chekka, Tyre)
b) Flow rates and seasonal fluctuations
c) Quality including minerals and potential pollution from inland sources
d) Cost of capture and transport through large floating bags or conduits

The Lebanese pressure group CIH and the Lebanese Syndicate of Divers have contributed to the scientific discourse and offered to assist the MEW in exploring these sources further, eventually with the participation of the Lebanese Army. The MEW has asked the Council of Ministers to commission the National Council for Scientific Research to conduct detailed studies. In conclusion, the potential capture of submarine freshwater springs will require more studies and time.

Source: L'eau douce en mer: providentielle pour les uns, incertains pour les autres (L'Orient Le Jour, 9/12/2014)

Desalination

Lebanon may find it an aberration to consider desalination to increase water supply because the country is blessed with mountains, snow, and a rainfall. At first glance, it does not make economic nor environmental sense to desalinate seawater and then pump the water to supply communities at higher altitudes. There is ample literature to show that desalination is an option of last resort:

- Desalination is still relatively expensive,
- Desalination plants require a large amount of energy, depending on the technology used and the availability of waste heat from power stations,
- Desalination plants would present formidable O&M challenges to the MEW and the RWE's,
- Desalination plants have their own environmental issues.

The best currently available technology for large scale desalination plants, which is Reverse Osmosis of seawater, can produce water at $0.75/m3 at the plant gate (long-run average cost, including capital and O&M). This could easily reach $1.5/m3, if not more, excluding delivery. How does this compare with water from dams and reservoirs in Lebanon? Based on the cost estimates provided in the NWSS, the long-run average cost for water supplied from dams and reservoirs would be in the order of $0.50/m3, and could reach $0.66/m3. In Table 26, we estimated that, through 2030 alone,

sea water desalination would probably cost Lebanon an additional $1.2 to $5.5 billion more than the proposed dams and reservoirs for the same amount of water.

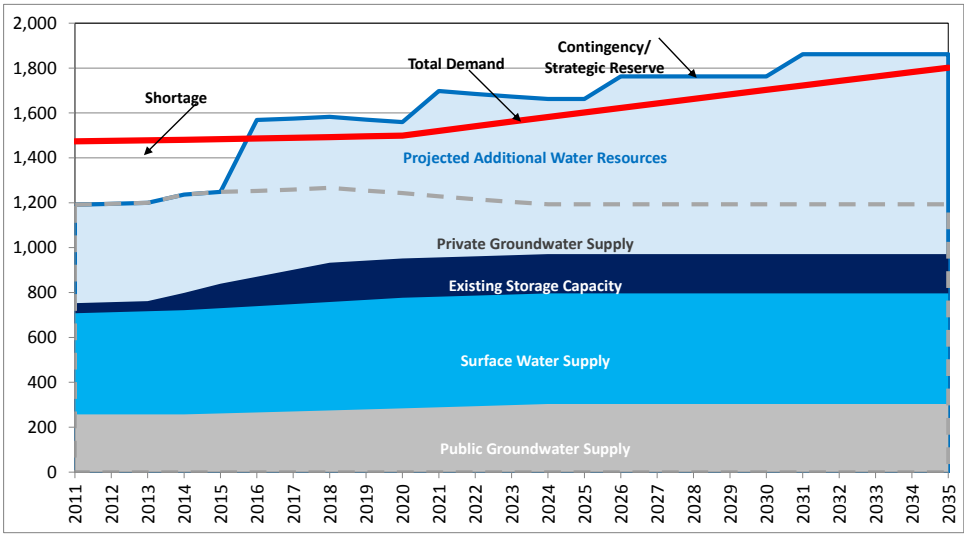
In conclusion, as long as natural water is available from sustainable sources, seawater desalination will remain unattractive in the foreseeable future.

Annex 11.4 describes three desalination technologies that are economically proven methods for separating fresh water from saline water on a large scale: Multi-stage flash, multiple-effect distillation, and reverse osmosis.

6.3 Priority Actions and Emergency Solutions for Deficit Reductions

The NWSS demand and supply forecasts for the period 2010-2020 shows a significant water deficit of about 283 MCM until 2015-2016, after which the projected additional water resources (from artificial recharge, treated wastewater reuse, and surface storage) will begin to materialize (see water supply and demand planning in Lebanon for moderate dry year in Figure 14).

Figure 14. Supply & Demand Planning in Lebanon for a Moderate Dry Year (2011 – 2035)



The following observations and conclusions can be derived from the demand and supply forecasts:

(1) The NWSS correctly anticipated deficits

(2) It did not foresee the scale or severity of the water deficit – partly due to unforeseeable factors (Syrian refugees) and the extreme variability/climate change

(3) Its projections and the bits of the strategy that rely on them need updating

(4) It does not have emergency contingency provisions within it except when all production initiatives have been implemented

(5) It will not/cannot be used to address the current emergency (2014 and beyond, depending on the duration of the Syrian conflict and seasonal variability).

Therefore, to address these limitations, this SEA concludes that:

a) The NWSS is deficient in terms of planning for emergency responses; the current water deficit is likely to extend for a number of years;

b) Urgent solutions need to be developed outside the framework of the NWSS, yet in harmony with Lebanon's policy framework and regulations, as well as the pending Water Code;

c) The NWSS needs to be updated in the light of such urgent solutions, and the NWSS strategic roadmap should be periodically updated by the MEW; and

d) The update, if significant enough such as the identification of new sources and capture methods and/or inter-basin transfer, may need a supplementary SEA (or EIA).

7. SELECTION OF THE «MOST SUITABLE STRATEGIC OPTION »

The requirement to select the most suitable strategic action in the SEA report is based on the assumption that the SEA study takes place in the ideal situation, i.e. where a number of alternative strategic plans are being considered before implementation has started. In such a case, the strategic alternatives would have been defined, at least in outline and the key factors affecting their feasibility and operational characteristics would have been developed to an extent sufficient to determine their broad environmental and social effects.

In the case of NWSS, implementation has already begun and no complete alternatives for achieving the same strategic objectives have been systematically set out in the strategy itself or in the documentation supporting the strategy. It is clear from interviews with staff and independent experts that some alternatives to individual components of the strategy were considered but were rejected – usually on the grounds of cost, as it became clear that preferable solutions, i.e. those presented in the NWSS itself, were available. It is also the case that the NWSS remains flexible, in that it allows for adjustment of the elements and targets of the strategy as time progresses and more information comes available.

The above notwithstanding, it is possible to draw some useful conclusions about the environmental and social suitability of the NWSS against the No Action Scenario and some of the partial alternatives that have been discussed or adopted by others in Lebanon or elsewhere in the region. Namely:

- The NWSS provides a coherent strategy in an area where action is vital. This is because of the future potential for severe water shortages and pollution of water courses coupled with potential economic disruption associated with small farmers who are reliant on irrigation water. The No-Action alternative is risky to human health and well-being as well as to economic growth and even the future social and political stability of the nation and there are no tested affordable alternatives that can meet future water demand.
- There are several potentially significant negative environmental and social impacts that may be associated with implementation of the NWSS (land take, ecological effects, risk associated with larger storage dams) but all of these can either be satisfactorily addressed through well-designed management measures and/or, the impact would not be significantly lessened by adoption of an available alternative.
- Where alternative approaches have been identified that might yield better environmental and social outcomes (for example use of grey water, agricultural reforms), these are not precluded by adoption of the NWSS, which can be adapted and enhanced to accommodate more effective approaches as they become available.

With the above in mind it is reasonable to conclude that **the NWSS is the most suitable strategic option from an environmental and social perspective, and is a necessary strategy which does not have irremediable negative impacts and for which there are no clearly superior available alternatives.** However, we cannot say this, with the same conviction, when we refer to the dams program. As explained in this report, **the dams programs must be reviewed and potentially framed and implemented so as to minimize its cumulative impact on Lebanon's ecology and natural heritage.** Lebanon's dam experience to date (Qaroun and Chabrouh) provides invaluable opportunities for learning, and this learnt knowledge, should be harnessed to benefit the planning, construction, and operation of future dams.

However, the NWSS must remain flexible and can be greatly enhanced by researching and adopting other options and/or complementary measures for achieving the same goals. For these measures to unfold, it is important that MEW continues to moderate an open-minded and transparent discourse on Lebanon's water strategy with all relevant stakeholders. In other words, water planning must not end in 2010 when the NWSS was compiled but, rather, should adapt to the growing uncertainties and emerging opportunities in the water sector. **In fact, the NWSS was endorsed by the Council of Ministers by (only) a *decision* thereby facilitating the process of amending and augmenting the strategy as need arises, by another decision.**

Table 37. NWSS Components and Alternatives

	Methods Proposed			
Strategic Objective	***NWSS***	***No Action***	***Blue Gold***	***Other***
1. Maximizing the potential and improving the quality of surface water resources	Up to 670MCM of static storage (about 18 dams and 23 hill lakes) – at least 9 dams are already under construction / advanced planning	Halt the commissioning of new dams	Reduce the number of dams; reduce the size of certain dams; explore and tap into submarine freshwater springs	Land use management, implementation of buffer zones to protect river courses that will drain into man-made reservoirs
2. Improving the management and protection of groundwater resources	Construction of wastewater networks and treatment plants		Same as NWSS	Land use management and implementation of "buffer" zones to protect fragile watersheds
3. Fulfilling deficits through groundwater and/or surface water	More efficient spring diversion and capture artificial recharge of up to 200 million m^3 by 2020 construction of remaining dams, surface storage up to 650 million m^3 by 2020	Slower approach, less coverage, de facto rationing.	Basically same as NWSS but with the following nuances: · establish interconnectivity between basins · intensive forestation for groundwater recharge · Capture water from submarine freshwater springs · harvest rainwater from rooftops · treat and reuse grey water	More but smaller Dams More aggressive Demand management Desalination
4. Ensuring proper and continuous access to high quality water supply	Reduce extraction from private wells and increase extraction from public wells; upgrade and /or extend water networks	Slower approach, less coverage, de facto rationing	Federative economy with greater PSP in water services	More use of PSP, more effective land use planning to restrict haphazard construction
5. Providing adequate quantities and quality of water for irrigation	Reuse of treated sewage effluent (TSE) Implementation of water-saving irrigation techniques	Business as usual (inefficient irrigation and crops in many parts of the country)	Use of more water-efficient technologies	Agricultural sector promotes different crops, production methods, discourages water-intensive products and phases out subsidy programs or low-value crops
6. Increasing coverage of wastewater collection networks and treatment capacities,	Completion of 12 coastal STPs (to serve 5.6 million people-equivalent) and 42 inland STPs (2 million people-equivalent)	Business as usual (discharge of untreated sewage into the environment)	Same as NWSS but with increased focus on decentralized sewage treatment	Faster and more comprehensive approach More use of PSP Regulate wastewater/sludge collection and disposal in non-sewered communities
7. Optimizing current wastewater treatment processes and sludge disposal.	Secondary treatment of municipal wastewater, sludge incineration		Same as NWSS but with increased focus on decentralized sewage treatment	More use of PSP, reduced reliance on sludge incineration in favour of sludge reuse for land rehabilitation

8. A FRAMEWORK TO OPTIMISE THE ENVIRONMENTAL AND SOCIAL EFFECTS OF THE STRATEGY

This chapter presents a framework to optimize the environmental and social effects of the NWSS. Rather than focusing on activity level mitigation measures, which are best addressed in site-specific Environmental Management Plans, this SEA addresses policy responses required for NWSS implementation. It also outlines climate change adaptation measures and NWSS monitoring requirements and parameters. It concludes with a section describing avenues for making the EIA/EMP process more robust.

8.1 POLICY RESPONSES

This section retraces the effects of the NWSS on key strategic areas (see Chapter 5) and summarizes the most important NWSS or other policy responses. The analysis organizes the proposed policy responses into three stakeholder groups: MEW, MOE, and other. Other agencies with policy responsibilities include the COM, CDR, other ministries (Agriculture), RWE, DGUP, and organizations with specific mandates such as the Higher Relief Council, the Régie, and the NCMS.

See policy responses in Table 41 on page 123.

8.2 ADAPTATION STRATEGIES

The ability to adapt to foreseen and unforeseen changes is paramount to the long-term effectiveness of the NWSS and its ability to *ensure water supply, irrigation and sanitation services over all the Lebanese territory on continuous basis and at optimal service levels, with a commitment to environmental, economic and social sustainability.*[79] Here we present a typology of climate change adaptation measures in the water sector, including "hard" and "soft" responses.

Table 38. Typology of climate change adaptation strategies in the water sector

Type of Strategy	*Examples of Measures*
A- Risk and loss acceptance ("Doing Nothing")	• Disappearance of some coastal aquifers, wetlands or rain-fed farming areas • Flooding or erosion of peri-fluvial areas with limited concerns
B- Risk and loss sharing	• Introduction of insurance schemes and financial pooling instruments against hydro-meteorological risk • Diversification of drinking water supply sources
C- Effect prevention technology and infrastructure ("Hard")	• Increasing dam capacity • Increasing inter-basin transfers • Implementing programs for improving water use efficiency • Developing desalination and wastewater reuse systems • Boosting the efficiency of irrigation systems, drinking water supply networks and sanitation • Rescaling infrastructure and installations (raising the height of dams and dykes, changing river transport infrastructure, etc. • Constructing flood-resistant buildings

[79] NWSS mission statement

D- Effect prevention: political, regulatory and institutional responses (''Soft'')	• Drought management plans • Financial incentives program for saving irrigation water • Changes to scaling standards and infrastructure operating rules • Rationing • Standards • Adoption of new types of decision including uncertainty management
E- Changing/ Reorganizing uses and activities	• Reallocation of the resource towards higher added value uses • Introducing water-friendlier or drought resistant crops • Shifting economic activities and housing away from flood zones
F- Research, exploitation of climate information	• Improving seasonal, annual and ten-year climate forecasting and modelling capacity • Developing tools to assist decision making and improving risk assessment methods at basin and sub-basin level (coupling climate/hydro models) • Defining appropriate vulnerability and adaptation indicators • Setting up early warning systems • Facilitating the production and provision of climate data for decision makers, technical services and the general public • Improving monitoring and warning systems
G- Capacity building and education	• Broadening decision makers' planning horizons • Building professional technical capacity in the sector as concerns major risk management • Public education and awareness raising

Source: Plan Bleu 2011

More specifically, the Second National Communication to the UNFCCC published in 2011 presented a set of adaptation measures in the water sector. The proposed measures were organized according to a five-point adaptation strategy:

(1) Increase the resilience of groundwater to climate change in coastal areas
(2) Implement water demand side management strategies to reduce water demand in the domestic, industrial and agriculture sectors
(3) Develop watershed management plans that take into consideration climate change
(4) Implement pilot initiatives to demonstrate the feasibility of alternative sources of water supply and develop necessary standards and guidelines
(5) Develop a water database to support decision-making.

8.3 MONITORING RECOMMENDATIONS

Successful NWSS implementation should rely on effective monitoring of key parameters and receptors. First and foremost is the ability to monitor NWSS implementation. Who is doing what? What has been achieved and what remains to be done? It is equally important to also monitor the affected receptors including water quality and ecology.

8.3.1 NWSS Implementation

As explained earlier in this SEA Report, the MEW currently has no mechanism in place to monitor NWSS implementation. Because many agencies are involved in the implementation of the NWSS, it is important to consolidate the information in one location. One option would be to setup a PMU-like structure inside MEW with a mandate to track progress in all 12 initiatives (investment and management) by maintaining regular contact with relevant stakeholders. At minimum, the proposed PMU would need to track and monitor:

i. Tenders (resource augmentation, conveyance, irrigation, and wastewater)
ii. Land expropriations
iii. Budget overruns
iv. Completion and reception of works
v. O&M training programs
vi. Water reform initiatives
vii. Water demand management initiatives
viii. Water resources management indicators
ix. Environmental guidelines and regulations

More generally, the PMU can also develop indicators for monitoring strategy implementation and act as the EIA liaison with MOE. Monitoring NWSS implementation is pivotal to assessing how effectively programs are achieving their strategic goals.

8.3.2 Water Quality

The proposed monitoring program should address sea and groundwater quality, both of which are expected to improve when STPs come inline. As stated earlier, ensuring proper O&M is paramount to the effectiveness of the wastewater program. At minimum, the following should be monitored:

i. Coastal water quality. The 2008-2010 monitoring program that the National Center for Marine Sciences implemented with FAO assistance must be expanded and continued. The program should produce continuous and real-time data. Pollution levels are expected to level off and decrease when STP gradually come inline.

ii. Groundwater quality in the coastal zone. Abstraction rates will begin to level and decrease when proposed dams begin to supply the networks and coastal cities. Although it is difficult to reverse the effect of seawater intrusion, artificial recharge in the coastal zone can potentially dilute brackish water and push back the saline front in localized areas.

iii. Groundwater quality inland. The gradual implementation of proposed irrigation schemes in the Bekaa valley is expected to relieve pressure on groundwater. Wastewater networks and treatment plants will also reduce groundwater pollution. Inland groundwater quality should be monitored in support of the agricultural sector (LARI) and consumers (RWE).

8.3.3 Ecological Effects of Dams

Because dams have a consequential effect on the natural environment, it is important to devise and implement a proper program for monitoring their ecological effects. The program should be commenced before construction to establish the baseline, and continued after dam completion. Pre-monitoring and post-monitoring are detailed below.

<u>Pre-monitoring</u>

Pre-monitoring would investigate ecosystems and species before the construction of the dam, aiming at making an ecological risk assessment of the dam construction on the aquatic and terrestrial species mainly endemic, threatened and rare species. Pre-monitoring findings should feed into the EIA study and help identify protection measures needed to lower the risk of species extinction. Pre-monitoring can help assess the natural restorable degree for damaged river ecosystem. This would reduce the missing actions to be taken, and further guide the implementation of river ecological management. There are four principal ecological elements to monitor and evaluate:

(1) Regional climate conditions,
(2) Hydrological conditions,
(3) Riparian conditions, and
(4) Biological conditions.

Post-monitoring

Post construction, monitoring of ecosystems and species should be undertaken to measure the changes in habitats and populations and to avoid missing mitigation action. Monitoring of the reservoir itself would produce information about the positive and the negative impacts of the impoundment. Downstream ecological changes can be evaluated by using the upstream ecology as reference.

More than 200 methods are used worldwide to prescribe river flows needed to maintain healthy rivers. However, very few of these are comprehensive and holistic, accounting for seasonal and inter-annual flow variation needed to support the whole range of ecosystem services that healthy rivers provide (Tharme, 2003). The most widely accepted methods are:

(1) DRIFT (Downstream Response to Imposed Flow Transformation) (King et al. 2003)
(2) BBM (Building Block Methodology) (King & Louw 1998)
(3) Savannah Process (Richter et al., 2006) for site-specific environmental flow assessment, and
(4) ELOHA (Ecological Limits of Hydrologic Alteration) for regional-scale water resource planning and management (Poff et al., 2010).

The "best" or more likely method for a given situation depends on the amount of resources and data available, the most important issues, and the level of certainty required.

In terms of location, several studies showed that the areas nearest the river and dam site are the most susceptible, due to changes in water quality. This affects bird populations, fish populations and river bank vegetation, the habitat of threatened otters, amphibians and reptiles, including tortoises. However, the silt level at the river mouth should also be monitored to make sure the function of the ecosystem is not altered.

Below is a preliminary list of monitoring parameters:

Environmental flows	• Water discharge volume to avoid sudden changes • Water quality (temperature, oxygen, sediments) • Downstream flow to evaluate minimum flow possible for species survival
Ecology	• Upper/downstream continuity of migration ways, especially for ensuring the life cycle of the endemic Dipper and the threatened Otters of Lebanon • Exotic invasive and non-invasive species, especially in the reservoir and downstream • Flood of the river that maintains nesting sites to many bird species • Bird mortality in the reservoir (due to inappropriate slopes) and downstream (due to sudden discharge) • Sandy walls that host nesting tunnels of kingfishers • Increased salinity at estuaries due to increased withdrawal of water upstream • Decreased biodiversity in brackish water at river's mouth due to reduced river flows and increased salinity

Anthropogenic activities	• Hunters and their activities (game, birds killed and left onsite, accumulation of cartridges, use of lead-filled cartridges, use of hunting hides) • Fishermen and their activities (number, fishing method, species, boats) • Visitors and tourist (numbers, trash left, disturbance, other pollution, benefits and disadvantages to local communities, use of bird-watching hides)

8.4 STRENGTHENING THE EIA / EMP SYSTEM

The EIA process in Lebanon has matured since Decree 8633/2012 was enacted. The number of pre-qualified consultants capable of preparing EIA's has increased. The number of EIA studies has also increased and the MOE is generally able to review and provide official comments to EIA reports within the statutory periods stipulated in Decree 8633/2012 (1 month for scoping report and 2 months for EIA report). However, the EIA process continues to face critical limitations.

For example:

(1) ***EIA consultants.*** MOE Decision 7/1 (dated 6/3/2003) stipulates that EIA consultants must be prequalified by the CDR to conduct "environmental studies". The list of pre-qualified firms at CDR also includes dozens of "conventional" engineering firms who design roads, bridges, and dams. The result is that many EIAs are prepared by the same firm that designed the project, putting EIA consultants in a situation of conflict of interest. Equally important, the MOE should become the custodian of the list of pre-qualified EIA and EMP consultants.

(2) ***EIA Review.*** The MOE is currently understaffed and under-resourced. Effective and timely review of EIA studies is therefore hampered by the occasional lack of technical resources and skills in several project domains. Although technical skills will accrue at the ministry with each EIA, multiple EIAs for several projects in the same sector will be reviewed by different employees at the ministry. The benefits of accumulating subject-matter experience and knowledge are lost if the members of the EIA review committee change (e.g., dams).

(3) ***Environmental Management Plans*** (Article 11 of Decree 8633/2012). MOE requires that all EIA studies include a detailed EMP. EIA consultants sometimes go to great lengths to prepare the EMPs and typically request the client to endorse the EMP in the form of a commitment letter. Once the MOE is satisfied with the Final EIA report and has issued its final opinion, the client can proceed with the project. The role of the EIA consultants has ended unless the Client reappoints the consultant to ensure application of the EMP by the contractor. Currently, MOE has no resources or means to monitor EMP compliance as prescribed in the EIA decree (Article 11.2).

Recently, and in connection with the NWSS, new problems have surfaced in the EIA system:

(4) ***Seeking the position of MOE in relation to an EIA study is mandatory***. Article 10.4 of Decree 8633/2012 stipulates that public institutions shall not implement or operate new projects prior to seeking the (environmental) position of the Ministry of Environment regarding the EIA report; and

(5) ***Retroactive application of the EIA decree***. Article 15 (on violations and penalties) stipulates that project owners must prepare an EIA study (or IEE) if the EIA decree was issued *before* the project started. If the EIA decree was issued *after* the project started, then the minimum requirement is to submit to the MOE an Environmental Management Plan for the project. [Experience to date has revealed some deficiencies in the Article; is the project start date

determined based on contract signature with the lending agency or contract signature with the contractor or effective commencement of works on site].

Several EIAs linked to NWSS programing were conducted before 2012. Several studies were not shared with the MOE and therefore did not go through a proper MOE review. No matter how late in the project cycle, **it is the recommendation of this SEA Report that MEW and MOE coordinate the review of all *past* EIAs for projects that have not yet been implemented yet.** If project implementation has started, then the client must produce an EMP to mitigate identified risks and seek MOE's approval. If on-going NWSS projects present significant environmental issues that have not been adequately addressed in the EIA, then the MOE should challenge the MEW to update the project EIA and, if needed, refer the project to the Council of Ministers for review. A "Stop Work" order may be warranted from the COM if it is determined that the environmental impacts are significant and unmitigated.

See EIA process flowchart in relation to the date of the EIA decree in Figure 15.

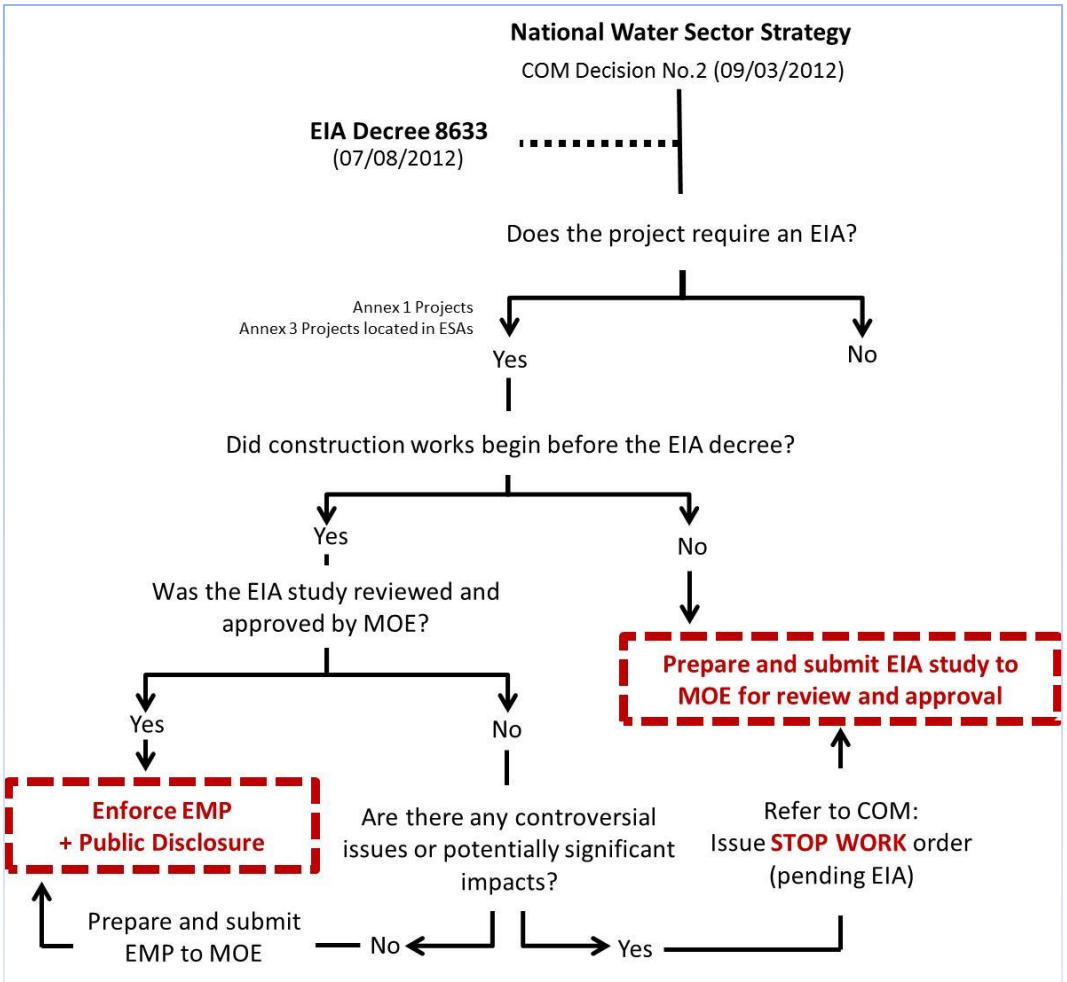


Figure 15. EIA decision flowchart in relation to the NWSS and the EIA Issuance Date

Table 39 clarifies which NWSS programs and initiatives require EIAs and/or IEEs.

Table 39. EIA and IEE Requirements for NWSS Initiatives based on Decree 8633/2012

Strategy Infrastructure Initiatives	*Summary Description*	*EIA / IEE Requirements based on Decree 8633/2012*
1. Optimizing surface water storage	• Improvement of the catchment of surface water springs	Not listed – See Article 5.3
2. Artificial recharge of groundwater aquifer	• Providing additional water by artificial recharge (during the wet season / excess flow)	Not listed – See Article 5.3
3. Surface storage: dams and hill lakes	• Construction of dams and hill lakes	Annex 1
4. Water supply transmission	• Construction of transmission pipes and water storage tanks	Not listed – See Article 5.3 Annex 1 if linked to "Integrated Domestic Water Supply Project"
5. Water supply distribution	• Construction of distribution pipes	
6. Irrigation rehabilitation and expansion	• Construction of irrigation channels	Annex 1 if >500 ha Annex 2 if >100 ha
7. Wastewater collection and treatment	• Construction of WW networks	Annex 2
	• Construction of STPs	Annex 1
	• Construction of sewage outfalls	Annex 1

Note: According to Decree 8633/2012, Annex 1 projects require a full EIA and Annex 2 projects require an IEE. Projects not listed in either Annex 1 or Annex 2 may also require an EIA or an IEE if located in environmentally sensitive areas listed in Annex 3.

Finally,

The EIA sector would greatly benefit from issuing guidance notes for dams, STPs, large-scale irrigation schemes, and artificial recharge –to serve as minimum requirements for EIA studies.

8.5 WATER DEMAND MANAGEMENT

Water Demand Management strategies and measures can have a very positive impact on the water sector, by reducing demand and water losses. All the people that we consulted agree that WDM has received too little attention in Lebanon and that much more needs to be done to reap the benefits of supply-side management strategies, which dominates the NWSS. Table 40 presents illustrative examples of demand side water management measures.

Table 40. Examples of Water Demand Side Management Measures

Type of use		*Demand side measure*	*"Soft"*	*"Hard"*
Municipal/domestic		(1) Promoting the use of water saving devices		●
		(2) Increasing the use of "grey" water (technology)		●
		(3) Reducing losses from distribution systems (UFW)	●	
		(4) Increasing domestic water pricing (tariffs)	●	
		(5) TSE reuse in agriculture & landscaping		
		(6) Seasonal forecasting	●	
Industrial		(7) Increasing the efficiency of water use and recycling		●
Cooling of thermal power plants		(8) Increasing the efficiency of water use and recycling by inland thermal power plants (coastline plants use seawater for cooling)		●
Agriculture	Rainfed	(9) Improving crop tolerance to drought (R&D)		●
		(10) Choosing drought tolerant crops (native species)	●	
	Irrigated	(11) Increasing the efficiency of irrigation		●
		(12) Changing irrigation water pricing	●	
		(13) Improving crop tolerance to drought		●

Water demand management is a multi-disciplinary science. It is important to promote WDM behavior among all major user groups including:

i. Households,
ii. Industry,
iii. Large consumers (tertiary sector: schools, government buildings, etc.), and
iv. Farmers

WDM requires a paradigm shift in people's behavior. This SEA Report strongly recommends that NWSS sponsors and sanctions a national social marketing campaign to promote behavior change in the water sector targeting Knowledge, Attitudes, and Practices (KAP). The campaign could be hosted and coordinated by the UNDP-sponsored National Center for Water Conservation and Management which must be institutionalized in the MEW to ensure long-term results. It would need to engage:

i. Government agencies
ii. Educational institutions
iii. NGOs
iv. Equipment and service providers

The goal is to target users from all angles (360° approach) as illustrated in Figure 16.

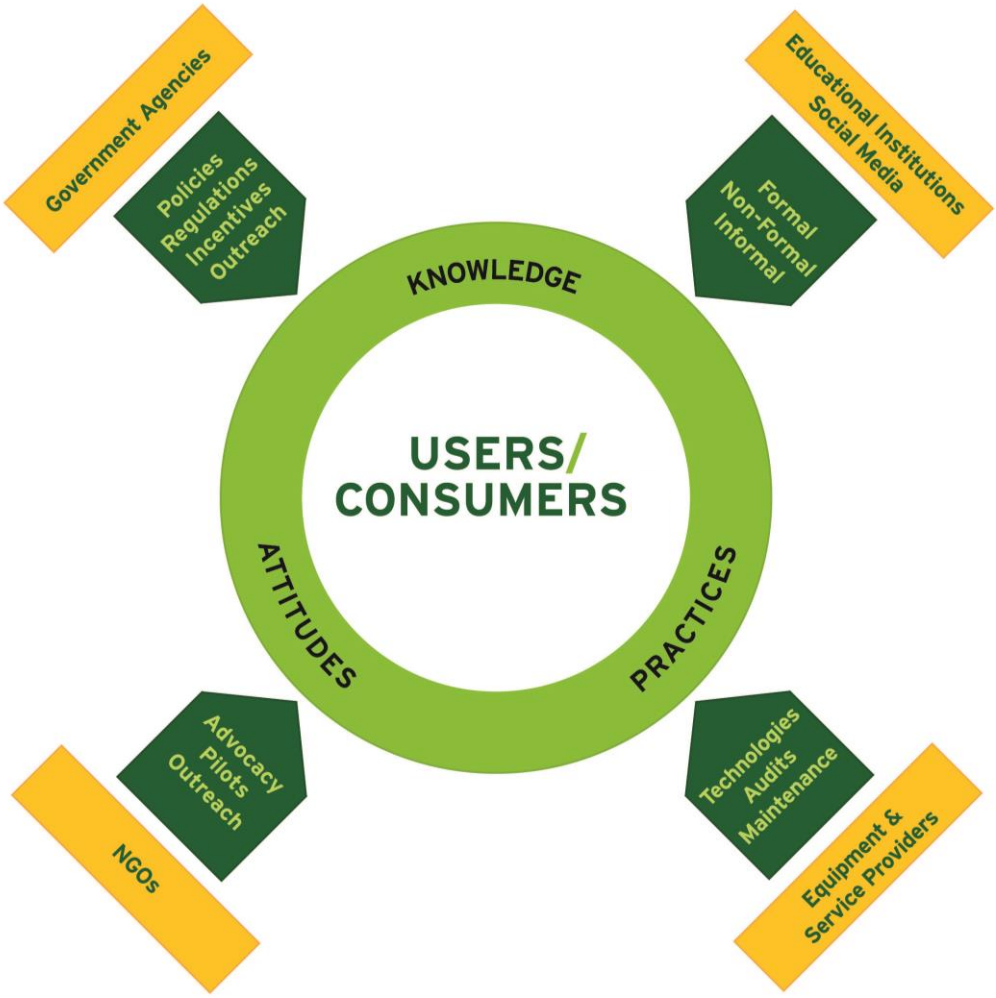


Figure 16. Systematic approach to behavior change in the water sector

Table 41. Policy Framework for Optimizing the Environmental and Social Effects of the NWSS

Key SEA Issues Requiring NWSS or Related Policy Response	*MEW*	*MOE*	*Others*
1. Climate Change adaptation	• Develop and implement drought management plans (incl. WDM strategies) for domestic, agricultural and industrial sectors • Extend the work and mandate of the recently completed UNDP "Groundwater Assessment Database Project" to support decision-making and update Lebanon's water budget	• Mobilize resources for next Climate Change report and share latest findings and CC scenarios with MEW to guide NWSS updates	• COM: prioritize climate change knowledge by significantly increasing funding for it • LRA: revamp its river hydrometric system (equipment and knowhow) • MEW-DGUP: Develop watershed management plans for all dams • COM: Review Disaster Management Planning (and panoply of redundant committees)
2. Effects on ecology and ecosystems	• Accelerate coordination of NWSS-related EIAs (notably dams) with MOE, including obsolescent EIAs; share EMPs for all STPs and dams with MOE for review and approval; incorporate approved EMPs in tender documents • Develop Guidance Notes for the construction and O&M of water projects (production, conveyance, wastewater)	• • Identify biodiversity hotspots, determine vulnerabilities and trends, and make guidance for management of water bodies including minimum environmental flows • Request EIA consultants to conduct comprehensive ecological baseline surveys for all dams	• NCSR and Universities: monitor the effects of impoundments on riparian ecosystems and species • MOA-MOE-Higher Council for Hunting: extend nascent hunting regulation to water-body dependent species • MOA**:** Review with MOE policy on "replacement trees" in favor of ecological restoration of affected ecosystems
3. Effects on marine environment and coastal waters	• Coordinate the completion and handover of STPs from CDR to WEs • Resolve all power supply issues to operate and maintain TSPs	• Monitor BOD_5 discharges into the Mediterranean Sea based on MOE Decision 8/1 (2001)	• NCSR-Pressure NGOs: Monitor bathing water quality along the coastline and inform the public (blue flag program)
4. Effects on underground water and karst	• Assess the potential impacts of NWSS dams program on underground water and karst (at project EIA level)	• Include in EIA Guidance Note the assessment of dams on underground water and Karst; request impact modeling and tracer studies as part of the EIA.	• Speleologists and caving groups: Participate in the discourse on the impact of dams and lobby for the protection of important Karst formations (e.g., Balaa)

Key SEA Issues Requiring NWSS or Related Policy Response	*MEW*	*MOE*	*Others*
5. Water-Energy Nexus	• Establish management information system to collect energy consumption data by the water sector (at WE level) • Analyze energy savings from Chabrouh Dam due to gravity transmission and distribution; extrapolate to other dams to establish a net energy balance • Review and update Lebanon's hydropower production potential post NWSS based on the preliminary work of SOGREAH	• Accelerate the review of all EIAs of proposed renewable energy projects (to offset lost hydropower production on Litani River –by NWSS)	• COM and RE stakeholders: review RE 2020 target and develop roadmap to get there (not limited to hydropower) • Remove barriers to hydropower production and clear-up the legal framework to incentivize the private sector
6. Man-made water bodies and buffers	• Coordinate the delineation of buffer zones for dams program based on the NLUMP (Zones N, P and S) in coordination with relevant agencies (MOA, MOPWT – DGUP) • Incorporate "buffer zones" in the planning and design of dams to protect the resource and prevent contamination	Prepare Guidance Notes (guidelines): 4. Man-made water bodies (specifying which activities are sanctioned, buffer zones, and erosion control-measures) in coordination with: MEW, MOA, and DGUP. 5. TSE discharge into watercourses based on TSE quality and volume of receiving water 6. Restoration of riparian habitats around man-made water bodies	• MEW-MOE-MOA: Develop Guidance Note on man-made water bodies; coordinate the management of buffer zones with Urban Planning agencies • MOA: prepare Guidance Note on erosion control measures to protect soils and slow down siltation around reservoirs
7. Catastrophic Failure and Emergency Planning	• Adopt (or adapt) the World Bank's classification system for dams • Capitalize on the recent work of the LRA to develop a template Emergency Action Plan for all large dams and STPs (emergency levels, notifications, actions, and termination) • Test EAPs with relevant authorities and downstream communities	• Include mandatory Emergency Action Plans for large dams and large STPs	• Presidency of the COM: Reorganize previously established committees for disaster response and management (see Climate Change policy response) • Discuss potential role of the Lebanese Armed Forces in protecting strategic reservoirs against sabotage

Key SEA Issues Requiring NWSS or Related Policy Response	*MEW*	*MOE*	*Others*
8. Water-Poverty Nexus	• Developing a fair and affordable water and wastewater pricing strategy that allows for cost recovery without penalizing the lowest-income groups • Assess periodically the WSS needs of unserved areas and groups including refugees	• Mainstream the recommendations and goals of water and poverty policy documents: MDG, Horizon 2020, Rio+20 National Report.	• MOA: Start planning for new crops in South Lebanon in anticipation of large conveyance and irrigation projects • DGUP and local municipalities: Conserve agricultural lands that will benefit by large scale irrigation schemes incl. Canal 900 (West Bekaa) and Canal 800 (South Lebanon)
9. Treated Sewage Effluent and sludge reuse	• Endorse guidelines for TSE and sludge reuse in agriculture and landscaping in coordination with the FAO and MOA • Capture opportunities for TSE reuse in the coastal area using storage ponds if needed (and thereby minimize direct discharge)	• Review and endorse MEW-FAO guidelines for TSE and sludge reuse • Develop with MEW guidelines for TSE discharge into water courses (inland STPs) to avoid loading the receiving waters.	• MOA-WE's**:** Monitor TSE and sludge reuse in agriculture and land reclamation; troubleshoot as needed.
10. Construction and excavation waste	• Enforce EMP mitigation measures for all excavation works and ensure site restoration before handover over	• Require site cleanup and restoration as part of construction close-out procedures (before reception of works) • For networks and large conveyance projects, develop guidance on EIA screening or initial EA (e.g., construction methods, soil conservation, archaeology)	• CDR: Include site cleanup and restoration in tender documents and as a precondition for final reception of works
11. Operation and Maintenance	• Enhance O&M systems (maybe license operators and require a training system as a licensing condition) • Enhance the O&M capabilities of WEs and/or improve their PSP skills (contract management and supervision)	• Ensure that Guidance Note on construction and O&M address this key SEA issue, with penalties for violators	• MOI: Enforce with MOE the mandatory pre-treatment of industrial wastewater according to MOE Decision 8/1 (2001) to avoid loading STPs
12. Transboundary Waters	• Respect all bilateral agreements (with Syria) regarding the damming of two transboundary rivers: Kebir and Aassi		• Strategically, COM must continue to declare and plan investment projects on all trans-boundary waters to reserve / secure Lebanon's water rights

9. RECOMMENDATIONS FOR INTEGRATING SEA FINDINGS IN THE NWSS

This Report identified 12 key issues potentially affected by the NWSS. It also presented several policy responses that would help mitigate or alleviate the environmental, social, and economic burden of the NWSS. In this chapter, the Consultant attempts to highlight a handful of priority recommendations for integrating SEA findings in the NWSS.

(1) **Mid-term appraisal of the NWSS.** There is a strong case for a "mid-term appraisal" of the NWSS through which lessons from experience so far could be learned, targets and methodologies could be re-assessed, and SEA safeguards could be implemented. The Consultant conducted this SEA some years after the NWSS was compiled. MEW therefore can now refer to actual experience to see, in part, where NWSS worked, was too ambitious, or was derailed by unforeseen events (budget overruns, Syrian refugee crisis, and 50-year drought occurrence). For example, if the levels of investment predicted by NWSS are shown to be far in excess of anything yet achieved, these must be revised or MEW must explain what new mechanisms are in place to transform their performance.

(2) **Iterative process for NWSS revisions.** Based on this mid-term appraisal, the MEW should review the NWSS and its strategic roadmap (2010-2020) and consider scaling-back its dams program in light of social, economic, and environmental constraints. MEW should address the legitimate concerns of the public in affected areas and ensure full compliance with EIA regulations. Revisions to the NWSS including its initiatives and timeline would need to be realistic and implementable in a resource-constrained environment, and should be endorsed by the Council of Minister (in the form of an addendum to the 2012 NWSS). NWSS should be viewed as an iterative process whereby appraisals and externalities bring about modifications and/or variances to the original strategy.

(3) **Implementation Unit for oversight and monitoring.** There is an urgent need to clearly assign responsibility for oversight and monitoring of the NWSS in one office (Implementation Unit) at the MEW. The officer/Director in charge would be required to report yearly to the Council of Ministers. By virtue of its mandate, this office would improve NWSS communication with other agencies (Agriculture, Environment, Urban Planning, etc.) and immunize the strategy from political and partisan interference. This office will need resources to discharge its mandate (oversight and monitoring); there may be strong donor interest for capacity building in monitoring systems and information management.

(4) **Improving the national water dialogue.** Since the MEW does not have direct power to require ministries and bodies outside its jurisdiction to undertake any action related to the NWSS, it has to rely on dialogue. Therefore, it may be useful to establish a national working group/forum/committee to address actions which require broad cross-sectoral co-operation especially (a) data sharing, (b) catchment protection, (c) climate change adaptation, and (d) Water Demand Management.

(5) Regulations, Guidance and Standards. This SEA Report has identified several areas where guidance and/or regulations are urgently needed to complement the NWSS interventions and protect natural resources. The concerned ministries should immediately pay attention to the following guidance and regulatory needs:

a. Classification of dams into small and large dams based on World Bank's OP 4.37 (Safety of Dams, October 2001, *Revised* April 2013). Such a classification would help determine which dams require an Emergency Action Plan.

b. Guidance Notes for the construction and O&M of water projects (production, conveyance, and wastewater). Such a Guidance Note would inform the EIA process and help it focus on the most important issues.

c. Guidance Notes on man-made water bodies specifying which activities are sanctioned and which are not, as well as buffer zones, and minimum erosion control-measures. This Guidance Note would also describe ecological measures to restore riparian ecosystems around inundated lands.

d. Guidance Notes on Treated Sewage Effluent discharge into water courses that take into consideration the quality of TSE and the volume of receiving waters.

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11. TECHNICHAL ANNEXES

ANNEX 11.1 GLOSSARY OF TERMS

Abstraction	*The process of taking water from a ground source, either temporarily or permanently*
Adaptation	*The ability of a species to survive in a particular ecological niche, especially because of alterations of form or behavior brought about through natural selection*
BOD	*The amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period*
Buffer zone	*An area that serves not for any anthropogenic use but as a conserved natural habitat where plants and animals can thrive. They protect the natural environment and help keep nearby ecological niches stable and functioning*
CAPEX	*Capital Expenditure creating future benefits*
Climate Change	*A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels*
Ecology	*The scientific study of interactions among organisms and their environment*
Ecosystems	*A community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system*
Environmental flows	*The quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well being that depend on these ecosystems*
Expropriation	*A process that occurs when a public agency takes private property for a purpose deemed to be in the public interest*
Flood	*An overflow of water that submerges land which is usually dry*
Impoundment	*Body of water confined within an enclosure, as a reservoir. Impoundment may or may not include a dam*
Karst	*A terrain with distinctive landforms and hydrology created from the dissolution of soluble rocks, principally limestone. It is characterized by sinkholes, caves, and underground drainage systems*
Landforms	*A specific geomorphic feature on the surface of the earth, ranging from large-scale features such as plains, plateaus, and mountains to minor features such as hills, valleys, and alluvial fans.*
Landscape	*All the visible features of an area of land, often considered in terms of their aesthetic appeal*
Macro-economy	*A branch of economics dealing with the performance, structure, behavior, and decision-making of an economy as a whole, rather than individual markets*
Nexus	*A connection or series of connections linking two or more things*
Protocol	*The set of rules, procedures, conventions and ceremonies that relate to relations between states*
Riparian habitats	*The interface between land and a river or stream*

Sedimentation	*The natural process in which material (such as stones and sand) is carried to the bottom of a body of water and forms a solid layer*
Sludge	*The residual, semi-solid material left from industrial wastewater, or sewage treatment processes*
Watershed	*The area of land where all of the water that is under it or drains off of it goes into the same place*

ANNEX 11.2 WATER BODY DEPENDENT BIRD SPECIES

The total number of Water Bodies Dependent Species (WBDS) in Lebanon is 187 bird species. They can be grouped into four categories:

- 7 sedentary WBDS,
- 19 summer breeding WBDS,
- 30 vagrant WBDS, and
- 131 migratory and wintering WBDS.

See full lists on next pages.

Keys

Abbreviations are used to indicate the species status, a question mark indicating uncertain status. Lower case abbreviations
(eg. R, sb, s, wv, pm) indicate that the species is uncommon or rare at the relevant season

R	=	Resident with definite breeding record
SB	=	Breeding summer visitor
S	=	Non breeding summer visitor
WV	=	Winter visitor
PM	=	Passage migrant, S in spring and A in autumn
FB	=	Formerly bred: no breeding records since 1987
V	=	Vagrant
E	=	Extinct in Lebanon
I	=	Introduced
CR	=	Critically Endangered as per BirdLife International 2012
EN	=	Endangered as per BirdLife International 2012
VU	=	Vulnerable as per BirdLife International 2012
NT	=	Near Threatened as per BirdLife International 2012

Under breeding, migrating and wintering: Bold numbers indicate common species at the relevant season. Under Degree of occurrence: Bold numbers indicate common species at the year level

TABLE (1): Water Bodies Dependent Sedentary/ Resident Species (R or r)

English Name	Scientific Name	STATUS	BREEDING		MIGRATING AND WINTERING				DEGREE OF OCCURRENCE				
			R	FB	PM S	PM A	WV	SV	Common	Un-common	Scarce	Rare	Very rare
		R, SB, pm, wv	1		1	1	1		**1**				
Common Moorhen	*Gallinula chloropus*	R, PM, wv	**1**			**1**	**1**		**1**				
Eurasian Coot	*Fulica atra*	R, PM, WV	**1**		**1**	**1**	**1**		**1**				
Yellow-legged Gull	*Larus michahellis*	R, PM, WV, S	**1**		**1**	**1**	**1**	1	**1**				
Zitting Cisticola	*Cisticola juncidis*	r	1							1			
Cetti's Warbler	*Cettia cetti*	R	**1**						**1**				
White-throated Dipper	*Cinclus cinclus rufiventris*	R	1						1				
Totals	7	7	7	0	3	4	4	1	6	1	0	0	0

TABLE (2): Water Bodies Dependent Summer Breeding Species (SB or sb)

English Name	Scientific Name	STATUS			MIGRATING AND WINTERING				DEGREE OF OCCURRENCE				
			SB	FB	PM S	PM A	WV	SV	Common	Un-common	Scarce	Rare	Very rare
Mallard	*Anas platyrhynchos*	PM, WV, sv, sb	1		**1**	**1**	**1**			1			
Garganey	*Anas querquedula*	PM, sb	1		**1**	1			1				
Little Grebe	*Tachybaptus ruficollis*	R, SB, pm, wv	**1**		1	1	1		**1**				
Little Bittern	*Ixobrychus minutus*	SB, pm, wv	**1**		**1**	1	1		1				
Black-crowned Night Heron	*Nycticorax nycticorax*	SB, PM, S	**1**		**1**	**1**		**1**	**1**				
Western Marsh Harrier	*Circus aeruginosus*	sb, PM, wv	1		**1**	**1**	1		1				
Water Rail	*Rallus aquaticus*	sb, PM, WV	1		**1**	**1**	**1**	1	**1**				
Little Crake	*Porzana parva*	pm, ?sb	0		1	1					1		
Spur-winged Lapwing	*Vanellus spinosus*	pm, sb	1		1	1					1		
Whiskered Tern	*Chlidonias hybrida*	sb, pm	1		1	1					1		
Eurasian Penduline Tit	*Remiz pendulinus*	sb, pm, wv	1		1	1	1				1		
Barn Swallow	*Hirundo rustica*	SB, PM, wv	**1**		**1**	**1**	1		**1**				

Savi's Warbler	*Locustella luscinioides*	sb, pm	1		1	1				1				
Great Reed Warbler	*Acrocephalus arundinaceus*	SB, PM	**1**		**1**	1			**1**					
Moustached Warbler	*Acrocephalus melanopogon*	SB, pm, wv	1		1	1	1				1			
Eurasian Reed Warbler	*Acrocephalus scirpaceus*	SB, PM, wv	1		**1**	**1**	1		1					
'Black-headed Wagtail'	*Motacilla flava feldegg*	SB, PM	**1**		**1**	**1**			**1**					
Grey Wagtail	*Motacilla cinerea*	sb, pm, wv	1		1	1	1				1			
White Wagtail	*Motacilla alba*	sb, PM, WV	1		**1**	**1**	**1**		1					
Totals	19	19	18	0	19	19	11	2	11	2	6	0	0	

TABLE (3): Water Bodies Dependent Vagrant Species (V) in Lebanon

English Name	Scientific Name	STATUS		
		Vagrant	Nb of Vagrants	Nb of Vagrant's records
Bean Goose	*Anser fabalis*	V	1	1
Greylag Goose	*Anser anser*	V	1	1
Mute Swan	*Cygnus olor*	V	1	3
Ruddy Shelduck	*Tadorna ferruginea*	V	1	3
Marbled Duck	*Marmaronetta angustirostris*	V	1	3
Red-crested Pochard	*Netta rufina*	V	1	1
Velvet Scoter	*Melanitta fusca*	V	1	2
Common Goldeneye	*Bucephala clangula*	V	1	1
Red-breasted Merganser	*Mergus serrator*	V	1	1
Sooty Shearwater	*Puffinus griseus*	V	1	1
Great Shearwater	*Puffinus gravis*	V	1	3
European Storm Petrel	*Hydrobates pelagicus*	V	1	3
Red-necked Grebe	*Podiceps grisegena*	V	1	2
Horned Grebe	*Podiceps auritus*	V	1	2
Pink-backed Pelican	*Pelecanus rufescens*	V	1	2

Purple Swamphen	*Porphyrio porphyrio*	V	1	2
Sociable Lapwing	*Vanellus gregarius*	V	1	2
Pacific Golden Plover	*Pluvialis fulva*	V	1	1
Caspian Plover	*Charadrius asiaticus*	V	1	4
Bar-tailed Godwit	*Limosa lapponica*	V	1	4
Eurasian Curlew	*Numenius arquata*	?pm, V	1	5
Red Knot	*Calidris canutus*	V	1	1
Sooty Gull	*Larus hemprichii*	V	1	1
Armenian Gull	*Larus armenicus*	V	1	4
Heuglin's Gull	*Larus heuglini*	V	1	2
Black-legged Kittiwake	*Rissa tridactyla*	V	1	4
River Warbler	*Locustella fluviatilis*	V	1	2
Clamorous Reed Warbler	*Acrocephalus stentoreus*	V	1	2
'Ashy-headed Wagtail'	*Motacilla flava cinereocapilla*	V	1	1
'Yellow-headed Wagtail'	*Motacilla flava lutea*	V	1	1
Totals	30	30	30	

TABLE (4): water bodies dependent Passage migrants (PM), winter visitors (WV) and summer visitor species (SV) in Lebanon

English Name	Scientific Name	STATUS	BREEDING			MIGRATING, WINTERING & SUMMERING				DEGREE OF OCCURRENCE				
			R	SB	FB	PMS	PMA	WV	SV	Common	Un-common	Scarce	Rare	V. rare
Greater White-fronted Goose	*Anser albifrons*	wv, pm				1	1	1			1			
Common Shelduck	*Tadorna tadorna*	pm, wv				1	1	1				1		
Gadwall	*Anas strepera*	wv						1					1	
Eurasian Wigeon	*Anas penelope*	PM, wv				**1**	**1**	1			1			
Mallard	*Anas platyrhynchos*	PM, WV, sv, sb		1		**1**	**1**	**1**			1			
Northern Shoveler	*Anas clypeata*	PM, WV				**1**	**1**	**1**			1			
Northern Pintail PM, WV, s	*Anas acuta*	PM, WV, s				**1**	**1**	1	1	1				
Garganey	*Anas querquedula*	PM, sb		1		**1**	1			1				
Eurasian Teal	*Anas crecca*	PM, WV			1	**1**	**1**	**1**		**1**				
Common Pochard	*Aythya ferina*	pm, wv				1	1	1				1		
Ferruginous Duck	*Aythya nyroca*	pm, wv, s				1	1		1			1		
Tufted Duck	*Aythya fuligula*	pm, wv				1	1	1			1			
Scopoli's Shearwater	*Calonectris d. diomedea*	PM, wv				1	**1**	1			1			
Yelkouan Shearwater	*Puffinus yelkouan*	PM, wv				1	**1**	1			1			
Leach's Storm Petrel	*Oceanodroma leucorhoa*	?wv						1						1
Little Grebe	*Tachybaptus ruficollis*	R, SB, pm, wv	1	**1**		1	1	1		**1**				
Great Crested Grebe	*Podiceps cristatus*	pm, wv, s				1	1	1	1			1		
Black-necked Grebe	*Podiceps nigricollis*	pm, wv				1	1	1				1		
Greater Flamingo	*Phoenicopterus roseus*	pm, ?wv				1	1	1					1	
Black Stork	*Ciconia nigra*	PM				**1**	**1**			1				
Western White Stork	*Ciconia ciconia*	PM				**1**	**1**			**1**				
Glossy Ibis	*Plegadis falcinellus*	pm, s				1	1					1		

Eurasian Spoonbill	*Platalea leucorodia*	pm				1	1						1	
Eurasian Bittern	*Botaurus stellaris*	wv, pm				1	1	1				1		
Little Bittern	*Ixobrychus minutus*	SB, pm, wv		**1**		**1**	1	1		1				
Black-crowned Night Heron	*Nycticorax nycticorax*	SB, PM, S		**1**		**1**	**1**		**1**	**1**				
Squacco Heron	*Ardeola ralloides*	PM, wv				1	1				1			
Cattle Egret	*Bubulcus ibis*	pm, wv				1	1	1			1			
Grey Heron	*Ardea cinerea*	PM, WV				1	**1**	**1**		**1**				
Purple Heron	*Ardea purpurea*	pm				1	1					1		
Great Egret	*Ardea alba*	pm, wv, s				1	1		1			1		
Little Egret	*Egretta garzetta*	PM, wv, S				**1**	**1**	1	**1**	**1**				
Great White Pelican	*Pelecanus onocrotalus*	PM				**1**	**1**			**1**				
Dalmatian Pelican	*Pelecanus crispus*	pm				1	1					1		
Northern Gannet	*Morus bassanus*	wv						1				1		
Pygmy Cormorant	*Phalacrocorax pygmeus*	wv, pm, s				1	1	1	1			1		
Great Cormorant	*Phalacrocorax carbo*	WV, PM, s				**1**	**1**	**1**	1	**1**				
Eleonora's Falcon	*Falco eleonorae*	pm			1									1
Osprey	*Pandion haliaetus*	pm				1	1				1			
Western Marsh Harrier	*Circus aeruginosus*	sb, PM, wv		1		**1**	**1**	1		1				
Hen Harrier	*Circus cyaneus*	pm, wv				1	1	1			1			
Pallid Harrier	*Circus macrourus*	pm, wv				1	1	1			1			
Montagu's Harrier	*Circus pygargus*	pm				1	1						1	
Water Rail	*Rallus aquaticus*	sb, PM, WV		1		**1**	**1**	**1**	1	**1**				
Corncrake	*Crex crex*	pm				1	1				1			
Little Crake	*Porzana parva*	pm, ?sb		0		1	1					1		
Baillon's Crake	*Porzana pusilla*	pm				1	1						1	
Spotted Crake	*Porzana porzana*	PM, wv				**1**	1	1				1		
Common Moorhen	*Gallinula chloropus*	R, PM, wv	**1**			**1**	**1**	**1**		**1**				
Eurasian Coot	*Fulica atra*	R, PM, WV	**1**			**1**	**1**	**1**		**1**				
Demoiselle Crane	*Anthropoides virgo*	pm				1	1					1		

Common Crane	*Grus grus*	PM, wv				**1**	**1**	1		**1**				
Eurasian Oystercatcher	*Haematopus ostralegus*	pm				1	1					1		
Black-winged Stilt	*Himantopus himantopus*	PM				**1**	**1**			**1**				
Pied Avocet	*Recurvirostra avosetta*	pm, wv				1	1	1				1		
Northern Lapwing	*Vanellus vanellus*	PM, WV				**1**	**1**	**1**		**1**				
Spur-winged Lapwing	*Vanellus spinosus*	pm, sb		1		1	1					1		
Eurasian Golden Plover	*Pluvialis apricaria*	pm, wv				1	1	1				1		
Grey Plover	*Pluvialis squatarola*	pm, wv				1	1	1				1		
Common Ringed Plover	*Charadrius hiaticula*	PM, wv, s				**1**	**1**	1	1	1				
Little Ringed Plover	*Charadrius dubius*	PM, s				1	1		1	1				
Kentish Plover	*Charadrius alexandrinus*	pm, s				1	1		1		1			
Greater Sand Plover	*Charadrius leschenaultii*	pm				1	1						1	
Eurasian Dotterel	*Charadrius morinellus*	pm, wv				1	1	1					1	
Eurasian Woodcock	*Scolopax rusticola*	PM, WV				1	1	1		1				
Jack Snipe	*Lymnocryptes minimus*	pm, wv				1	1	1				1		
Great Snipe	*Gallinago media*	pm				1	1						1	
Common Snipe	*Gallinago gallinago*	pm, wv				1	1				1			
Black-tailed Godwit	*Limosa limosa*	pm				1	1					1		
Whimbrel	*Numenius phaeopus*	pm				1	1						1	
Eurasian Curlew	*Numenius arquata*	?pm, V				0	0							
Spotted Redshank	*Tringa erythropus*	pm				1	1					1		
Common Redshank	*Tringa totanus*	pm, wv				1	1	1			1			
Marsh Sandpiper	*Tringa stagnatilis*	pm, ?wv				1	1				1			
Common Greenshank	*Tringa nebularia*	PM, wv				**1**	**1**	1		1				
Green Sandpiper	*Tringa ochropus*	PM, wv				**1**	**1**	1		1				
Wood Sandpiper	*Tringa glareola*	PM				**1**	**1**							
Terek Sandpiper	*Xenus cinerea*	pm				1	1							1
Common Sandpiper	*Actitis hypoleucos*	PM, wv, s				**1**	**1**	1	1	1				

Ruddy Turnstone	*Arenaria interpres*	pm				1	1					1		
Sanderling	*Calidris alba*	pm				1	1							1
Little Stint	*Calidris minuta*	PM				**1**	**1**			**1**				
Temminck's Stint	*Calidris temminckii*	pm				1	1					1		
Curlew Sandpiper	*Calidris ferruginea*	pm, s				1	1		1			1		
Dunlin	*Calidris alpina*	PM, WV				1	**1**	**1**		1				
Broad-billed Sandpiper	*Limicola falcinellus*	pm				1	1					1		
Ruff	*Philomachus pugnax*	PM, wv, s				**1**	**1**	1	1	1				
Red-necked Phalarope	*Phalaropus lobatus*	pm				1	1						1	
Cream-coloured Courser	*Cursorius cursor*	sb, pm		1		1	1					1		
Collared Pratincole	*Glareola pratincola*	pm				1	1				1			
Black-winged Pratincole	*Glareola nordmanni*	pm				1	1					1		
Common Gull	*Larus canus*	WV, pm, s				1	1	**1**	1		1			
Audouin's Gull	*Larus audouinii*	pm			1	1	1					1		
Great Black-backed Gull	*Larus marinus*	pm, wv				1	1	1						1
Yellow-legged Gull	*Larus michahellis*	R, PM, WV, S	**1**			**1**	**1**	**1**	1	**1**				
Caspian Gull	*Larus cachinnans*	wv, ?pm						1						1
Lesser Black-backed Gull	*Larus fuscus*	PM, WV, s				**1**	**1**	**1**	1	**1**				
Great Black-headed Gull	*Larus ichthyaetus*	pm, wv				1	1	1				1		
Common Black-headed Gull	*Larus ridibundus*	PM, WV				**1**	**1**	**1**		**1**				
Slender-billed Gull	*Larus genei*	pm, wv				1	1	1				1		
Mediterranean Gull	*Larus melanocephalus*	pm, wv				1	1	1				1		
Little Gull	*Larus minutus*	pm, WV				1	1	**1**			1			
Gull-billed Tern	*Gelochelidon nilotica*	pm				1	1						1	
Sandwich Tern	*Sterna sandvicensis*	pm, wv				1	1							1
Common Tern	*Sterna hirundo*	PM			1	1	1			1				
Little Tern	*Sternula albifrons*	pm			1								1	
Whiskered Tern	*Chlidonias hybrida*	sb, pm		1		1	1					1		

White-winged Tern	*Chlidonias leucopterus*	PM				1	1			1				
Black Tern	*Chlidonias niger*	pm				1	1						1	
Pomarine Skua	*Stercorarius pomarinus*	pm, wv				1	1	1				1		
Arctic Skua	*Stercorarius parasiticus*	pm, wv				1	1	1					1	
White-throated Kingfisher	*Halcyon smyrnensis*	pm, wv			0	1	1	1				1		
Common Kingfisher	*Alcedo atthis*	PM, WV,s	0	0		1	1	1		1				
Pied Kingfisher	*Ceryle rudis*	wv, pm			1	1	1	1					1	
Eurasian Penduline Tit	*Remiz pendulinus*	sb, pm, wv		1		1	1	1				1		
Savi's Warbler	*Locustella luscinioides*	sb, pm		1		1	1				1			
Great Reed Warbler	*Acrocephalus arundinaceus*	SB, PM		**1**		**1**	1			**1**				
Moustached Warbler	*Acrocephalus melanopogon*	SB, pm, wv		1		1	1	1				1		
Sedge Warbler	*Acrocephalus schoenobaenus*	PM, wv				**1**	1	1					1	
Eurasian Reed Warbler	*Acrocephalus scirpaceus*	SB, PM, wv		1		**1**	**1**	1		1				
Marsh Warbler	*Acrocephalus palustris*	PM				1	**1**			1				
Willow Warbler	*Phylloscopus trochilus*	PM				1	**1**			1				
Bluethroat	*Luscinia svecica*	PM, WV				**1**	**1**	**1**		**1**				
Western Yellow Wagtail	*Motacilla flava*	PM				**1**	**1**			**1**				
'Sykes's Wagtail'	*Motacilla flava beema*	PM				**1**	**1**			**1**				
'Grey-headed Wagtail'	*Motacilla flava thunbergi*	PM				**1**	**1**			**1**				
'Black-headed Wagtail'	*Motacilla flava feldegg*	SB, PM		**1**		**1**	**1**			**1**				
Citrine Wagtail	*Motacilla citreola*	pm				1	1					1		
Grey Wagtail	*Motacilla cinerea*	sb, pm, wv		1		1	1	1				1		
White Wagtail	*Motacilla alba*	sb, PM, WV		1		**1**	**1**	**1**		1				
Water Pipit	*Anthus spinoletta*	PM, wv				**1**	**1**	1		1				
Totals	*131*	131	4	18	6	125	124	70	18	45	21	40	16	7

ANNEX 11.3 METHODOLOGY AND CALCULATIONS USED TO VALUE SELECTED NWSS BENEFITS

Value of Coastal Water Quality Improvements as a result of WW Treatment

a. Basis of Benefit Estimate. WB 2004 annual damage cost estimate as a result of *"pollution (untreated municipal wastewater, seafront solid waste dumps, etc.) and uncontrolled development of resorts and vacation homes all the way to the shoreline uncontrolled"* from $99 M (low est.) to $126 M. The average of these = **$113 M (in year 2000 prices)** and includes:

- **i.** International tourism revenue losses (estimated via a comparison to Tunisia; adjusting for differences in kilometers of beaches and domestic prices)
- **ii.** Intrinsic Value (ecological and non-use value of coasts estimated based on a Willingness to Pay survey carried out at Junieh, then aggregated to all of Lebanon); and
- **iii.** Domestic Travel Costs (travel costs incurred by people having to go to further beaches for recreation; likely that this estimated cost is underestimated, see WB 2004 Pg. 22)

Converting $113 M to **2013 prices = $169 M** (price conversion factor = 1.5 based on average inflation/GDP Deflator data obtained from WB database and from The Business and Economy Database of Lebanon)

b. Assumption needed on WB Damage Cost Estimate. As this includes damages as a result of both 1. Uncontrolled coastal development and 2. Wastewater discharges, we need to eliminate the damages attributable to 1. Uncontrolled developments (WB does not try to separate the two). So two scenarios are assumed, and to provide a potential range:

- **i.** 25% of this damage is due to wastewater ($42 M)
- **ii.** 75% is due to wastewater ($127 M)

c. Physical Data and Assumptions on Coastal Wastewater Generated (WW Generated Data Set A.)

- **i.** Baseline section of the draft SEA reports 222 MCM/year (2010) and 394 MCM/year (2030) of total wastewater generated from BMLWE, NLWE and SLWE (excl. BWE). Baseline section also states that "Lebanon's coastline receives around 162 MCM/ year of untreated or partially treated sewage. Source: MOE/UNDP/ECODIT, 2011."
- **ii.** Therefore, **162 MCM/year of wastewater going to the coast in 2010**. This represents 73% of the total wastewater generated from these areas, which goes to the coast (162 MCM divided by 222 MCM). 73% is assumed to continue. 73% of 394 MCM (2030) **= 287 MCM generated that would potentially go to the coast for 2030.**
- **iii.** Also requires an estimate for the quantity of coastal wastewater for the year 2000, which would represent the quantity associated with the WB's damage estimate:

  Data for total wastewater generated by these areas in 2005 was obtained from "Wastewater treatment and reuse in Lebanon: key factors for future agricultural uses" (Karaa K., Karam F., Tarabey N., 2005) Amount = 198 MCM/yr. Again multiplied by 73% = **145 MCM/yr (2005) going to the coast.**

  Yearly values for wastewater going to the coast from year 2000 through 2030 extrapolated (linearly) based on the above three numbers (2005, 2010 and 2030). In year 2000, the damage cost resulting from the quantity of wastewater going to the coast (**127 MCM, yr 2000**) is tied to the estimated value range of $42 M to $127 M (see 1.b above).

Key Physical Data and Assumptions on Coastal Wastewater Treated (Scn. B. business as usual, & C. LWSS)

Year	2000	2005	2007	2010	2012	2015	2020	2030
A. Coastal WW Generated (MCM/Yr)	127.1	144.5	151.5	162.0	174.5	193.3	224.7	287.3
B. Business as usual Scenario								
% of coastal WW treated	**0%**	**0%**	**10%**	**25%**	**30%**	**30%**	**30%**	**30%**
Quantity going to the coast untreated	127.1	144.5	136.4	121.5	122.2	135.3	157.3	201.1
C. LWSS Scenario								
% of coastal WW treated	**0%**	**0%**	**10%**	**25%**	**30%**	**80%**	**95%**	**95%**
Quantity going to the coast untreated	127.1	144.5	136.4	121.5	122.2	38.7	11.2	14.4

Scn. B: 25% in 2010 based on WB2011 (40 MCM treated), others are assumptions. **Scn. C**: based on info from LWSS; extrapolated over time as needed. Assumes no increase in treatment w/o NWSS.

d. Values assumed to increase proportionally with the increase in quantity of untreated coastal wastewater over time. Benefits of implementing LWSS = difference between damage values associated with Scn. C and Scn. B. Present Value calculated for 2013 – 2020, and 2013 – 2030, using a 3% social discount rate.

Detailed Calculations

	Value Estimates for Coastal Water Improvements	Low	High	
i	WB 2004 Int. Tourism Losses (Tunisia benefits transfer)	$ 63,438,000	$ 74,375,000	
ii	WB 2004 Intrinsic Value (based on Junieh WTP)	$ 27,115,000	$ 40,205,000	
iii	WB 2004 Domestic Travel Costs (to further beaches)	$ 8,715,000	$ 12,180,000	
	TOTAL WB 2004 Coastal Damage Est. (annual, 2000)	**$ 99,268,000**	**$ 126,760,000**	Damage cost to the above 3 sub-items as a result of uncontrolled development and wastewater
	Average (2000 prices)	$	113,014,000	
	Average (2013 prices)	**$**	**169,229,168**	1.497 Price Conversion Factor (see Inflation worksheet)
	Portion assumed due to wastewater (low)	**$**	**42,307,292**	25% i.e., eliminating those attributable to uncontroled developments
	Portion assumed due to wastewater (high)	**$**	**126,921,876**	75% i.e., eliminating those attributable to uncontroled developments
	Reduced pollution (benefits) as a result of LWSS over time	*see detailed calculations below*		WB 2000 cost increased over time with increases in WW, benefits calculated based on decreases in WW as a result of treatment with the LWSS
	Social Discount Rate		*3%*	
	Present Value of Benefits 2013 - 2020 (US$ M, range)	**$233**	**$699**	7 years
	Present Value of Benefits 2013 - 2030 (US$ M, range)	**$608**	**$1,825**	17 years

DETAILED ANNUAL BENEFITS STREAM CALCULATIONS:

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
A	**Coastal Wastewater Generated (MCM/yr)**	127.1	130.6	134.1	137.6	141.0	**144.5**	148.0	151.5	155.0	158.5	**162.0**	168.3	174.5	180.8	187.1	193.3
25%	*Cost low (US$ M)*	*$ 42.3*	*$ 43.5*	*$ 44.6*	*$ 45.8*	*$ 47.0*	*$ 48.1*	*$ 49.3*	*$ 50.4*	*$ 51.6*	*$ 52.8*	*$ 53.9*	*$ 56.0*	*$ 58.1*	*$ 60.2*	*$ 62.3*	*$ 64.4*
75%	*Cost high (US$ M)*	*$ 126.9*	*$ 130.4*	*$ 133.9*	*$ 137.4*	*$ 140.9*	*$ 144.4*	*$ 147.8*	*$ 151.3*	*$ 154.8*	*$ 158.3*	*$ 161.8*	*$ 168.1*	*$ 174.3*	*$ 180.6*	*$ 186.8*	*$ 193.1*
	Note: damage cost increases pro-rated with WW quantity over time																
B	**Business as usual: % Treated without NWSS**	**0%**	0%	0%	0%	0%	0%	0%	**10%**	10%	10%	**25%**	25%	**30%**	30%	30%	30%
	Quantity untreated (MCM)	127.1	130.6	134.1	137.6	141.0	144.5	148.0	136.4	139.5	142.7	121.5	126.2	122.2	126.6	130.9	135.3
25%	*Cost low (US$ M)*	*$ 42.3*	*$ 43.5*	*$ 44.6*	*$ 45.8*	*$ 47.0*	*$ 48.1*	*$ 49.3*	*$ 45.4*	*$ 46.4*	*$ 47.5*	*$ 40.4*	*$ 42.0*	*$ 40.7*	*$ 42.1*	*$ 43.6*	*$ 45.1*
75%	*Cost high (US$ M)*	*$ 126.9*	*$ 130.4*	*$ 133.9*	*$ 137.4*	*$ 140.9*	*$ 144.4*	*$ 147.8*	*$ 136.2*	*$ 139.3*	*$ 142.5*	*$ 121.3*	*$ 126.0*	*$ 122.0*	*$ 126.4*	*$ 130.8*	*$ 135.2*
C	**% Treated with the NWSS**	0%	0%	0%	0%	0%	0%	0%	10%	10%	10%	25%	25%	**30%**	47%	63%	**80%**
	Quantity untreated (MCM)	127.1	130.6	134.1	137.6	141.0	144.5	148.0	136.4	139.5	142.7	121.5	126.2	122.2	96.4	68.6	38.7
25%	*Cost low (US$ M)*	*$ 42.3*	*$ 43.5*	*$ 44.6*	*$ 45.8*	*$ 47.0*	*$ 48.1*	*$ 49.3*	*$ 45.4*	*$ 46.4*	*$ 47.5*	*$ 40.4*	*$ 42.0*	*$ 40.7*	*$ 32.1*	*$ 22.8*	*$ 12.9*
75%	*Cost high (US$ M)*	*$ 126.9*	*$ 130.4*	*$ 133.9*	*$ 137.4*	*$ 140.9*	*$ 144.4*	*$ 147.8*	*$ 136.2*	*$ 139.3*	*$ 142.5*	*$ 121.3*	*$ 126.0*	*$ 122.0*	*$ 96.3*	*$ 68.5*	*$ 38.6*
	Difference between C (with scenario) and B (without scenario)																
25%	*Cost low (US$ M)*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ 10.0*	*$ 20.8*	*$ 32.2*
75%	*Cost high (US$ M)*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ 30.1*	*$ 62.3*	*$ 96.5*

	YEAR	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
A	**Coastal Wastewater Generated (MCM/yr)**	199.6	205.9	212.1	218.4	224.7	**230.9**	237.2	243.5	249.7	256.0	**262.3**	268.5	274.8	281.1	287.3	
25%	*Cost low (US$ M)*	*$ 66.4*	*$ 68.5*	*$ 70.6*	*$ 72.7*	*$ 74.8*	*$ 76.9*	*$ 79.0*	*$ 81.1*	*$ 83.1*	*$ 85.2*	*$ 87.3*	*$ 89.4*	*$ 91.5*	*$ 93.6*	*$ 95.7*	
75%	*Cost high (US$ M)*	*$ 199.3*	*$ 205.6*	*$ 211.9*	*$ 218.1*	*$ 224.4*	*$ 230.6*	*$ 236.9*	*$ 243.2*	*$ 249.4*	*$ 255.7*	*$ 261.9*	*$ 268.2*	*$ 274.5*	*$ 280.7*	*$ 287.0*	
	Note: damage cost increases pro-rated with WW quantity over time																
B	**Business as usual: % Treated without NWSS**	**30%**	30%	30%	30%	30%	30%	30%	**30%**	30%	30%	**30%**	30%	**30%**	30%	30%	
	Quantity untreated (MCM)	139.7	144.1	148.5	152.9	157.3	161.7	166.0	170.4	174.8	179.2	183.6	188.0	192.4	196.7	201.1	
25%	*Cost low (US$ M)*	*$ 46.5*	*$ 48.0*	*$ 49.4*	*$ 50.9*	*$ 52.4*	*$ 53.8*	*$ 55.3*	*$ 56.7*	*$ 58.2*	*$ 59.7*	*$ 61.1*	*$ 62.6*	*$ 64.0*	*$ 65.5*	*$ 67.0*	
75%	*Cost high (US$ M)*	*$ 139.5*	*$ 143.9*	*$ 148.3*	*$ 152.7*	*$ 157.1*	*$ 161.4*	*$ 165.8*	*$ 170.2*	*$ 174.6*	*$ 179.0*	*$ 183.4*	*$ 187.7*	*$ 192.1*	*$ 196.5*	*$ 200.9*	
C	**% Treated with the NWSS**	83%	86%	89%	92%	95%	95%	95%	95%	95%	95%	95%	95%	**95%**	95%	95%	
	Quantity untreated (MCM)	33.9	28.8	23.3	17.5	11.2	11.5	11.9	12.2	12.5	12.8	13.1	13.4	13.7	14.1	14.4	
25%	*Cost low (US$ M)*	*$ 11.3*	*$ 9.6*	*$ 7.8*	*$ 5.8*	*$ 3.7*	*$ 3.8*	*$ 3.9*	*$ 4.1*	*$ 4.2*	*$ 4.3*	*$ 4.4*	*$ 4.5*	*$ 4.6*	*$ 4.7*	*$ 4.8*	
75%	*Cost high (US$ M)*	*$ 33.9*	*$ 28.8*	*$ 23.3*	*$ 17.5*	*$ 11.2*	*$ 11.5*	*$ 11.8*	*$ 12.2*	*$ 12.5*	*$ 12.8*	*$ 13.1*	*$ 13.4*	*$ 13.7*	*$ 14.0*	*$ 14.3*	
	Difference between C (with scenario) and B (without scenario)																
25%	*Cost low (US$ M)*	*$ 35.2*	*$ 38.4*	*$ 41.7*	*$ 45.1*	*$ 48.6*	*$ 50.0*	*$ 51.3*	*$ 52.7*	*$ 54.0*	*$ 55.4*	*$ 56.8*	*$ 58.1*	*$ 59.5*	*$ 60.8*	*$ 62.2*	
75%	*Cost high (US$ M)*	*$ 105.7*	*$ 115.1*	*$ 125.0*	*$ 135.2*	*$ 145.8*	*$ 149.9*	*$ 154.0*	*$ 158.1*	*$ 162.1*	*$ 166.2*	*$ 170.3*	*$ 174.3*	*$ 178.4*	*$ 182.5*	*$ 186.5*	

Note: "A" excludes Mount Lebanon and Bekaa: Domestic & Commercial Wastewater Generated that goes into the sea or nearby stream/rivers/aquifers that go into the sea (MCM/yr)

Source: Adapted from, CDR 2001, found in Karaa K., Karam F., Tarabey N. Wastewater treatmen t an d reu se i n Leban on :for 2005

2010 and 2030 from baseline (WB, 2011)

Note: "B" 25% in 2010 based on WB2011 (40 MCM treated), moving forward are assumed no increase in treatement w/o NWSS for comparison purposes

Note: "C" based on info from LWSS; extrapolated over time as needed.

Value of Reduced Salinity of Coastal Aquifers as a result of reduced GW Abstractions

e. Basis of Benefit Estimate. The potential damage estimate to coastal aquifers resources from saline water intrusion is valued using the cost of treatment approach (i.e., valued using the cost of potentially desalinating desalinating) the resource (i.e., aquifer's safe yield) as a proxy estimate of the damage caused.

- **i.** Unit cost of desalination used is US$ 0.56 / m3. This is the estimated average cost assuming RO desalination with unit capacities ranging from 1000 – 60,000 m3/day reported in Karagiannis and Soldatos, (2008) Desalination 223: 448-456 (see http://www.rac.es/ficheros/doc/00731.pdf).

f. Physical Data and Assumptions on Coastal Groundwater Abstractions.

- **i.** Baseline section of the draft SEA (like SOER 2010) indicate **a total of 503 MCM/year in total groundwater well abstractions** (legal, illegal, public) in BMLWE, NLWE and SLWE
- **ii.** Two scenarios are assumed for **the portion** of these total groundwater abstractions, which are **associated with coastal aquifer / aquifers impacted by saline intrusion**, and to provide a potential range: **25% (i.e., 125.7 MCM/yr) and 50% (251.3 MCM/yr)**
- **iii.** Referring to the entire country, the WB Lebanon 2012-2016 Country Water Sector Assistance Strategy also states that "Groundwater is over-extracted (0.7 BCM against total recharge of 0.5 BCM)". Assuming that this same ratio 71% (0.5 BCM/0.7 BCM) is applicable to coastal aquifers, the **safe yield** of the coastal aquifers is estimated to range **between 89.8 MCM/yr to 179.5 MCM/yr** (i.e., 71% of the coastal aquifer abstractions numbers presented in 2.b.ii above)
- **iv.** Implementing the LWSS is assumed to reduce over-abstractions so that there will be **no more saline intrusion by 2025 (Scenario B)**. Without the LWSS, saline intrusion is assumed to continue as it currently is (Scn. A – baseline).

g. Valuation. The current damage (2013) is estimated to range between $26.9 M ($0.56 x 89.8 MCM/yr) and $53.9 M ($0.56 x 179.5 MCM/yr). By 2020, and after implementing the LWSS, this damage reduces to zero and continues into the future as such. Benefits of implementing LWSS = difference between values associated with Scn. B and Scn. A. Present Value calculated for 2013 – 2020, and 2013 – 2030, using a 3% social discount rate.

Detailed Calculations

	Value Estimates for Reduced Saline Intrusion	Total GW Abstr. (MCM/yr)	Est. Coastal GW Abstr. (MCM/yr)	Est. Coastal GW Abstr. (MCM/yr)	
			25%	**50%**	assumed coastal aquifer abstractions portion (%)
	BMLWE	*195*	*48.8*	*97.6*	
	NLWE	*151*	*37.6*	*75.3*	
	SLWE	*157*	*39.3*	*78.5*	
	TOTAL	**503**	**125.7**	**251.3**	Source: Baseline Below; % assumed
	Safe Yeild (MCM/Yr)	71%	**89.8**	**179.5**	Source: WB Lebanon 2012-2016 Country Water Sector Assistance Strategy: "Groundwater is over-extracted (0.7 BCM against total recharge of 0.5 BCM)" = 0.5/0.7 general ratio for whole country)
	Cost to desalinate (US$/m3, and **US$ M/yr**)	$ 0.56	**$ 50.3**	**$ 100.5**	Source for costs: Karagiannis and Soldatos, (2008) Desalination 223: 448-456 (in http://www.rac.es/ficheros/doc/00731.pdf); average cost for RO of Brackish water with units ranging from 1000 - 6000 m3/day
	Reduction in saline intrusion as a result of LWSS over time	*see detailed calculations below*			Valuation of damage to the resource = cost of treating (i.e., desalinating) the resource (i.e., safe yield)
	Social Discount Rate			*3%*	
	Present Value of Benefits 2013 - 2020 (US$ M, range)		**$98**	**$406**	
	Present Value of Benefits 2013 - 2030 (US$ M, range)		**$197**	**$811**	

DETAILED ANNUAL BENEFITS STREAM CALCULATIONS:

	YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
A	**Saline Intrusion w/o the LWSS**	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
25%	*Cost low (US$ M)*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*
50%	*Cost high (US$ M)*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*
	Note: damage cost increases pro-rated with WW quantity over time																		
B	**Saline Intrusion with the LWSS**	**100%**	92%	83%	75%	67%	58%	50%	42%	33%	25%	17%	8%	**0%**	0%	0%	0%	0%	0%
25%	*Cost low (US$ M)*	*$ 50.3*	*$ 46.1*	*$ 41.9*	*$ 37.7*	*$ 33.5*	*$ 29.3*	*$ 25.1*	*$ 20.9*	*$ 16.8*	*$ 12.6*	*$ 8.4*	*$ 4.2*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*
50%	*Cost high (US$ M)*	*$ 100.5*	*$ 92.2*	*$ 83.8*	*$ 75.4*	*$ 67.0*	*$ 58.6*	*$ 50.3*	*$ 41.9*	*$ 33.5*	*$ 25.1*	*$ 16.8*	*$ 8.4*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*
	Difference between B (with scenario) and A (without scenario)																		
25%	*Cost low (US$ M)*	*$ -*	*$ 4.2*	*$ 8.4*	*$ 12.6*	*$ 16.8*	*$ 20.9*	*$ 25.1*	*$ 29.3*	*$ 33.5*	*$ 37.7*	*$ 41.9*	*$ 46.1*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*	*$ 50.3*
50%	*Cost high (US$ M)*	*$ -*	*$ 8.4*	*$ 16.8*	*$ 25.1*	*$ 33.5*	*$ 41.9*	*$ 50.3*	*$ 58.6*	*$ 67.0*	*$ 75.4*	*$ 83.8*	*$ 92.2*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*	*$ 100.5*

Increase in Bird Watching Recreational Value as a result of Reservoirs

Methodology

h. Basis of Benefit Estimate. WB 2004 estimates the annual recreational value of migratory bird watching in the Shouf Cedar Biosphere Reserve (SBR) at $43,500 in the year 2000. This assumes that the current number of visitors to SBR continue. Converting $43,500 to 2013 prices = $65,138 (price conversion factor = 1.5). WB 2004 continues to estimate that the aggregated value for all of Lebanon would be $1.6 M (in 2000). These values do not cover the existence value of birds, especially endangered species, nor their ecological value.

i. Physical Data and Assumptions on Bird Watching.

i. There are two water bodies in / around SBR: Ammiq Wetlands and the Qaroun Resrvoir.

ii. Again, two scenarios are assumed, and to provide a potential range: between 50% and 75% of the total bird watching in SBR is carried out at or near these water bodies and/or because of these two water bodies. 50% of $65,138 = $32,569 ; and 75% = $48,853 gives the potential value range of bird watching as a result of the two water bodies. This is $16,284 and $24,427 respectively per water body.

iii. The LWSS provides a detailed list of when each dam / reservoir is planned to be completed, with a total of 28 planned by 2020, as follows:

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
No. of Water Bodies Built	1	1	2	11	6	-	-	-	7
Cumulative	1	2	4	15	21	21	21	21	28

j. Valuation. Applying the range of $16,284 to $24,427 in bird watching benefits per water body to the number of water bodies built under the LWSS. Present Value calculated for 2013 – 2020, and 2013 – 2030, using a 3% social discount rate.

Detailed Calculations

	Value Estimates for Increased Bird Watching	Total GW Abstr. (MCM/yr)		
	2000 Recreational Value of Bird Watching in SBR	$ 43,500		2000 estimate of the annual recreational value of migratory bird watching in the Shouf Cedar Reserve assuming the current number of visitors to SBR continues: WB 2004
	2013 Price	$ 65,138	1.497	Price Conversion Factor (see Inflation worksheet)
	Water Body Areas in/near SBR (No.)	1.0		
	Low Value Estimates per Water Body Area	$ 32,569	50%	Assumed SBR bird watching done in or b/c of the wetland & lake
	High Value Estimates per Water Body Area	$ 48,853	75%	Assumed SBR bird watching done in or b/c of the wetland & lake
	Water Body Areas as a result of NWSS over time	*seebelow*		
	Social Discount Rate		*3%*	
	Present Value of Benefits 2013 - 2020 (US$ M, range)	**$3,679,556**	**$5,519,334**	
	Present Value of Benefits 2013 - 2030 (US$ M, range)	**$9,820,312**	**$14,730,468**	

	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Number of Water Bodies Built	1.00	1.00	2.00	11.00	6.00	-	-	-	7.00	-	-	-	-	-	-	-	-	-	-
	Cumulative No. of Water Bodies Built	1.00	2.00	4.00	15.00	21.00	21.00	21.00	21.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
50%	*Value low (US$)*		$ 65,138	$ 130,275	$ 488,533	$ 683,946	$ 683,946	$ 683,946	$ 683,946	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927	$ 911,927
75%	*Value high (US$)*		$ 97,707	$ 195,413	$ 732,799	$ 1,025,918	$ 1,025,918	$ 1,025,918	$ 1,025,918	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891	$ 1,367,891

Averted Expenditure in Private Water Purchases

Methodology

k. Basis of Benefit Estimate. WB 2010 Water Sector: Public Expenditure Review: "The opportunity costs of failing public sector provision are high, amounting to about USD 307 million, equivalent to the total annual household cost for private water provision."

l. Physical Data, Assumptions on Water Supply, and Valuation.

The following domestic water data was obtained from the baseline section (Demand) and from the NWSS (Supply). The difference (deficit) between anticipated domestic demand and supply is assumed as quantities which require purchasing by households from private vendors. The WB2010 USD 307 million estimate is applied to the deficit in 2010, and subsequently prorated with the deficits calculated for future year.

Estimated annual water demand in Mm^3 by sector (2010 -2035)						
Sector	***2010***	***2015***	***2020***	***2025***	***2030***	***2035***
Domestic	505.0	460.0	427.0	467.0	512.0	562.0
Estimated domestic water suppy based on Pg. 37 of the NWSS						
lcd (Urban)	180.0	174.0	167.0	176.0	185.0	194.0
Pop (M)	4.4	4.8	5.3	5.7	6.4	6.8
MCM/yr (Calc)	291.1	306.8	320.6	368.7	430.1	482.9
Deficit Between Demand and Supply, assumed as purchased from private vendors						
Diff MCM	213.9	153.2	106.4	98.3	81.9	79.1
in LCD	132.3	86.9	55.4	46.9	35.2	31.8
Cost	$ 307.0	$ 219.9	$ 152.6	$ 141.0	$ 117.5	$ 113.5

Detailed Calculations

			-50%	50%
	Social Discount Rate	*3%*		
	Present Value of Benefits 2013 - 2020 (US$ M, range)	$196	**$ 98**	**$ 294**
	Present Value of Benefits 2013 - 2030 (US$ M, range)	$1,002	**$ 501**	**$ 1,504**

	Item (sources Pg. 37 of NWSS)	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***2025***	***2026***	***2027***	***2028***	***2029***	***2030***	***2035***
A.	Domestic Demand (MCM/yr)	505	496	487	478	469	460	453	447	440	434	427	435	443	451	459	467	476	485	494	503	512	562
B.	Domsetic Consumption / Supply??? (LCD)	180	179	178	176	175	174	173	171	170	168	167	169	171	172	174	176	178	180	181	183	185	194
C.	Population (M)	4.43	4.51	4.59	4.67	4.75	4.83	4.92	5.00	5.09	5.17	5.26	5.36	5.45	5.55	5.64	5.74	5.87	5.99	6.12	6.24	6.37	6.82
	Calculations (w/NWSS):																						
D.	Domsetic Consumption / Supply? (MCM/yr - Calculated from B. & C.)	291	294	298	301	304	307	310	313	315	318	321	330	339	349	359	369	381	393	405	418	430	483
E.	Difference MCM/yr (A. - D.)	214	202	189	177	165	153	144	134	125	116	106	105	104	102	100	98	95	92	89	85	82	79
F.	Cost (US$ M) for private water provision w/NWSS	**$ 307**	$ 289	$ 272	$ 254	$ 237	$ 220	$ 206	$ 193	$ 179	$ 166	$ 153	$ 151	$ 149	$ 146	$ 144	$ 141	$ 137	$ 132	$ 128	$ 123	$ 117	$ 113
	Calculations (w/o NWSS):																						
G.	Domsetic Consumption / Supply? (MCM/yr - assumed no change)	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291	291
H.	Difference MCM/yr (A. - G.)	214	205	196	187	178	169	162	156	149	143	136	144	152	160	168	176	185	194	203	212	221	271
I.	Cost (US$ M) for private water provision w/NWSS	**$ 307**	$ 294	$ 281	$ 268	$ 255	$ 242	$ 233	$ 223	$ 214	$ 205	$ 195	$ 207	$ 218	$ 230	$ 241	$ 252	$ 265	$ 278	$ 291	$ 304	$ 317	$ 389
	Calculations (savings from NWSS):																						
J.	Savings (US$ M) associated with private water provision b/c of NWSS (I. - F.)	$ -	$ 5	$ 9	$ 14	$ 18	$ 23	$ 27	$ 31	$ 35	$ 39	$ 42	$ 56	$ 70	$ 83	$ 97	$ 111	$ 129	$ 146	$ 164	$ 181	$ 200	$ 275

Source for (Cost, F. & I.) $307 M: WB 2010 Water Sector: Public Expenditure Review
"Total annual household cost for private water provision"
Cost in the future prorated for difference (deficit) that requires purchasing

Estimated Cost of Sea Water Desalination vs. Dams

Methodology

- **i.** The quantities of water made available from the Dams (dynamic capacities) were obtained from the NWSS.
- **ii.** The CAPEX and OPEX of dams is obtained from the NWSS as explained in the calculations below. To provide a higher-end estimate, a 30% increase in costs / overruns was used.
- **iii.** The range in CAPEX and OPEX per m3 of sea water desalination were estimated based on review of several sources which have reported such costs for larger-scale desalination projects in various parts of the world. These were applied to the same quantities as those which would be made available by the Dams.
- **iv.** The savings are calculated as the difference in present value between the two above.

Detailed Calculations

Cost of Desalination Alternative	Low	High					
CAPEX $M /MCM	$5.00	$10.00	Based on a review of various literature reporting costs of larger scale sea water desalination				
OPEX $M /MCM	$0.35	$1.00					
i.e., long term equivilent $per m3 (CAPEX + OPEX / m3 long-run average)	$ 0.78	$ 1.86					
Volume of Water Provided by Dams	*seebelow*						
Social Discount Rate		*3%*	**Dams**		**Difference / Savings**		
Present Value of Desal Costs 2011 - 2020 (US$ M, range)	**$2,471**	**$5,304**	**$1,869**	**$2,429**	*$603*	*$2,874*	
Present Value of Desal Costs 2011 - 2030 (US$ M, range)	**$3,625**	**$8,599**	**$2,339**	**$3,041**	*$1,286*	*$5,558*	

Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Volume from Dams		0.80	1.00	4.20	43.90	189.10	-	-	-	280.10	-	-	-	-	-	-	-	-	-	-
Cumulative Volume from Dams		0.80	1.80	6.00	49.90	239.00	239.00	239.00	239.00	519.10	519.10	519.10	519.10	519.10	519.10	519.10	519.10	519.10	519.10	519.10
Desal cost Low	-	$ 4.3	$ 5.63	$ 23.10	$ 236.97	$ 1,029.15	$ 83.65	$ 83.65	$ 83.65	$ 1,582.19	$ 181.69	$ 181.69	$ 181.69	$ 181.69	$ 181.69	$ 181.69	$ 181.69	$ 181.69	$ 181.69	$ 181.69
Desal cost High	-	$ 8.8	$ 11.80	$ 48.00	$ 488.90	$ 2,130.00	$ 239.00	$ 239.00	$ 239.00	$ 3,320.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10	$ 519.10
CAPEX of DAMS (Pg. 78 & 89 of NWSS)	$ 174	253	285	339	214	170	135	135	161	111										
OPEX of DAMS (from Pg. 51, applied to Dams listed in Pg 89)		0.10	-	0.40	9.60	16.60	-	-	-	47.40	-	-	-	-	-	-	-	-	-	-
Cumm. OPEX		0.10	0.10	0.50	10.10	26.70	26.70	26.70	26.70	74.10	74.10	74.10	74.10	74.10	74.10	74.10	74.10	74.10	74.10	74.10
CAPEX + OPEX Low (per NWSS estimates)	$ 174	$ 253	$ 285	$ 340	$ 224	$ 197	$ 162	$ 162	$ 188	$ 185	$ 74	$ 74	$ 74	$ 74	$ 74	$ 74	$ 74	$ 74	$ 74	$ 74
CAPEX + OPEX high (30% CAPEX & OPEX overruns)	$ 226	$ 329	$ 371	$ 441	$ 291	$ 256	$ 210	$ 210	$ 244	$ 241	$ 96	$ 96	$ 96	$ 96	$ 96	$ 96	$ 96	$ 96	$ 96	$ 96

Inflation Data (GDP Deflator)

Used for Price Conversions (e.g., 2000 prices converted to 2013 prices) where applicable

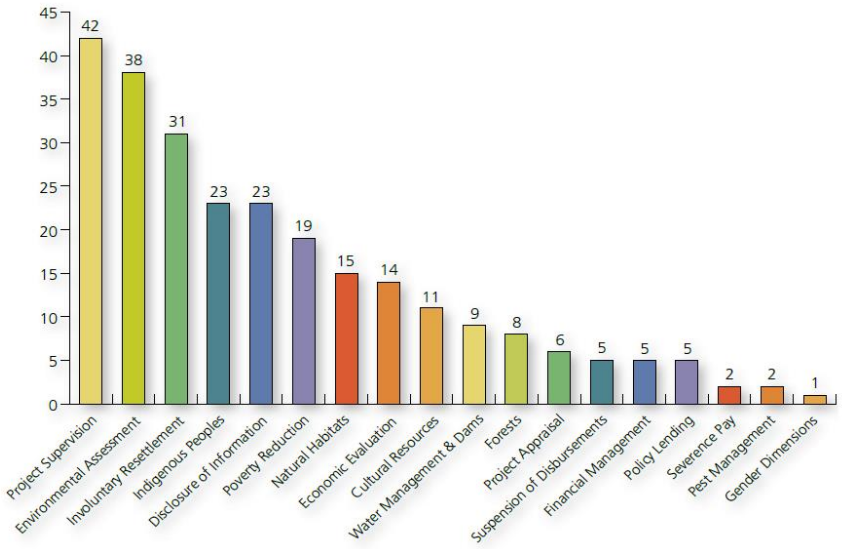
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Inflation rate (Leb Data)	1.30%	4.30%	3.00%	1.70%	-2.60%	5.60%	9.30%	5.50%	3.40%	4.60%	3.10%	n/a	http://www.databank.com.lb/default.asp?catid=2&ChildCount=2#s_2
Factor	1.00	1.04	1.07	1.09	1.06	1.12	1.23	1.30	1.34	1.40	1.445	n/a	
Inflation rate (WB)	-1.63%	4.97%	1.57%	0.95%	-0.66%	2.03%	3.88%	9.86%	6.17%	0.13%	4.85%	5.63%	http://databank.worldbank.org/data/views/reports/tableview.aspx#
Factor	1.00	1.05	1.07	1.08	1.07	1.09	1.13	1.24	1.32	1.32	1.388	1.466	
Avg	-0.17%	4.64%	2.29%	1.32%	-1.63%	3.82%	6.59%	7.68%	4.79%	2.36%	3.98%	5.63%	
Factor	1.00	1.05	1.07	1.08	1.07	1.11	1.18	1.27	1.33	1.36	1.418	**1.497**	

ANNEX 11.4 IFIS POLICIES ON EXPROPRIATION AND INVOLUNTARY RESETTLEMENT

This Annex was generously prepared by Mr. Jean-Roger Mercier for ECODIT in support of this SEA Report.

Expropriations and assistance to resettlement if and where needed

Access to land by poor and family farmers has since the late 80's been a recurrent battleground between activist NGOs, supported by very visible personalities (artists, religious leaders, etc.) and the International Financial Institutions (IFIs). Facts on demonstrations as well as on statistics from international complaint mechanisms confirm this statement.



Source: World Bank's Inspection Panel – 15 year report – 2009

Consequently, IFI social policies worldwide have laid emphasis on enhanced processes to protect and help the local people and communities losing access to their lands, rightly considered of prime importance for their basic livelihoods. Requirements by the IFI are way beyond, procedurally and financially, what a Government usually does to barely compensate for land lost.

Historically, the World Bank (IDA/IBRD, later shared by the IFC) was the first IFI to adopt an operational policy on involuntary resettlement (Operational Directive 4.30 of 1990, soon thereafter converted into the Operational Policy/Bank Procedure format as OP/BP 4.12) and the regional development banks followed suit rapidly.

A major change was IFC's adoption of its Environmental and Social Performance Standards (2006) where PS 5 deals specifically with Land acquisition and involuntary resettlement.[80] IFC's performance standards are of relevance because they form the foundation for the Equator Principles, now adopted by some 80 commercial banks around the world and applied to all investments/loans above US$10 M.

The World Bank (IDA/IBRD), on its side, is revamping its environmental and social safeguard policies as part of a major 2-year consultation effort and the policy/procedures on involuntary resettlement will be part of that revamping process, which specifically also aims for greater integration of

[80] Guidance provided here: http://www.ifc.org/wps/wcm/connect/4b9767004980 08d3a417f6336b93d75f/Updated_GN5-2012.pdf?MOD=AJPERES)

environmental and social requirements. IFIs have produced ample guidance on the management of involuntary resettlement.[81]

Treatment of expropriation risks and other limitations of access to land in Strategic Environmental and Social Assessment (SESA), the process adopted by the WB in 2011 during the latest revision of OP/BP 4.01 on Environmental Assessment, is not entirely set in stone. Policy guidance can be retrieved here.[82]

Dealing with squatters and other illegal settlers:

One of the issues that haunt governments dealing with IFIs is that of squatters and illegal settlers, groups that Governments, by definition, simply chase out of the land under consideration for (e.g. biodiversity) development projects. IFIs require a more humane treatment of such settlers and this generates direct additional costs and often conflicts between Governments and the IFIs, the Governments, in particular, fearing some forms of legal precedents.

Biodiversity is particularly a case in point since a dilemma is often presented in, for instance, gazetted forests occupied by illegal settlers, where either the settlers are moved out and biodiversity restored or better managed, or settlers are allowed to stay at the cost of biodiversity protection. IFIs have included the issues related to squatters and other illegal settlers in their guidance.

Limitation of access by riparian human communities (typically wood collection, but also poaching):

Another case in point is limitation of access to natural resources by riparian communities and people in the case of additional nature protection provided (National parks, other status of protected areas). IFIs treat that as « economic » displacement (vs. « physical » displacement in the case of ousting people) and this also is dealt with in IFI guidance on involuntary resettlement.

[81] For example, World Bank Handbook http://go.worldbank.org/MRNITY6XN0

[82] *http://siteresources.worldbank.org/ENVIRONMENT/Resources/244380-1236266590146/Policy_SEA_WB.pdf*

ANNEX 11.5 PUBLIC-PRIVATE-PARTNERSHIP OPTIONS

Although there is a multitude of types of contracts for private sector operations of water and wastewater systems, a brief description of the various options for private sector participation in the water services delivery is given below.

- **Service Contracts**: Service contracts include supply and civil work contracts, technical assistance contracts, plus sub-contracting or contracting out aspects of the water supply service. These sub-contracts can address a wide range of activities, ranging from meter reading, billing and invoicing and customer service management, to design activities, O&M support and construction activities. In cases of political and/or social opposition against PSP in the water sector, service contracts can be a good means to introduce the efficiency of the private sector to the public sector. At the same time it can be a first careful step towards further private sector involvement.
- **Management Contracts**: A management contract resembles a service contract, to the extent that only services are provided and no capital investments are made and very limited commercial risks are transferred from the utility or public authority to a private party. The main difference is that rather than contracting out various 'bits and pieces' the authority or utility contracts out its operations in full, or at least a significant part of it. Investment responsibilities remain with the public sector, so consequently management contracts particularly address the improvement of service standards to existing customers. Since there are no private sector investments, service area expansion or increasing treatment and production capacities are not facilitated by a management contract.
- **Lease Contracts**: Lease contracts include the transfer of the entire operation of a utility in a certain area to a private party. The utility leases its infrastructure to an operator against a lease fee, while the operator, in exchange, gets the right to collect water charges from consumers for its own account. Typical tasks of an operator under a lease contract include the optimisation of billing and collection rates, bringing down operational costs, increasing customer focus, and improving the overall quality of the infrastructure by seeing to professional maintenance
- **BOT Type Contracts**: BOT, build-own-operate-transfer (BOOT), and Rehabilitate-own-Transfer (ROT) schemes come in a wide variety, and are similar to lease contracts. However, BOT contracts are particularly aimed at bulk supply, rather than at retail services. BOT and alike contracts are typically used for new infrastructure to be built (or: 'green field' projects). In the water sector this type of contract is used particularly for water and wastewater treatment infrastructure. BOT contracts are usually concluded for a duration between 10 and 30 years.
- **Concession Contracts** (full utility / retail): A concession contract leaves the entire commercial and capital investment risks to a private operator, which is typically allowed to use already existing infrastructure to supply customers with water and wastewater services. A concession contract thus combines the BOT characteristic of large-scale investments and the lease characteristics of taking on the responsibility for an entire system and its operation. The typical duration for a Concession contract is around 25 years.
- **Divestiture / Full privatization** (retail): Under a divestiture arrangement the assets of a utility are transferred to a private (or public -private) party or joint venture. In a full divestiture, the private sector has full responsibility for operations, maintenance, and investment in a utility. The private party thus becomes the owner of the infrastructure.

ANNEX 11.6 TECHNOLOGICALLY AND ECONOMICALLY PROVEN DESALINATION TECHNOLOGIES

- Multi-stage flash (MSF) which is a proven large scale desalination technique widely used in the Arabian peninsula. The largest individual desalination units (of any process) exceed 80,000m3/d and use the MSF process however all large MSF systems are coupled to the heat rejected from fossil fired thermal power plants. MSF requires pumping power similar to that of seawater reverse osmosis (SWRO) but by also using low grade heat they produce a very high quality distilled water. MSF is a very robust but capital intensive process with a large scale track record of several decades. The main shortcoming of is that it requires large quantities of heat.

- Multiple-effect distillation (MED) is a thin film technique which produces the same high quality distilled water as MSF using the same, or slightly less heat and significantly less pumping power. MED systems typically use 65-75% less pumping power than SWRO or MSF which has made the process increasingly popular in the Arabian peninsula where unit capacities now exceed 45,000m3/d. Large MED units are also almost exclusively coupled with fossil power plants or in some cases very large petro-chemical facilities with abundant heat sources. MED is a more proprietary process than MSF with only one serious contractor capable of providing units larger than 20,000m3/d. Like MSF the main shortcoming of MED for this project is that it requires large quantities of heat.

- Reverse Osmosis (RO) is a method of separating water from dissolved salts by passing feedwater through a semipermeable membrane at a pressure greater than the osmotic pressure caused by the dissolved salts. There are currently between 3 and 5 companies that produce commercially proven RO membranes suitable for use on seawater and there are many contractors experienced in engineering, procurement and construction (EPC) of large SWRO facilities. Individual RO membranes are predominantly provided in a commoditized standard configuration of 8" diameter by 40" long spiral wound element. Each RO membrane element produces a nominal 20-25m^3/d under ideal conditions so many thousand membranes are incorporated into the largest operating facilities which today produce over 300,000m^3/d.

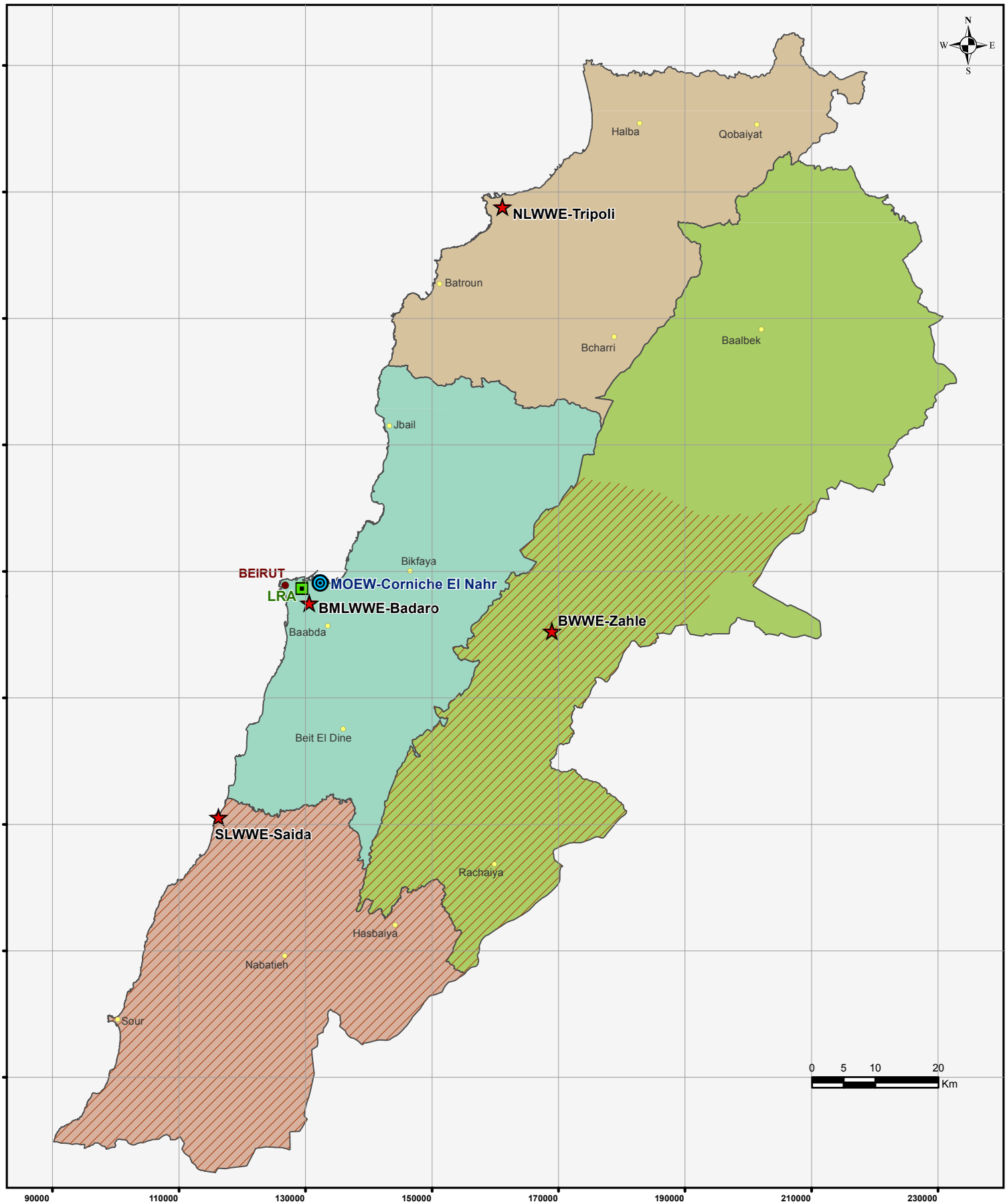
Both MED and MSF require large quantities of heat while the RO process is driven solely by pressure difference across semi-permeable membranes. It is very likely that improvements in SWRO technology in the near future will reduce the cost and simplify the operating and maintenance requirements. These may include the large diameter membranes discussed above which are becoming more widely commercially available and could demonstrate acceptable performance and life by 2015/2016. There are also possibilities for new membrane materials to offer proven performance improvements in the same time frame.

SWRO is now widely utilized for large scale desalination projects on several continents and is widely accepted as having the potential to produce the lowest cost of desalted water among all currently commercialized processes. Many projects larger than 100,000m3/d are already operating. SWRO is a very modular technology based around many parallel RO membranes. The process has been shown to be reliable and scalable. In most cases the capacity of the project is limited by local demand and other practical considerations rather than what can be achieved by the process. Only a few projects have been larger than 150,000m3/d. Since SWRO can be located anywhere along a coast it can, in many cases, be beneficial to have multiple desalination projects built in phases that help avoid or reduce the need to invest in transmission pipelines.

ANNEX 11.7 MAPS

1. Water & Wastewater Institutions in Lebanon
2. Water Resources & Wastewater Management in North Lebanon WE
3. Water Resources & Wastewater Management in Beirut & Mount Lebanon WE
4. Water Resources & Wastewater Management in South Lebanon WE
5. Water Resources & Wastewater Management in Bekaa WE
6. Water Resources & Management in Litani River Basin
7. Surface & Underground Water Resources in Lebanon
8. Geology & Tectonic Risk of Surface Water Infrastructure
9. Location of Environmental Sensitive Areas & Large Water Infrastructure in Lebanon
10. Irrigation Perimeters & Poverty Linkages

Water & Wastewater Establishments in Lebanon



Legend

- Capital City
- Main Towns
- Ministry of Energy & Water (MOEW)

Litani River Authority (LRA)

- Head Office in Bechara El Khoury
- Boundary

Regional Water & Wastewater Establishments

- Head Offices
- North Lebanon (NLWWE)
- Beirut & Mount Lebanon (BMLWWE)
- South Lebanon (SLWWE)
- Bekaa (BWWE)

Project

Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info

No.: Infrastructure-Establishments-Map 01
Scale: 1:800,000
Projection: Lambert Conformal Conic

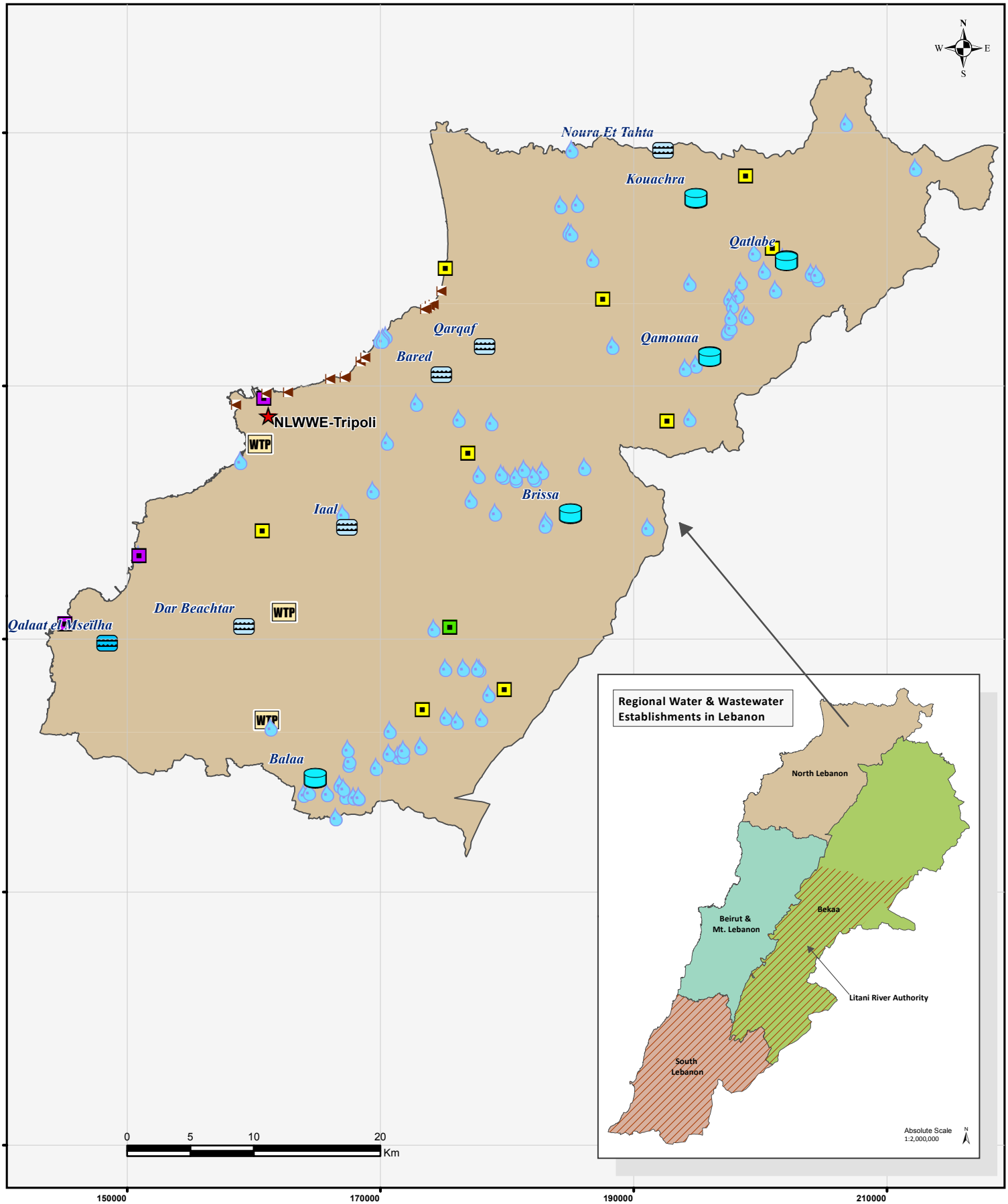
Source

This map was prepared by ECODIT based on the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

Every effort has been made to ensure the accuracy of the information displayed on this map. The international boundaries are approximate. Plan Bleu/ECODIT do not assume any responsibility for any decision that may arise from the use of the map.

Water Resources & Wastewater Management in North Lebanon
Water & Wastewater Establishment



Legend

- NLWWE Boundary
- Head Office
- Main Springs
- Hill-Lakes
- WTP Water Treatment Plant
- Sea Sewer Outfalls

Dams
- Planned
- Under Construction

Wastewater Treatment Plants-CDR
- Planned
- Under Construction
- Completed

Project

Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info

No.: Infrastructure-NLWWE-Map 02
Scale: 1:400,000
Projection: Lambert Conformal Conic

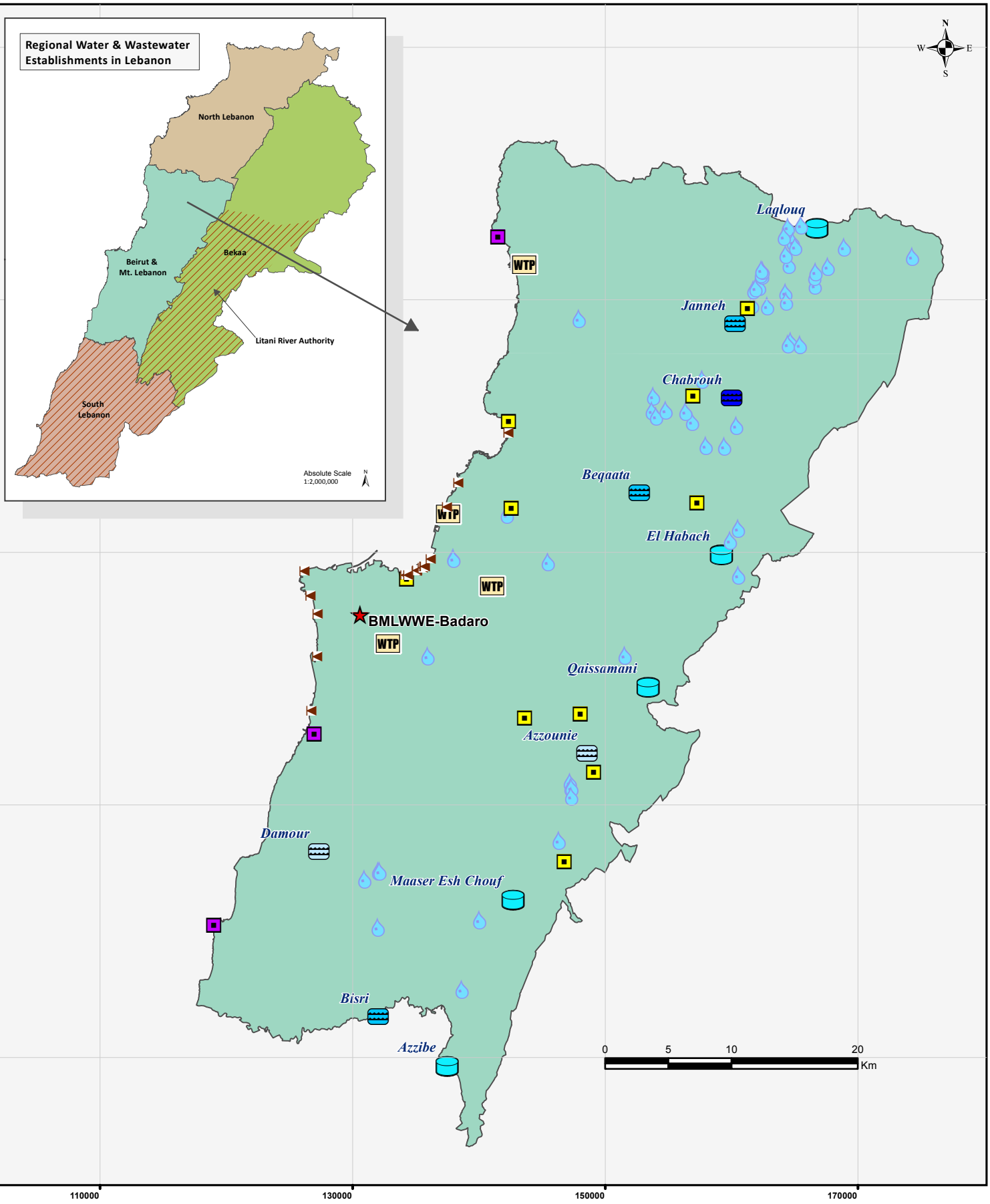
Source

This map was prepared by ECODIT based on CDR Progress Report (October 2013) & the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

Every effort has been made to ensure the accuracy of the information displayed on this map. The international boundaries are approximate. Plan Bleu/ECODIT do not assume any responsibility for any decision that may arise from the use of the map.

Water Resources & Wastewater Management in Beirut & Mount Lebanon Water & Wastewater Establishment



Legend

- BMLWWE Boundary
- Head Office
- Main Springs
- Hill-Lakes
- Water Treatment Plant
- Sea Sewer Outfalls

Dams

- Planned
- Under Construction
- Completed

Wastewater Treatment Plants-CDR

- Planned
- Under Construction
- Completed

Project

Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info

No.: Infrastructure-BMLWWE-Map 03
Scale: 1:400,000
Projection: Lambert Conformal Conic

Source

This map was prepared by ECODIT based on CDR Progress Report (October 2013) & the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

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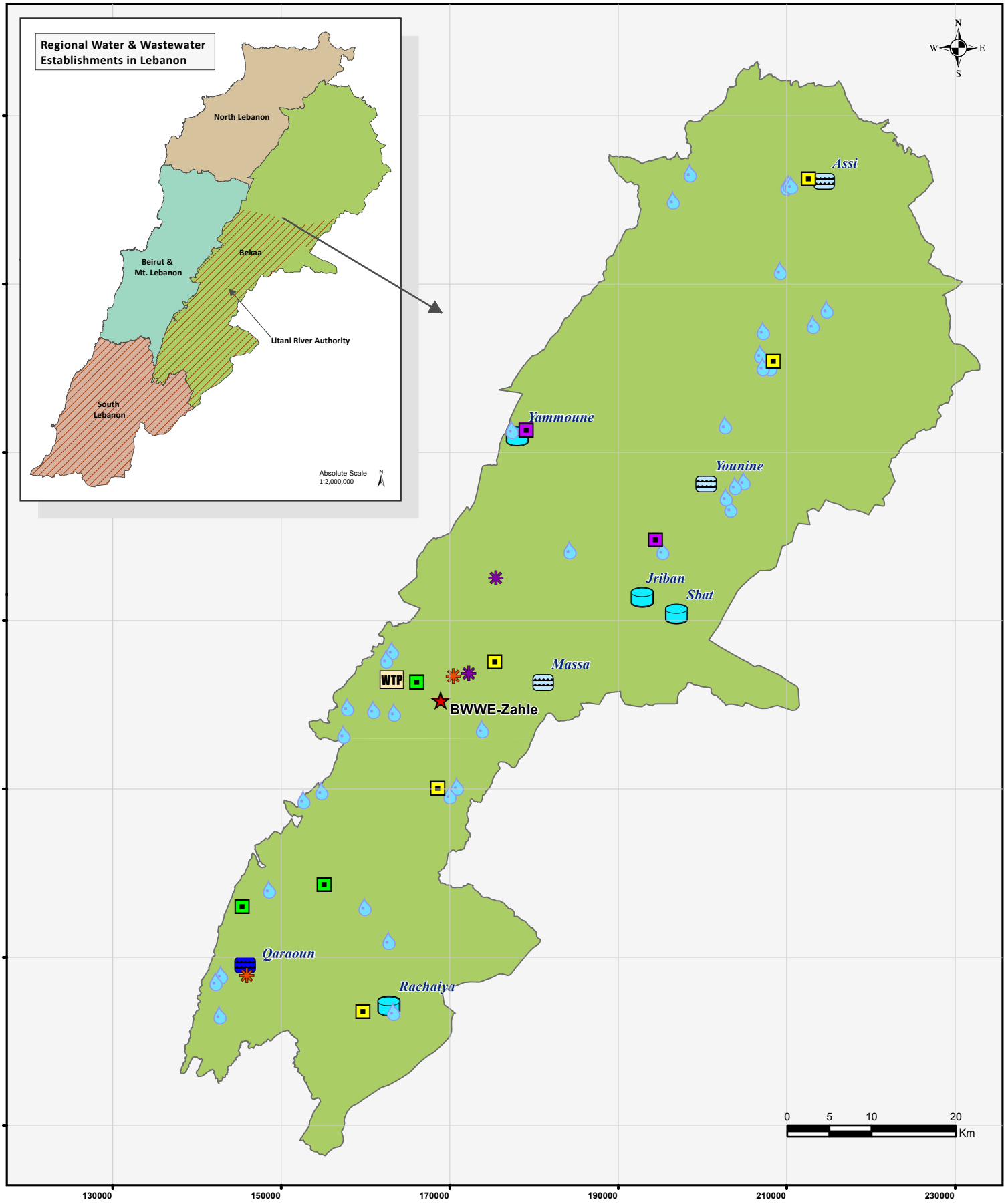
Water Resources & Wastewater Management in Bekaa Water & Wastewater Establishment



Legend

- BWWE Boundary
- Head Office
- Main Springs
- Hill-Lakes
- WTP — Water Treatment Plant

Dams
- Planned
- Completed

Wastewater Treatment Plants

CDR
- Under Preparation
- Under Construction
- Completed

USAID
- Completed
- Under Construction

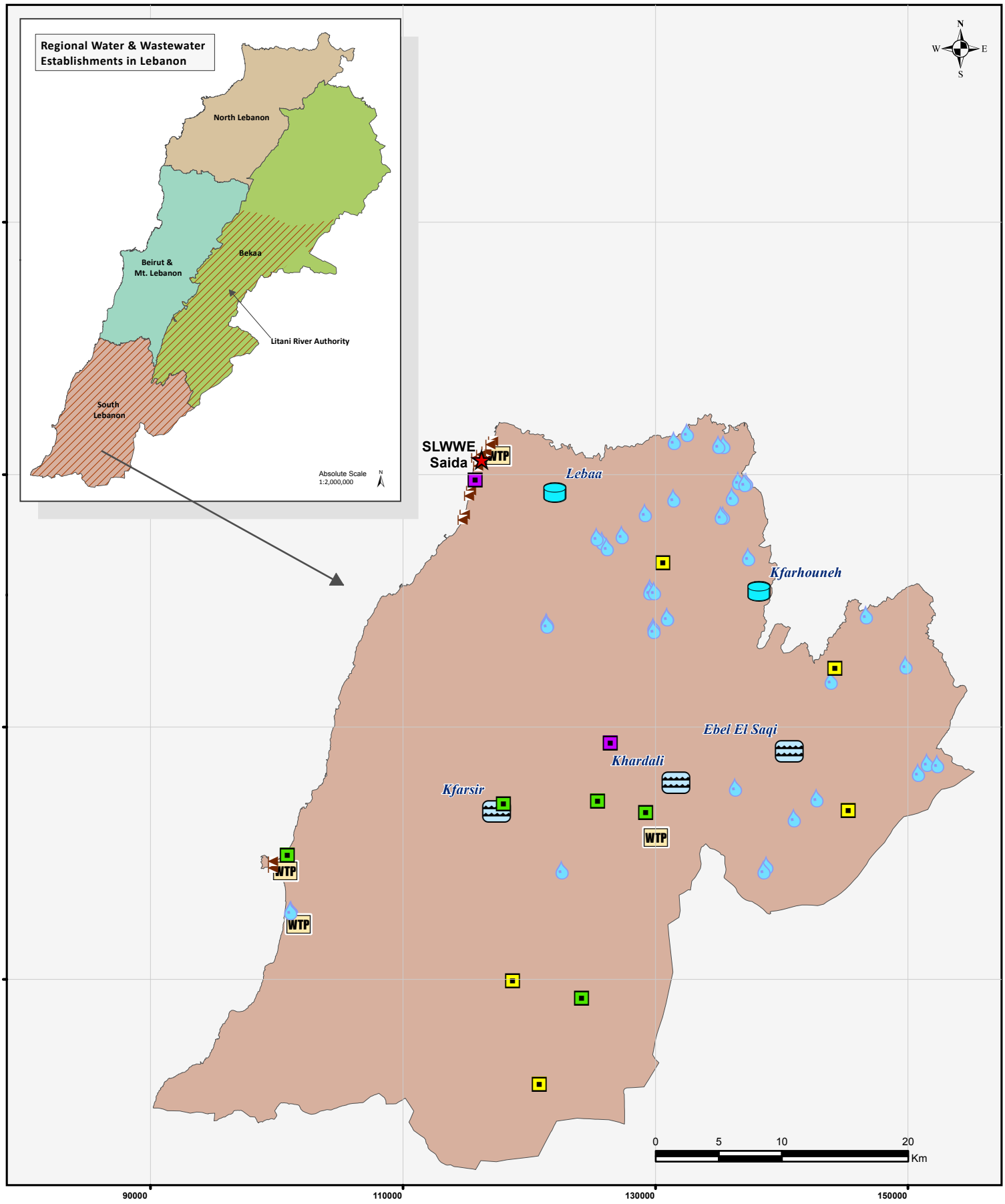
Project
Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info
No.: Infrastructure-BWWE-Map 05
Scale: 1:600,000
Projection: Lambert Conformal Conic

Source
This map was prepared by ECODIT based on CDR Progress Report (October 2013) & the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer
Every effort has been made to ensure the accuracy of the information displayed on this map. The international boundaries are approximate. Plan Bleu/ECODIT do not assume any responsibility for any decision that may arise from the use of the map.

Water Resources & Wastewater Management in South Lebanon
Water & Wastewater Establishment



Legend

- SLWWE Boundary
- Head Office
- Main Springs
- Hill-Lakes
- Water Treatment Plant
- Dams (Planned)
- Sea Sewer Outfalls

Wastewater Treatment Plants-CDR

- Planned
- Under Construction
- Completed

Project

Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info

No.: Infrastructure-SLWWE-Map 04
Scale: 1:400,000
Projection: Lambert Conformal Conic

Source

This map was prepared by ECODIT based on CDR Progress Report (October 2013) & the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

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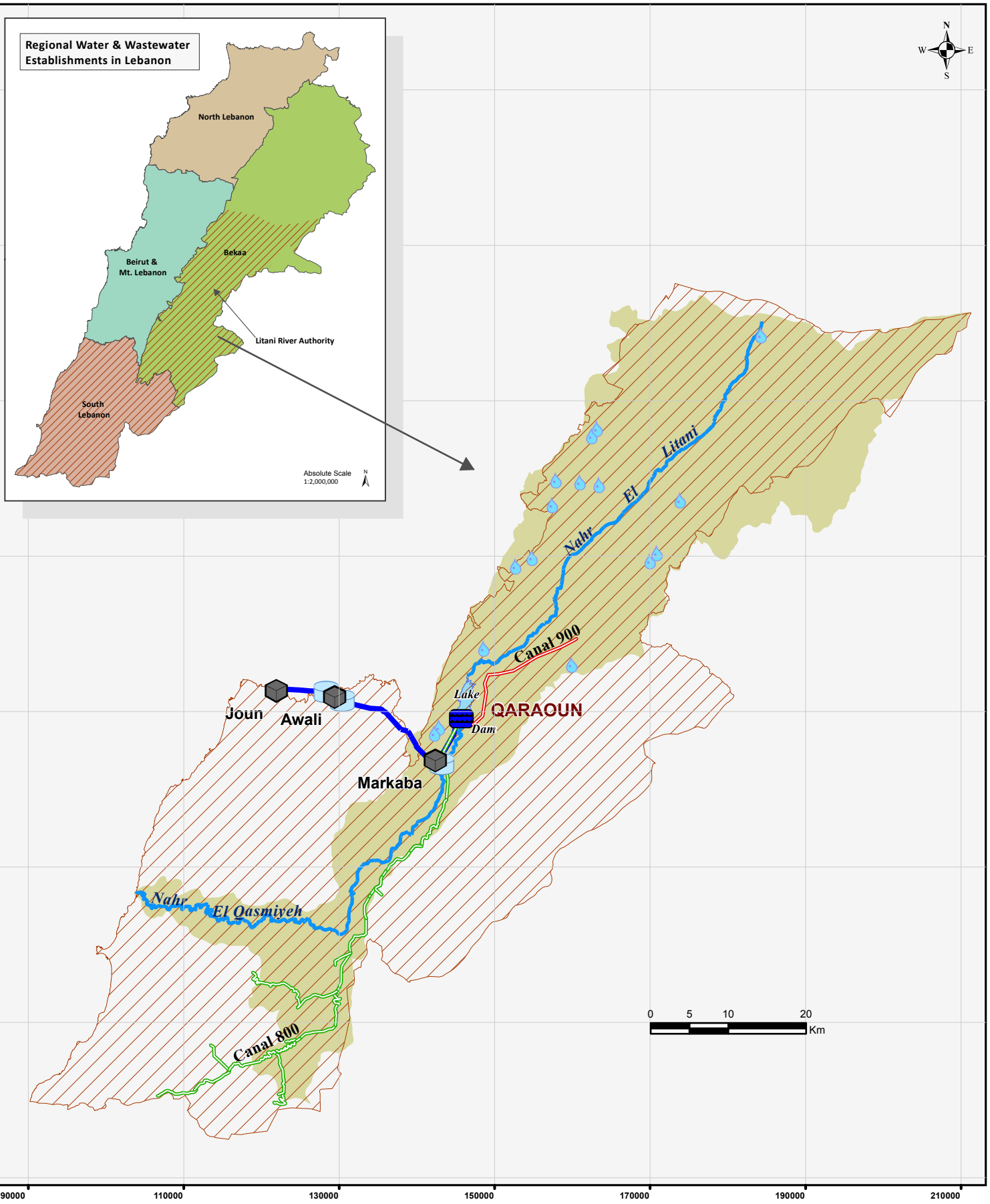
Water Resources & Management in Litani River Basin



Legend

- LRA Boundary
- Litani River Watershed
- Qaraoun Lake
- Qaraoun Dam (Completed)
- Water Basin
- River
- Main Springs
- *Hydropower*
  - Line
  - Plant
- *LRA Irrigation Projects*
  - Canal 800
  - Canal 900

Project

Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info

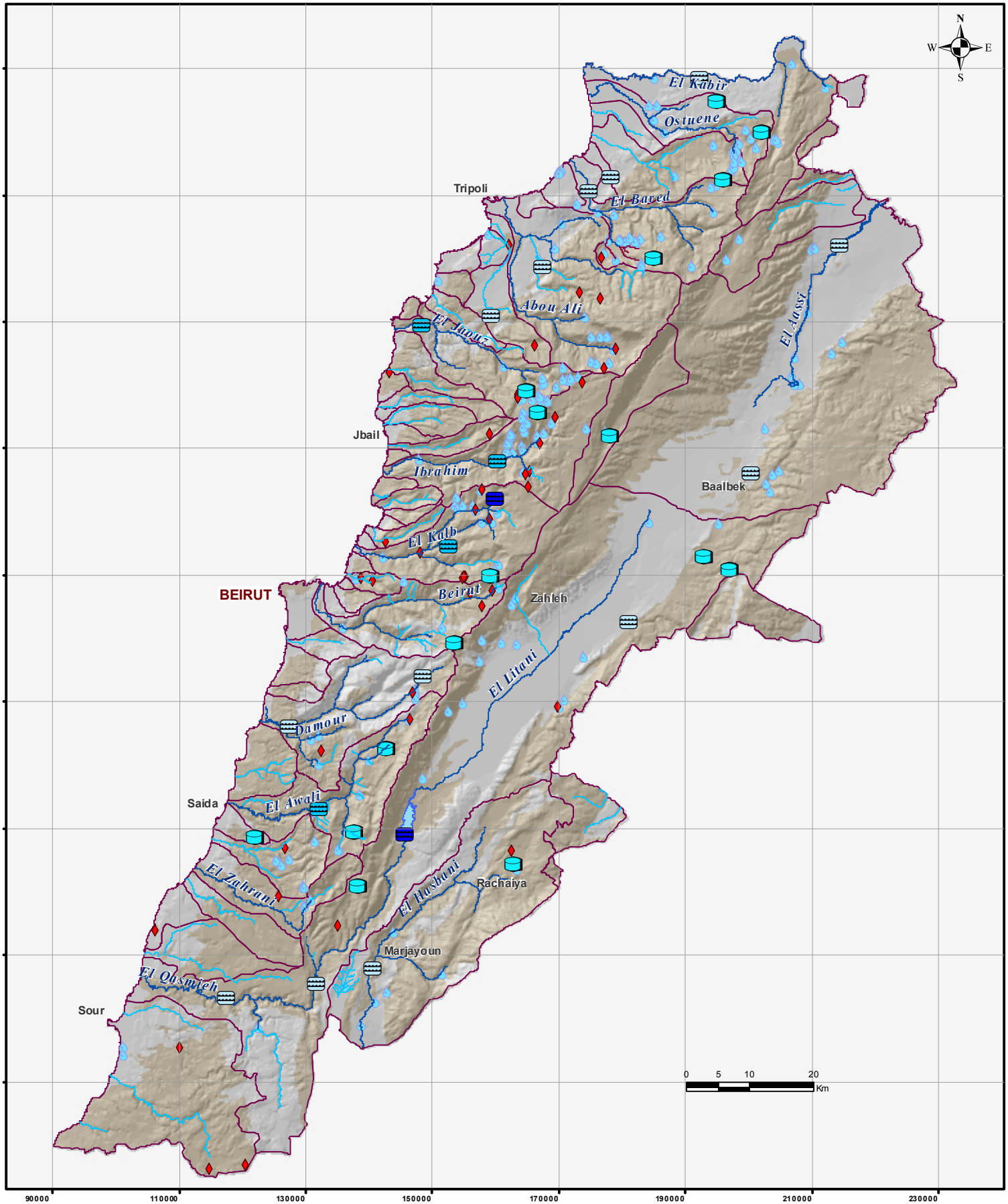
No.: Infrastructure-LRA-Map 06
Scale: 1:650,000
Projection: Lambert Conformal Conic

Source

This map was prepared by ECODIT based on the shapefiles provided by Litani River Authority & the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

Surface & Underground Water Resources in Lebanon



Legend

- Watersheds
- Qaraoun Lake
- Karst Coverage
- Important Caves
- Hill-Lakes
- Main Springs

Rivers

- Permanent
- Seasonal

Dams

- Planned
- Under Construction
- Completed

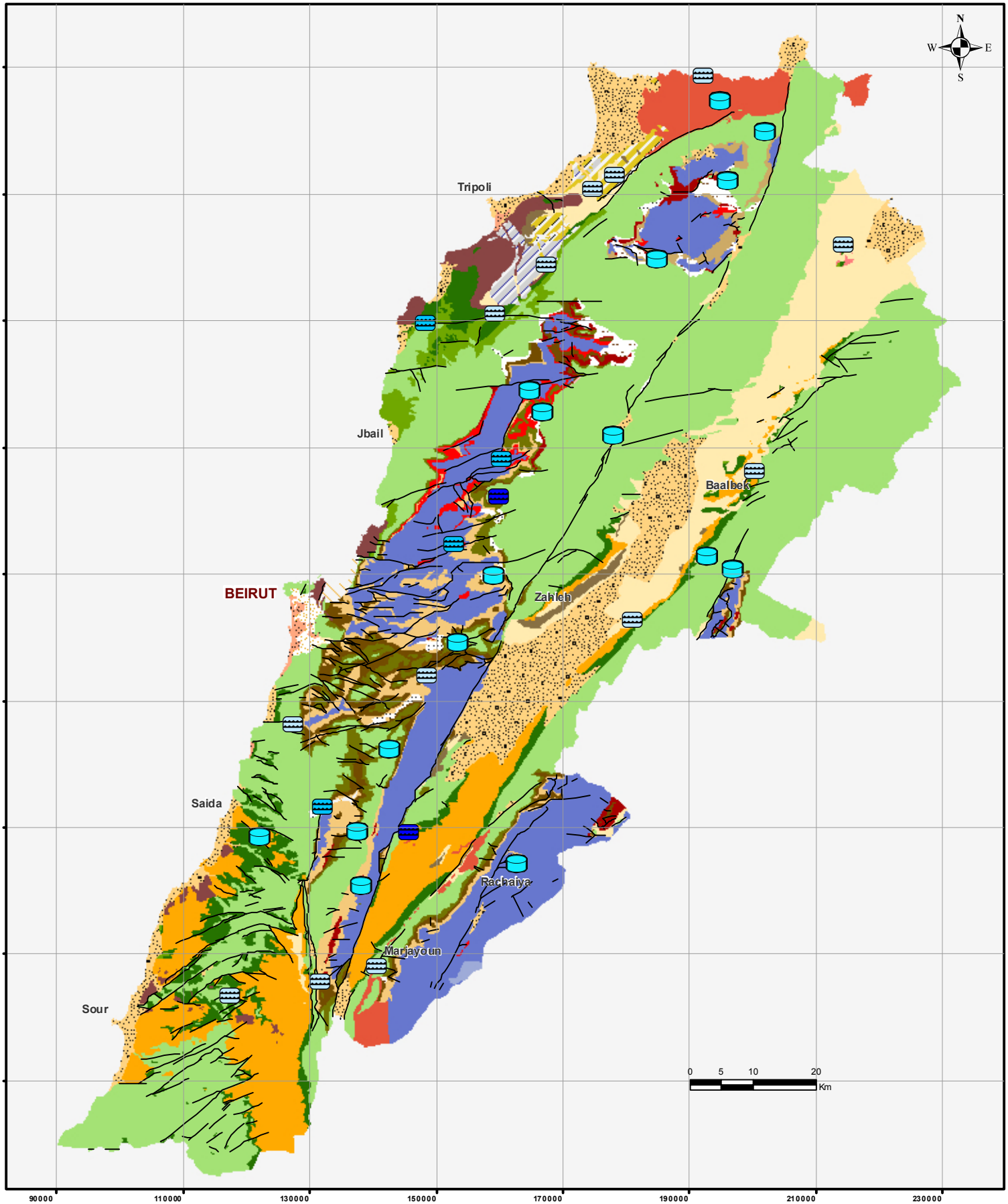
Project
Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info
No.: Opportunities-S&UWR-Map 07
Scale: 1:800,000
Projection: Lambert Conformal Conic

Source
This map was prepared by ECODIT based on the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

Geology & Tectonic Risk of Surface Water Infrastructure



Legend

Dams

- Planned
- Under Construction
- Completed
- Hill-Lakes
- Faults

Geological Periods

Jurassic: j2-3, j4-7

Cretaceous: c1, c1-2, c2, c3, c4, c5, c6

Paleogene: e

Neogene: m2, ml, ncg, p

Quaternary: qaa, qar, qcpb, qd, qgl, qsl, qsr, qta

Eruptive Rocks: bc, bj, bm, bp, bq

Project
Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info
No.: Constraints-Geology-Map 08
Scale: 1:800,000
Projection: Lambert Conformal Conic

Source
This map was prepared by ECODIT based on the Geo-Database of the National Land Use Master Plan (2004) & Carte Géologique du Liban prepared by Dubertret (1955)

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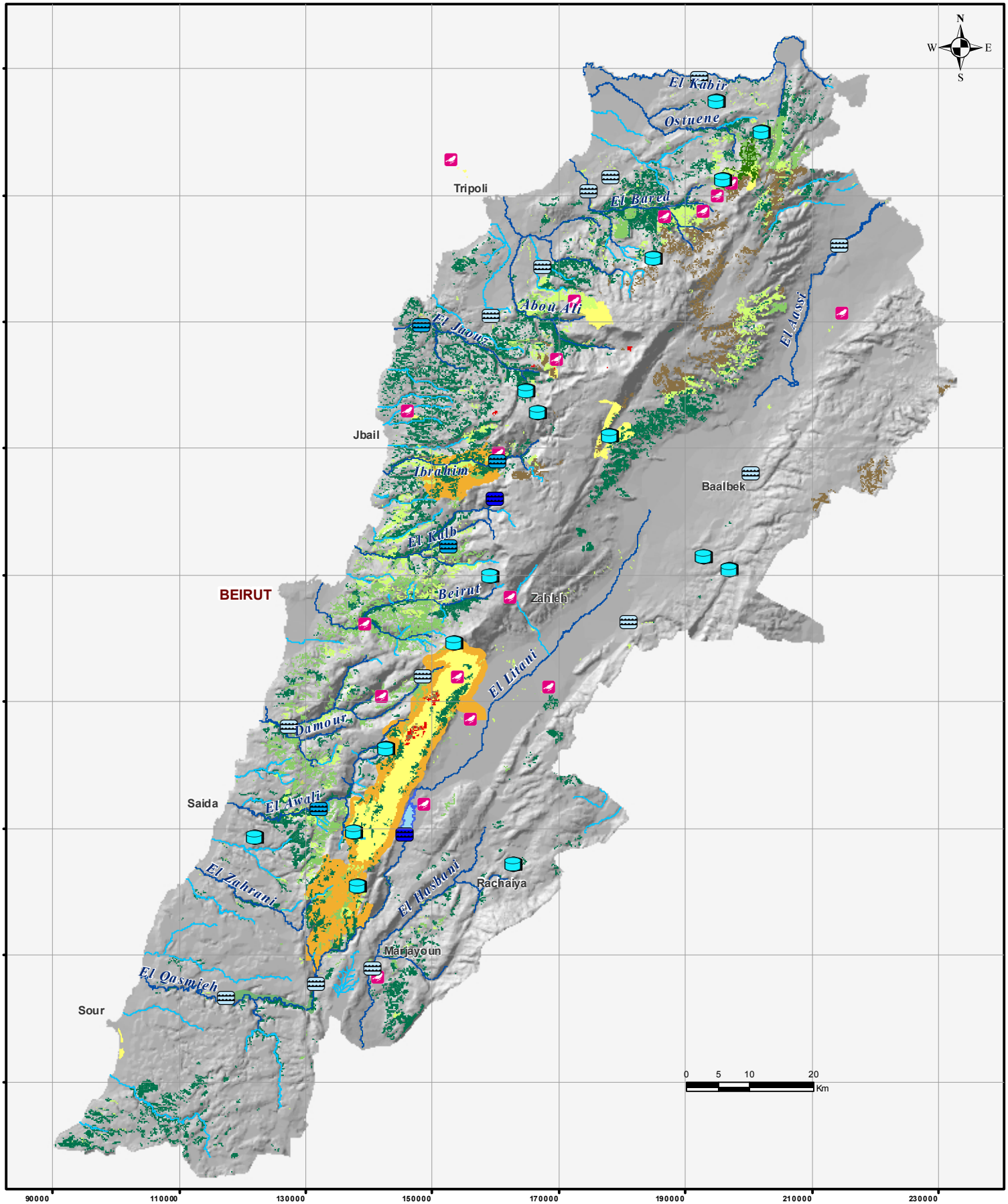
Location of Environmental Sensitive Areas & Large Water Infrastructure in Lebanon



Legend

- Qaraoun Lake
- Hill-Lakes

Dams

- Planned
- Under Construction
- Completed

Rivers

- Permanent
- Seasonal

Biodiversity

- Protected Area
- Biosphere Reserve
- Important Bird Area

Forest Type

- Mixed forest
- Quercus
- Cypress
- Juniper
- Pine
- Fir
- Cedars

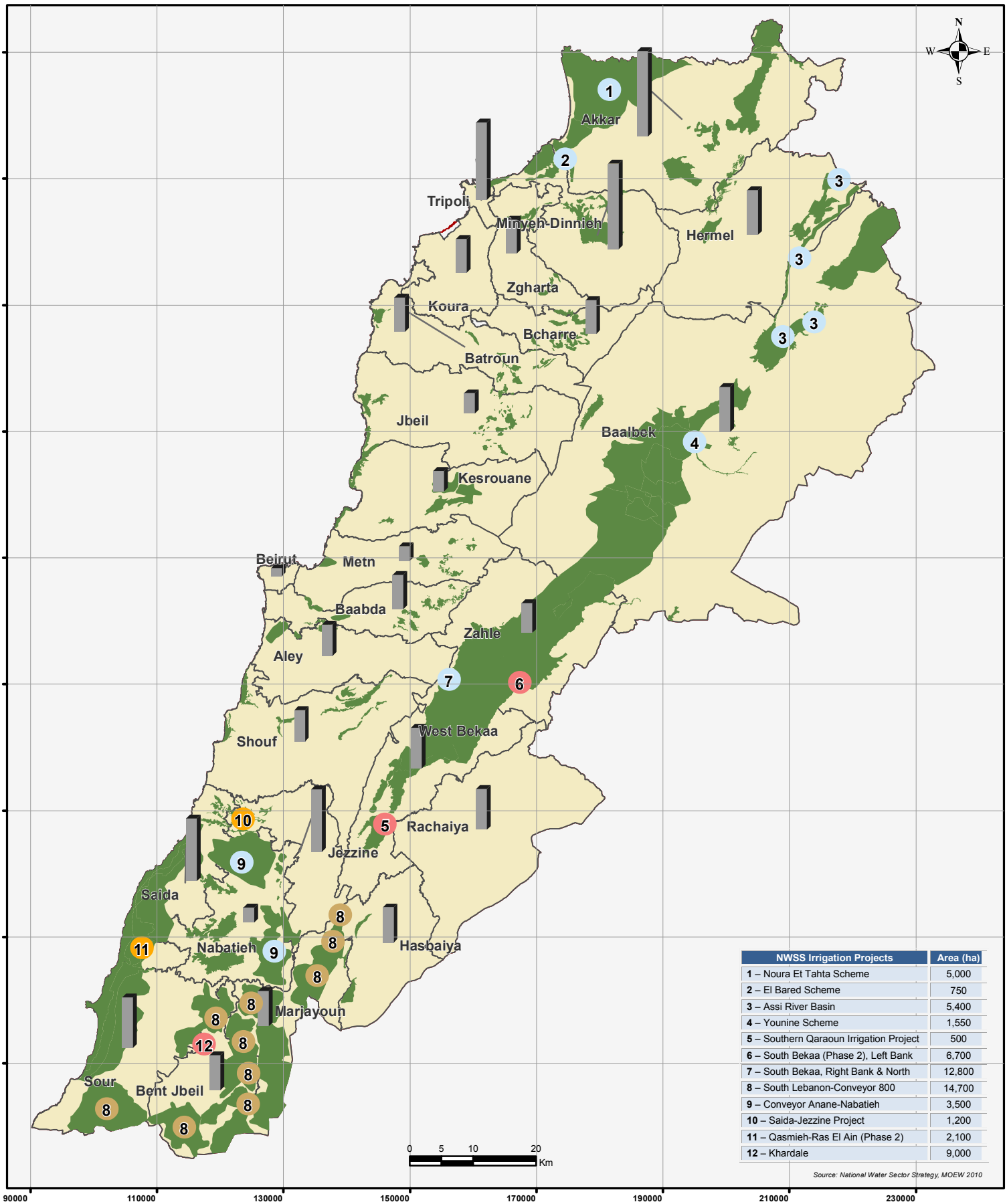
Project
Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info
No.: Constraints-ESA-Map 09
Scale: 1:800,000
Projection: Lambert Conformal Conic

Source
This map was prepared by ECODIT based on the Geo-Database of the National Land Use Master Plan (2004)

Disclaimer

Irrigation Perimeters & Poverty Linkages



NWSS Irrigation Projects	Area (ha)
1 – Noura Et Tahta Scheme	5,000
2 – El Bared Scheme	750
3 – Assi River Basin	5,400
4 – Younine Scheme	1,550
5 – Southern Qaraoun Irrigation Project	500
6 – South Bekaa (Phase 2), Left Bank	6,700
7 – South Bekaa, Right Bank & North	12,800
8 – South Lebanon-Conveyor 800	14,700
9 – Conveyor Anane-Nabatieh	3,500
10 – Saida-Jezzine Project	1,200
11 – Qasmieh-Ras El Ain (Phase 2)	2,100
12 – Khardale	9,000

Source: National Water Sector Strategy, MOEW 2010

Legend

- Caza Boundary
- Existing Irrigation Perimeters
- Upper Povery Line
- 32%

NWSS Irrigation Projects

- 1 Planned
- 6 Study Under Preparation
- 8 Under Construction
- 10 Completed

Project
Strategic Environmental Assessment of the National Water Sector Strategy, Plan Bleu/ECODIT, 2014

Map Info
No.: Constraints-Poverty&Irrigation-Map 10
Scale: 1:800,000
Projection: Lambert Conformal Conic

Source
This map was prepared by ECODIT based on the Geo Database of the National Land Use Master Plan (2004), Growth, Poverty & Income Distribution (UNDP, 2008), Census of Agriculture Activities (MOA, 2010)

Disclaimer
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12. ADMINISTRATIVE ANNEXES

ANNEX 12.1 SEA TEAM COMPOSITION

Team Member	*Position*	*Analysis*
Karim El-Jisr	Team Leader	• Legal and regulatory systems and pollution standards; • TSE and sludge reuse standards; • Analysis of environmental impacts; • Analysis of NWSS alternatives; • Coherence with national policy; objectives and institutional frameworks
Raymond Colley	SEA Expert	• Senior advice to SEA team; • Recommendation on best approaches for site-specific EIAs; • Review draft deliverables (internally);
Zuhier el Hassan	Water Resources Management Expert	• Environmental safeguards for water and wastewater infrastructure; • Impact of proposed investments/interventions on hydrology • Institutional requirements for O&M and EMP at WE level • Performance evaluation • Emergency response requirements in case of catastrophic failure
Ghassan Jaradi	Ecology Expert	• Impact of water bodies on birds (local and migratory) and on habitats; • Value of environmental flows; • Impact of impoundments on micro-ecosystems; • Mitigation measures to ensure “no-net-loss”
Redha Hamdan	Social-Scientist	• Direct and indirect impacts of the NWSS on poverty incl. the impact of irrigated agriculture on poverty alleviation; • Household water utilization and expenditure, and willingness-to-pay (water and wastewater) • Impact of water infrastructure on property value; • Social impact of land expropriation and compensation procedures • Impact of the Syrian crisis on the water sector
Osama Abu Rayan	Environmental Economist	• Analysis of costs and benefits of alternative options; • Valuation of water bodies based on tourism/eco-tourism revenues, hunting, and property value
Naji Tannous	Energy Expert	• Impact of NWSS on hydropower generation in Lebanon; • Other sources of RE linked to NWSS including biogas, micro-hydropower, and non-river sources; • Opportunity for using photovoltaic systems in water pumping

Team Member	*Position*	*Analysis*
Capricia Chabarekh	Environmental Specialist	• Baseline environmental conditions; • Available climate change data and discussion on adaptation and mitigation
Rita Stephan	GIS & Land Management Specialist	• Baseline environmental conditions • GIS analysis and mapping of infrastructure, opportunities and constraints

ANNEX 12.2 CONSULTATIONS & INTERVIEWS

Name and Position	*Discussion Points*	*Date*
South Lebanon Water and Wastewater Establishment Ramzi Ramadan - Head of Projects and Programs Joseph Kassab - Manager of Saida Wastewater Networks and Treatment Plant Amal Al Chidiac - Head of Laboratory Service Mohammad Kattine - Head of Operation of Fakher El Dine Wells Metri Abi Jreiche - GIZ Technical Advisor Bassem Ghayda - USAID/LWWSS/ DAI/CDM Smith Nidal Hachicho - Head of Customer Service	Comments and feedback related to every NWSS infrastructure initiative in South Lebanon	25/09/2013
Beirut and Mount Lebanon Water and Wastewater Establishment Georges El Kadi - Head of Service; Projects and Programs Maher Chrabieh - Head of Department; Water Treatment Plants in Northern Beirut Nabil Samaha - Head of Service; Transmission in Mount Lebanon Boulos Saeid - Head of Laboratories Department	Comments and feedback related to every NWSS infrastructure initiative in Beirut and Mount Lebanon	07/10/2013
Bekaa Water and Wastewater Establishment Maroun Mousallem Director General Sleiman Al Jamal - Head of Laboratory Service Mohammad Ismail - Service of distribution and maintenance Khalil Azar - Head of Studies and Projects Service Bilal Al Chamali - Vice director of the Operation and Maintenance Project at Al Bonyan for Engineering and Contracting – Contractor for Bekaa WWE Rafik Chehab - Manager of Iaat-Baalbeck STP	Comments and feedback related to every NWSS infrastructure initiative in Bekaa	08/10/2013
North Lebanon Water and Wastewater Establishment Jamal Krayyem - Director General Gaby Nasr - Director of Exploitation Nisrine Abdullah - Head of Studies Department Blondie Mirad - Responsible of Process at Tripoli STP; Degremont Maya Yaghmour - Admin assistant; Degremont	Comments and feedback related to every NWSS infrastructure initiative in North Lebanon	09/10/2013
Ziad Zakhour - Advisor to the Minister of Energy and Water. *SEA NWSS Focal Point at MEW (July 2014)*	Overview on Infrastructure initiative I.3 of the National Water Sector Strategy (NWSS) related to Surface Storage (dams and lakes)	09/09/2013 31/7/2014

Name and Position	*Discussion Points*	*Date*
Ziad Khayat - Manager, Lebanese Center for Water Management and Conservation	Work and programs of the Lebanese Center for Water Management and Conservation and its mandate	16/09/2013
Chadi Mohanna, Director of Rural Development and Natural Resources, Ministry of Agriculture	Permitting procedures related to (1) cutting trees, (2) thinning and pruning and (3) compensation schemes with MOEW linked to the construction of dams	27/09/2013
SEA- NWSS Joint Review Committee Samer El Hachem - Officer, Department of Natural Resources Protection – MOE Bassam Sabbagh - Head of Service of Urban Environment – MOE Vahakn Kabakian - Project Manager UNDP-MOE Manal Mousallem - Advisor to the Minister of Environment UNDP-MOE Raymond Colley – SEA Expert, ECODIT Consultant	Objectives of the SEA of the NWSS (national and regional level) The preparation of the SEA study The influence of the SEA-NWSS on downstream EIAs	22/10/2013
Nabil Amacha – Environmental Unit Manager in Litani River Authority	Canal 800 and Canal 900 Projects; Water data and monitoring in LRA; Litani river cleanup campaign of 2008; USAID's Litani River Basin Management Project including Dam Failure Analysis for Qaraoun lake	26/12/2013
Ghassan Gibran – Director of Projects in Litani River Authority	The effect of Canal 800 and Canal 900 on Litani Hydropower Plants; LRA irrigation schemes	22/01/2014
Adel Abou Jaoude – Project Manager Janneh Dam, Khatib Alami	Project Phases; Setback distances and implication on expropriation ; Dam failure risk assessment and mitigation; Hydropower generation; Sedimentation	10/03/2014
Maher Chrabieh - Head of Department; Water Treatment Plants in Northern Beirut, BMLWWE	Dbaye Water Treatment Plant: Water sources, capacity of treatment, O&M capabilities; additional water from Janneh Dam	03/04/2014
Georges El Kadi - Head of Service; Projects and Programs, BMLWWE	Land expropriation for Janneh dam; Water supply emergency response of BMLWWE in case of drought periods; Expansion of Dbaye Water Treatment Plant (and erection of related water infrastructure) to meet additional water supply from Janneh Da; Quality standards for water supply; Potential artificial recharge of wells; Blue Gold 5-year Plan	08/04/2014

Name and Position	*Discussion Points*	*Date*
Charbel Nahas - Economist, Former Minister of Telecommunications and Labor	Expropriation procedures and compensations; Archeological value of Nahr Ibrahim	11/04/2014
Abdo Tayar - Advisor to the Minister of Energy and Water. *SEA NWSS Focal Point at MEW (from inception through June 2014)*	Draft Water Code; NWSS Implementation Status and Monitoring; NWSS sources of funding; Syrian Crisis; SEA – NWSS public consultation process	14/04/2014
Randa Nemer - Advisor to the Minister of Energy and Water, Wastewater Sector	Updated status of STPs, Standards for the reuse of TSE and sludge, O&M capabilities of WWEs to operate STPs, Inflow for Industrial wastewater into STPs, EIAs for STPs	15/04/2014
Civic Influence Hub (Blue Gold): Nizar Al Awar (Water Expert), and Ziad El Sayegh (CEO)	Blue Gold initiatives; Private Sector Participation in the water sector; Monitoring the water sector reform process	22/04/2014
National Council for the Environment (NCE):* presided by HE Minister Mashnouq.	The Consultant presented summary findings of the NWSS and received feedback and comments. Environment Minister Mashnouq requested a two-page executive summary in Arabic for discussion at the Council of Ministers.	11/8/2014
Karim Osseiran - Energy Consultant and advisor to the Minister of Energy and Water	Hydropower generation capacity; SOGREAH report; micro-hydro power capacity and barriers	22/08/2014

*Photo of August 11 meeting with the National Council for the Environment:

ANNEX 12.3 SITE VISITS

Site	*Date*
Jeita Spring and Cave	24/10/2013
Chabrouh Dam	24/10/2013
Boqaata Dam	24/10/2013
Dbayeh Water Treatment Plant	25/10/2013
Ras el Ain Spring and Reservoirs	06/11/2013
Sour Sewage Treatment Plant	06/11/2013
Qasmieh-Ras El Ain Irrigation Channel	06/11/2013
Batroun STP	05/01/2015
Chekaa STP	20/03/2014
Bsharre STP (small-scale)	23/01/2015