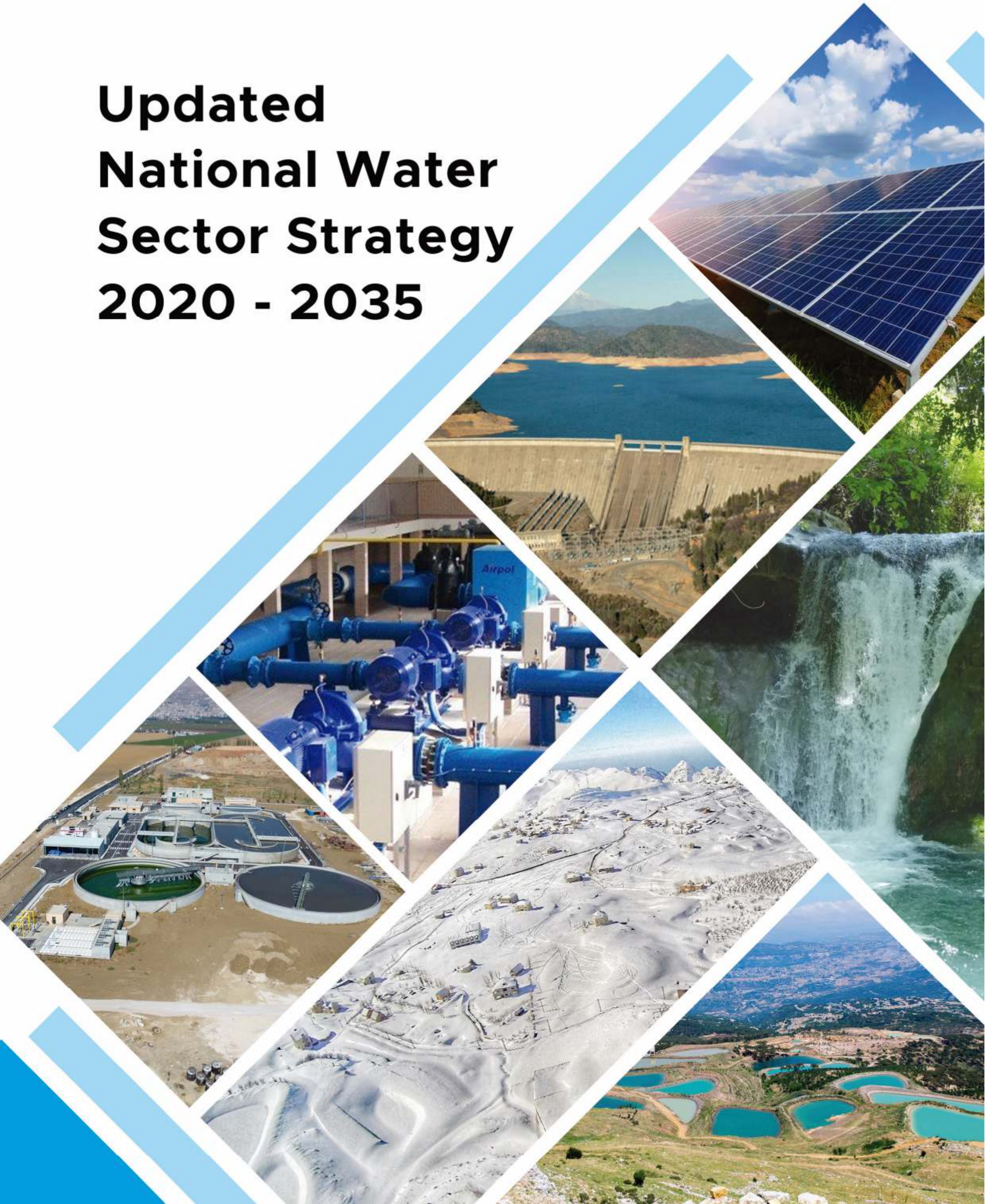
REPUBLIC OF LEBANON
MINISTRY OF ENERGY AND WATER

Updated National Water Sector Strategy 2020 - 2035



CONSULTANT

FOREWORD

It gives me great pleasure to present the Updated National Water Sector Strategy of 2020 after more than 10 years since a comprehensive strategy was set.

The rapid global and local environmental degradations, climate change, increased desertification, population growth, and shifts in economic sectors amplify the pressure on the importance of reliable water supply. As such, a solid national water sector strategy becomes more and more critical.

Updating the National Water Sector Strategy of 2020 was made possible by a generous grant from UNICEF. A consortium of five renowned local companies in the Lebanese water sector, and three international experts, worked relentlessly over a period of one year (from June 2019 to June 2020) to gather, analyze, and map the data putting together this long-awaited strategy. Following the multiple crises faced at the end of 2019, the Updated NWSS was revised in 2022 to make sure it takes into account the actual situation of the country and that of the public institutions, as well as the comments raised in the Strategic Environmental Assessment by more than 70 sector stakeholders interviewed during the process.

As you will read in this summary report, the updated strategy focuses primarily on reform initiatives under Pillar 1, considered as the basis for relaunching the sector towards a sustainable management and an improved service provision. A clear and well-defined action plan is proposed, and work has started since 2020 between the Ministry of Energy and Water, the Water Establishments and the donors' community to achieve the action plan's targets. Pillar 2 is not any less important, where light is shed on the importance and urgency of setting a national information system for the water sector as a cornerstone to achieving an Integrated Water Resources Management in the years to come; and last but not least, Pillar 3 comes to fill the infrastructure gaps that would allow access to services for all.

Finally, I would like to thank everyone who has worked on this study, knowing that it has been a tedious and complicated task, but a satisfying one. This updated strategy should be a live document and the Ministry will work on reviewing it periodically, making it the basis of all interventions in the water sector.

With this comprehensive strategy in hand, I am optimistic that both, decision-makers and citizens, will refer to it frequently and implement it properly to reach the ultimate objective of the Ministry which is "safe and equitable access to services for all Lebanese".

Minister of Energy and Water

Dr. Walid Fayad

The present volume is the core of the ***Updated National Water Sector Strategy – 2020***, to which are annexed the following supporting detailed technical documents:

Annex I : PILLAR I - REFORMS AND GOVERNANCE

- Section A Strategy Pillar – SDG 6
- Section B Current Legal and Institutional Frameworks
- Section C Human Resources of MoEW & WE's
- Section D Water Tariff Analysis
- Section E Strategic Recommendations

Annex II : PILLAR II – INTEGRATED WATER RESOURCES MANAGEMENT

- Section A Available Water Resources and the Impact of Climate Change
- Section B Surface Water Resources Management
- Section C Groundwater Resources Management
- Section D Guidelines for Water Quality Monitoring
- Section E Wastewater Reuse and Sludge Management
- Section F Strategic Environmental and Social Assessment

Annex III : PILLAR III – SERVICE COVERAGE: CURRENT SITUATION OF THE WATER SECTOR

- Section A Existing Water and Wastewater Facilities
- Section B Demand Criteria and Resulting Water Balances
- Section C Appendices

Annex IV : PILLAR III - SERVICE COVERAGE: PROPOSED PROJECTS

- Section A Selection Criteria and Prioritization of Projects
- Section B Proposed Projects

Annex V : DRAWINGS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Bm^3	Billion cubic meter
BMLWE	Beirut and Mount Lebanon Water Establishment
BWE	Beqaa Water Establishment
CDR	Council for Development and Reconstruction
CM	Customer Management
EIB	European Investment Bank
EU	European Union
HR	Human resources
IFRS	International Financial Reporting Standards
IWMI	International Water Management Institute
l/c/d	Liters per capita per day
l/sec	Liters per second
LBP	Lebanese Pound
LRA	Litani River Authority
m^3/d	Cubic meter per day
m^3/h	Cubic meter per hour
masl	Meters above sea level
MCM	Million cubic meter
MENA	Middle East and North Africa region
Mm^3	Million cubic meter
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
NGO	Non-Governmental Organization
NLWE	North Lebanon Water Establishment
NRW	Non-Revenue Water (unaccounted for water)
NWSS	National Water Sector Strategy
SLWE	South Lebanon Water Establishment
UFW	Unaccounted for Water
UN	United Nations
WE	Water Establishment
WEs	Water Establishments

1 THE STRATEGY FRAMEWORK

1.1 BACKGROUND AND CONTEXT

The Ministry of Energy and Water (MoEW) prepared and adopted the Lebanese National Water Sector Strategy (NWSS) in 2010 which was endorsed by the Government of Lebanon in 2012 (Resolution No.2, Date 09/03/2012).

The NWSS of 2012 put an end to a phase and started a new phase that allowed for the first time the development of a wide and comprehensive national vision for the water sector and for the affirmation of the general principles of the national water policies on the short, medium and long terms.

Since then, the MoEW has been implementing the management and infrastructure roadmaps identified in the strategy and in parallel, the Council for Development and Reconstruction (CDR) and the Water Establishments (WEs) prepared regional water, wastewater and irrigation master plans, and executed projects across the country.

Seven years later, in 2019, the MoEW decided that it was time to review what has been realized from the original roadmaps and to update the water and wastewater strategies of 2012 not only by revisiting the water master plans, wastewater collection and treatment plans, storage / dams master plans, and irrigation plans, but more importantly by setting a detailed action plan to implement reforms and create a hydrogeological data management system.

The present document is the consolidated updated strategy; It merges the National Water and Wastewater strategies of 2012 into one consolidated strategy that we shall call “Updated National Water Sector Strategy 2020”. It maintains the main strategic principles of the water policies adopted by the Government of Lebanon in 2012, but reassesses the then set priorities in light of today’s actual context, and sets the ground for the period extending between 2020 and 2035. It takes into account the adopted Water Code (law 192/2020) and its structuring principles, which are in turn in line with the water sector organizing Law 221/2000 and its amendments, as well as studies and projects completed between 2012 and 2021 in the fields of potable water, wastewater and irrigation, and management initiatives implemented during the same period. This update can be considered as a shift from a strategy of theory and general principles into practical, implementable plans, projects and governance initiatives that set the ground to move towards the UN’s Sustainable Development Goal SDG 6 and realize the principles of an Integrated Water Resources Management (IWRM). While doing so, the updated NWSS 2020 targets as well SDG 2 (Zero Hunger), SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), SDG 14 (Life below Water), SDG 15 (Life on Land) and SDG 17 (Partnerships for Goals); these will be explored throughout the document.

1.2 CURRENT SITUATION

The period between the years 2010 and 2021 was one full of instabilities in the region and in Lebanon. The influx of displaced Syrians into the country as a result of the conflict in Syria has had major impacts on the Lebanese economy. The presence of more than 1.5 million displaced Syrians has put additional pressure on the already frail infrastructure of Lebanon, and particular strain on the water resources and the wastewater systems. Despite this sudden increase in the population of Lebanon, the economic and financial situation remained stable until the Lebanese currency witnessed a sudden devaluation in the last quarter of 2019 and is still experiencing a downward trend until today.

Faced with a social upheaval, road blockages, demonstrations in every region, a dire health situation due to the Covid 19 pandemic, the water sector was severely impacted at different levels:

a- The employees stopped attending to work at first due to the pandemic and later due to the devaluation of their salaries and the great increase in prices, especially gasoline.

b- The working conditions deteriorated with lack of electricity and stationery, slowing down the flow of work.

c- Contractors operating water and wastewater systems threatened to stop or stopped their work due to the devaluation of their contracts.

d- All ongoing projects stopped due to the inability of contractors to pay for material at their old contract prices.

e- Donors of the international community converted their aid to crisis response and assisted the WE in continuing their service provision at a minimum, by providing chemicals, repairs and fuel as much as funds were made possible.

Despite this gloomy picture, the MoEW the WEs and the LRA, with the support of the donors, the UN agencies and the WASH partners, are still keen on setting a strategy that will ensure the long-term sustainability of the water sector through implementation of reforms at the legal, institutional, financial, commercial and operational levels, while managing the crisis situation faced today by the water sector and the country as a whole.

1.3 VISION

Based on the United Nations' SDG 6, the MoEW aims at providing safe, equitable and affordable water and wastewater services to all, and to properly allocate the water resources to the different economic sectors (agriculture, industry, tourism, services, etc..) based on the priorities of the Government's recovery plan.

1.4 OBJECTIVES

The Ministry aims at achieving a financially sustainable sector, that is citizen-centered and service oriented, and which would ultimately allow to reach an integrated approach of the water sector, as per Law 192/2020.

1.5 METHODOLOGY

The methodology that was adopted to update the NWSS evolved around three pillars detailed in the following section and consists in:

- Assessment of the legal, institutional, tariff and financial activities of the sector and then propose applicable reforms/action plan in close coordination with WEs and MoEW.
- Assessment of the surface and groundwater resources management including the analysis of the collected hydrological data, the impact of climate change, water balance estimation, and suggestion of the required studies etc.
- Assessment of the water sector infrastructure condition status (operational, needs rehabilitation, needs modification, and locations where infrastructure is needed).

To develop this methodology, all available data and necessary information including masterplans, studies, design projects, hydrological data, institutional reforms implemented by others, legal documents of the water sector, etc. were collected from relevant stakeholders such as the MoEW, the four Water Establishments (BMLWE, SLWE, NLWE, BWE), Litani River Authority (LRA), other governmental entities like CDR, Ministry of Environment (MoE), Ministry of Agriculture (MoA), Council of the South, and donors involved in the water sector, UN Agencies, local and international NGOs, and else.

The collected information covers all what is available to date on:

- Water governance and tariffs of the four WEs,
- Available updated data on population count, growth rates and water demand,
- Available water resources and water balance by sector, for each WE
- Status of the production, treatment, conveying and distribution systems of potable and irrigation water
- Status of the collection, conveying, and treatment of sewage
- Status of all implemented and planned projects and large scale projects in progress such as dams, hill lakes, treatment plants, water conveyors, …
- Conducted hydrogeological and hydrological studies and other relevant studies,
- Available regional water, wastewater, and irrigation master plans,

It shall be noted that the cut-off date for the collection of various types of data and projects implementation is set on March 31, 2022. However, the MoEW intends to keep this strategy dynamic in nature and to review it on a yearly basis or when needed to accompany the fast changes in the Lebanese context.

2 PILLARS

To achieve the intended objectives, the updated NWSS 2020 is based on the following three pillars:

Pillar 1 Implementing Reforms and Improving Sector Governance

Pillar 1 aims at building solid legal, institutional, financial, commercial and monitoring frameworks and implementing the identified reforms to ultimately achieve a sustainable management of the sector. It also includes an enhancement of the communication mechanisms, a higher transparency with stakeholders, and a shift in the data sharing culture.

Pillar 2: Integrated Water Resources Management

Pillar 2 targets the coordinated development and management of water through IWRM, in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment. This means that infrastructure shall be re-positioned as part of a more comprehensive system and not as an objective in itself. Achieving IWRM requires continuous measurement of available groundwater and surface water resources (in terms of quantity and quality) across the country, and the creation of an Integrated Hydrological Information System (IHIS) that ultimately allows for better planning of infrastructure and adequate water allocation among economic sectors. In addition, this pillar sets the ground for an improved water quality through the application of LIBNOR standards for water quality, and more importantly through Water Safety Plans for each water source. To close the loop for an IWRM, this pillar touches upon the impact of climate change, disaster risk management, non-conventional water resources and required standards for wastewater reuse and sludge management.

Pillar 3: Service Coverage

The proposed projects in the water, wastewater and irrigation sectors were selected following an exhaustive data collection of all projects executed to date, and following prioritization criteria that take into account the real water demands, the water balance of each system, the importance of shifting from energy consuming sources to energy saving ones, as well as the effect of climate change on Lebanon and the urgency of storing surface and groundwater where judged technically and financially feasible to ensure water availability during the longer dry season.

2.1 PILLAR 1: IMPLEMENTING REFORMS AND IMPROVING SECTOR GOVERNANCE

In Lebanon, water supply falls under the jurisdiction of the four public WEs each enjoying a certain degree of autonomy and operating under the tutelage of the MoEW.

As for the Litani river basin, the LRA was established under the Law dated August 14, 1954 amended on December 30, 1955. Since its establishment, LRA was considered to be a public institution with an administrative and financial personality and autonomy. Within LRA functions, the implementation of irrigation, drying, drinking water and electricity projects. In face of the major environmental challenges and with the exacerbation of health, economic, technical, and social problems resulting from the water pollution of river, the concerned authorities realized that water governance has become a necessary element to achieve sustainable development. Therefore, the Lebanese Parliament issued Law No. 63/2016 to define an integrated plan to address water pollution in the Litani river basin from the source to the estuary and assigned to LRA the water governance over the entire basin in coordination with all concerned parties, and allocated the necessary funds with a seven-year period for the implementation of the project (1100 billion Lebanese pounds to treat the water pollution sources of the Litani River, and 3 billion LBP for the benefit of LRA to perform the governance tasks).

Water sector governance is faced with a very challenging situation that affects various areas of the sector management. In general, the performance of the four WEs does not match the admitted standards for public utilities, with water shortages facing customers in several areas including the modern downtown Beirut. The financial situation is also difficult and alarming in some cases where MoEW is requested to provide an equilibrium subsidy.

This is accompanied with a lack of transparency, unreliable accounting books, and poor management of financial and technical data. Such inconsistency in reporting varies from one WE to another.

Various components are tackled under this pillar in order to achieve an improved water sector governance in preparation for an IWRM and to implement the needed reforms, as detailed hereunder.

2.1.1 Component 1: The legal framework

2.1.1.1 Challenges

The current legal framework is composed of 4 main legal documents: i) the Ottoman decision number 320/1920, ii) decision number 144/S/1920, iii) the sector's organizing law 221/2000 and its amendments, and iv) the Water Code law 192/2020.

The main features of these decisions and laws are as follows:

1. At the institutional level, law 221 of 29 May 2000 and its amendments identified and specified the prerogatives of MoEW and the WEs.
2. At the legal level, the legal provisions of the Arrêtés laws 144/1925 and 320/1926 and of the Water Code promulgated by law 192 in October 2020 target the harmonization of the management of the water sector and take into account the international principles in this field.

The multiplicity of legal documents governing the sector results in overlaps, contradictions and inconsistencies. Although the Law 192/2020 is known as the Water Code, yet it cannot be considered as a compilation of water governing laws similar to what a Code should be. To obtain a real Code, an in-depth revision of all valid water laws should be done. On the other and, many articles of Law 192 will not be clear and implementable unless its bylaws are drafted and approved.

It is also worth mentioning that the Organizational decrees governing the work of WEs and based on Law 221/2000, need revision and updating following more than 20 years of implementation.

2.1.1.2 Recommended Initiatives

To overcome these challenges, the following is being or will be undertaken:

1. Under the Technical Assistance program entitled "Water Reforms Program" implemented by AFD and financed by the European Union Delegation in Lebanon, a legal advisor was appointed to undertake the following tasks:

    a. In-depth revision of all legal documents governing the water sector with identification of overlaps and inconsistencies, with the aim of producing a Code.

    b. Prioritization of bylaws required by Law 192/2020 based on importance and urgency.

    c. Development of bylaws in consultation with appointed stakeholders.

    Once the bylaws are cleared by the Minister of Energy and Water, they will be presented to the Council of Ministers for approval.

    Among the most important executive decrees to be drafted, the following are highlighted:

    - Decree on vested rights over water;
    - Composition and organization of the National Water Council;
    - Planning at Basin (watershed) level;
    - Operations subject to authorizations;
    - Tariffs and fees regime;
    - Public services delegation types and arrangements;
    - Public utility services in flood-risk areas;
    - Prevention of water deficits;
    - Reuse of treated wastewater.

2. The legal advisor of the AFD Technical Assistance team will review the organizational decrees of the WEs and propose the necessary changes that reflect the experience and lessons learned so far by the sector.

2.1.2 Component 2: The Institutional Framework – Status of Human Resources

2.1.2.1 Challenges

a. MoEW is understaffed and lacks qualified management and technical staff able to supervise properly the activities of WEs and ensure the overall sector management.

b. Understaffing is also a recurrent issue at all WEs that is often highlighted as the key factor behind the WEs lack of operational capacity and their low levels of service.

c. There are large gaps between the number of staff specified in the WEs and MoEW's organizational decrees and the number of positions occupied.

d. An average of 26% of the positions defined in the decrees are filled by permanent staff within the four WEs (20% for NLWE, 37% for BMLWE, 23% for BWE, and 12% for SLWE). By adding the temporary staff that are recruited to fill some critical positions, the sum of permanent and temporary staff combined covers only 50% of the planned positions (49% in NLWE, 51% in SLWE, and 52% in BWE).

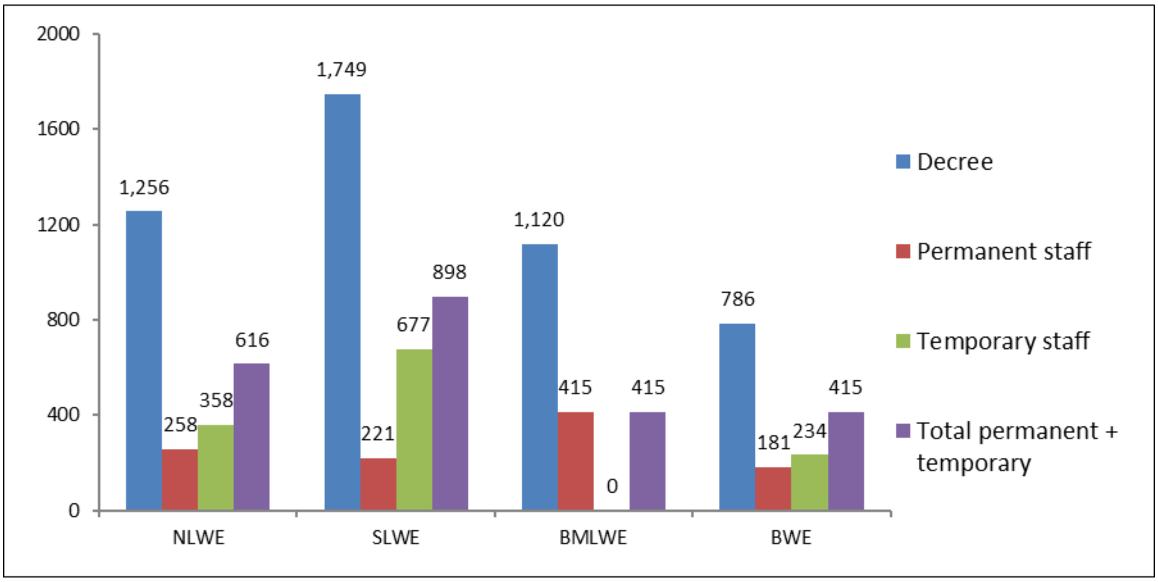


Figure 1 Staffing status of the 4 WEs (2020)

e. The above numbers do not include the number of staff working for the WEs subcontractors (under *On Demand* contracts); including them could narrow the staffing gap and reduce the apparent need for mass recruitment within the WEs.

f. The number of staff does not reflect the performance of WEs: it is important to analyze the qualification of existing staff to better understand possibilities of improving performance of existing staff or the necessity to recruit more qualified personnel.

g. Employees are assigned several tasks that do not correspond to their initial training or specialization, including management functions to employees that do not have the required profiles, thus creating a poor working environment that directly affects efficiency and performance.

h. The current recruitment of temporary staff poses challenges around the sustainability of their position and highlights the difference in financial status as compared to permanent staff.

i. According to law 221/2000, WEs have the mandate of managing the wastewater and irrigation systems, but their current organizational charts do not include these services which means that, not only are they already understaffed for delivering water supply services, but they also have to provide two other challenging services.

j. They need to outsource some of their tasks to private operators, but lack an efficient and effective contracting framework and internal technical skills to properly supervise private operators.

k. Funding agencies (donors and NGO's) provide temporary technical assistance to build MoEW's and the WEs capacities on specific tasks, but these agencies do not implicate themselves in financing permanent staff or any type of employment at the level of MoEW and the WEs.

2.1.2.2 Recommended Reforms

The capacity-building of the water institutions is fundamental to the future of the sector. There is no point in planning activities or investments if the sector does not have the human and technical resources required to implement them. It is a cross-cutting challenge that should be addressed by several priority initiatives:

a. To fill the staffing gaps within the different WEs departments and within MoEW, an authorization by the Council of Ministers to recruit permanent staff is required. The no-recruitment policy means that the water institutions' organizational decrees need to be reviewed.

b. If MoEW and the WEs are given the opportunity to recruit permanent staff in the short term, they will conduct an in-depth analysis of the skills of their permanent staff and prioritize recruitment according to the identified crucial and essential gaps and needs. It will also inform the work required to structure technical assistance and capacity-building actions, and identify legal or regulatory measures to enable the WEs to improve service operation.

c. Analysis of indicators such as i) staff categories (knowing that categories 1 to 3 have management responsibilities, and categories 4 and 5 are task execution teams), ii) the main profiles, positions and tasks of permanent and temporary staff, and iii) qualifications and position of engineers, will enable a general analysis of MoEW and the WEs' situation and help define strategic orientations for their development and for service management improvements.

d. The objective is not to achieve the staff volumes set out in the organizational decrees but to review these decrees, which are outdated and are no longer aligned with the water institutions' mission or to the opportunities for developing service management in the coming years.

e. Currently, the WEs are delegating the management of specific services to the private sector (through Ghob Talab projects) and redirecting their focus on contract management, but this also requires staff that specialize in managing performance-based contracts and that have the technical skills to supervise and monitor private operators.

f. The recruitment of engineers and staff with business management degrees is crucial in order to develop a customer service oriented strategy and to improve service management.

g. It would be more efficient to include less details in the organizational decrees brought forward for adoption by the Council of Ministers, and instead set out the main orientations to give the WEs the ability to develop their organization charts in line with their evolving needs. For example, LRA's organization chart has never been formalized by a Council of Ministers decree. However, this allows LRA to adapt its structure to new projects or new tasks without causing any major obstacles. This approach provides greater flexibility and should be used to inform the review of the WEs organizational decrees.

h. It is recommended to create a cell within the MoEW to follow up on the implementation of all the strategy recommendations and action plans in the field of water governance, water and wastewater tariff policy, and the administrative reforms. This cell would be composed of one legal and institutional expert, one water and wastewater strategy expert, a dams' expert, an irrigation expert, one financial analyst, and one public administration expert.

Table 1 Percentage of WEs permanent staff by categories (2020)

Category	NLWE	BMLWE	BWE	SLWE
I & II	11 %	5 %	2 %	4 %
III & IV	84 %	94 %	96 %	85 %

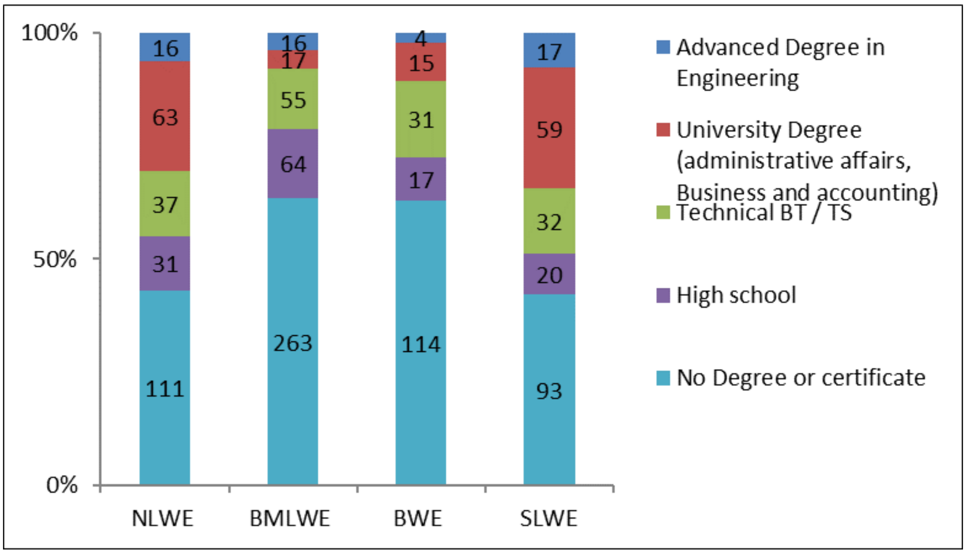


Figure 2 Overview of WE staff qualifications (2020)

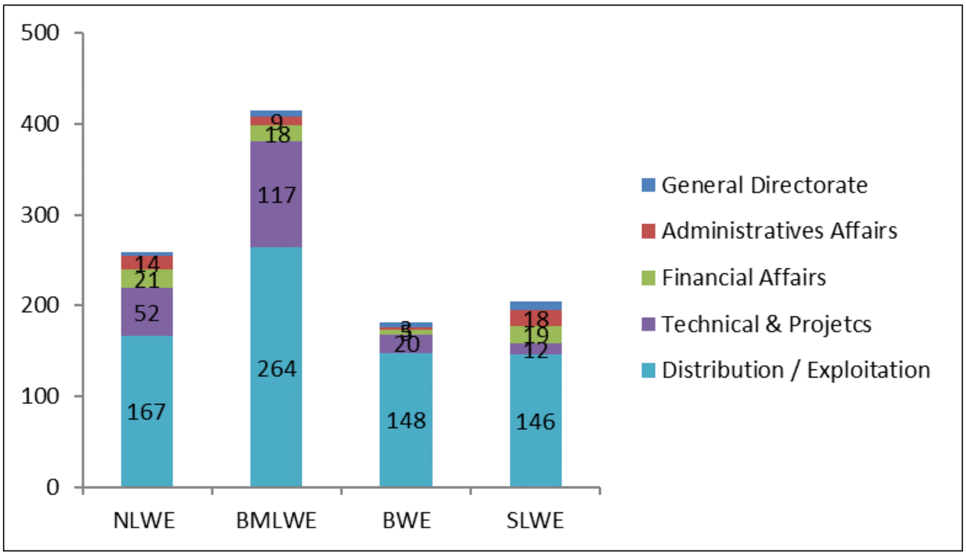


Figure 3 Staff allocation by main departments (2020)

2.1.3 Component 3: Supervision, Monitoring & Reporting

2.1.3.1 Challenges

a. The current tutelage framework is highly administrative, involves close supervision by the MoEW over the WEs and does not focus on monitoring their performance, leading the tutelage to suffer from a loss of purpose and effectiveness. As such, the MoEW spends a lot of time validating procedures that are part of the WEs day-to-day management, restricting, to some extent, the WEs ability to develop their institutions.

b. MoEW and the WEs have very limited human technical capacities for producing technical reviews and proper reporting or for monitoring activities across the entire sector and across the country, as there is no specific body dedicated to conduct this activity. As a consequence, the current sector data is incomplete and full of discrepancies and does not enable systematic monitoring.

c. The sector's transparency is hampered by the lack of reliable data communicated to users; this results in lack of trust from users in the water institutions (especially the WEs which are the service providers), and partly explains the low recovery rate of water bills.

d. The sector also suffers from lack of communication and coordination between its institutions leading to a dilution of responsibilities in the different segments of the services management. For instance, large infrastructure projects are financed by donors through the Council for Development and Reconstruction, which contracts the private sector to carry out the work. WEs, who are the ultimate service providers, have little involvement in the project preparations and management. As a consequence, there is little consideration paid to the technical and financial capacities of the service operator (WE) when designing the facilities.

In reality, the infrastructure project implementation framework is more as set out in the diagram below:

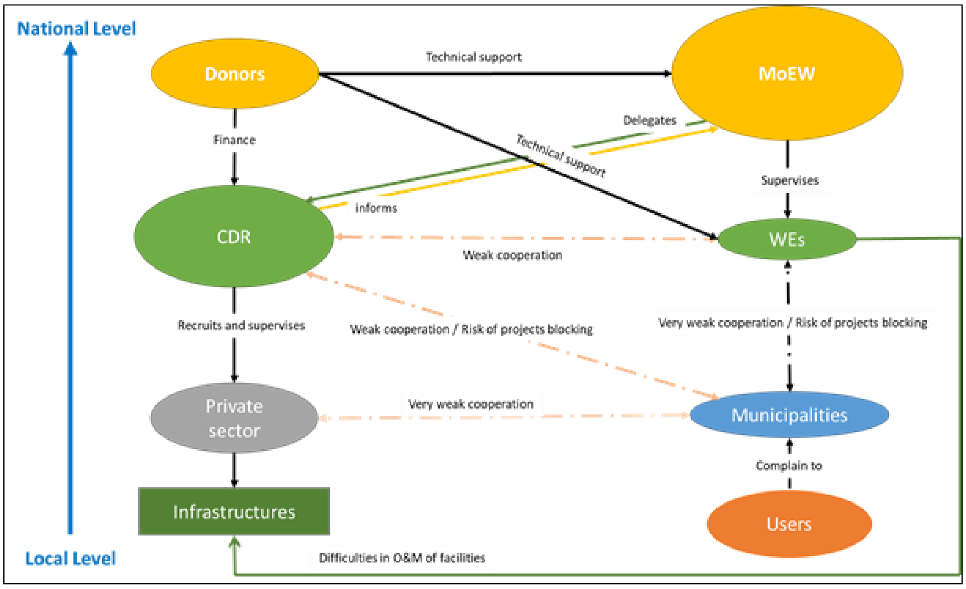


Figure 4 WE involvement according to current practice

The donors provide technical assistance to the WEs and the MoEW; the latter delegates the monitoring of works to the CDR that has a very large sphere of influence. WEs have very little influence and there is poor cooperation between the WEs and the CDR.

Municipalities also appear to have an influence over project implementation, mostly because they are the main point of contact for users and are able to block projects should they wish. There is poor cooperation between the WEs and municipalities, and between the municipalities and the CDR. There is also poor communication between the WEs and the users (as described previously).

2.1.3.2 Recommended Reforms

- The creation of a monitoring department within MoEW is a top priority. It is strategic to enhance the administrative supervision framework of MoEW by restructuring the Ministry's supervisory functions, focusing them on the WEs performance. This framework development has to be carried out progressively through specific support provided to MoEW and the WEs. A targeted legal assessment has to be carried out to specify the appropriate procedure to creating such a department. This would greatly improve transparency and coordination within the sector's institutions and enhance communication with users.
- The WEs organizational and operating decrees should be reviewed and directed towards defining guidelines for their internal organization, restructuring specific procedures and progressively developing a framework for the WEs performance monitoring.
- To reach these objectives, several actions should be undertaken as follows:

  a. Set up a unit to coordinate and supervise the implementation of the updated NWSS.

  b. Set up a unit in charge of performance monitoring within the MoEW administrative supervision department (Directorate of Exploitation), composed of internal administrative supervision department staff and trained on performance monitoring through a specific long-term technical assistance that will support the Ministry and the WEs with developing a shared WEs performance monitoring framework.

c. Standardize the structure of reports and audits.

The Technical Assistance will support the Ministry and the WEs in structuring three types of reports:

- Annual activity reports: Including the financial and business reports already prepared by the WE but which need to be standardized to enable the Ministry to cross-reference data and results.
- Monthly activity reports: These are new and will be introduced with the aim of developing a culture of reporting and transparency on key activity and performance indicators.
- Annual external audit and evaluation of WE: WEs should appoint an auditor at the end of the first year of the strategy, and that the monitoring and supervision technical assistance will review the first reports and ToRs and will work to improve and standardize the initial framework. The annual WE external evaluation is a new provision that will be added to the administrative supervision decrees. The aim of this evaluation will be to review the activities implemented, identify bottlenecks and blockages, and produce recommendations for improving services and internal operating methods.

d. Progressively develop a framework for performance monitoring within each WE.

With the support of the dedicated technical assistance, MoEW and WEs will progressively develop a shared framework for WE performance monitoring.

The first step will involve assessing the monitoring capacities of each WE in order to define basic key performance indicators to be monitored, and to set targets for developing improved indicators within an achievable timeframe. Indicators will be reviewed and progressively developed after four years, in order to be able to set contractual KPI and establish performance-based contracts between the MoEW and the WEs.

The below graph shows the relationship that should be developed between stakeholders in order to achieve the reforms proposed in this strategy and in the Water Code.

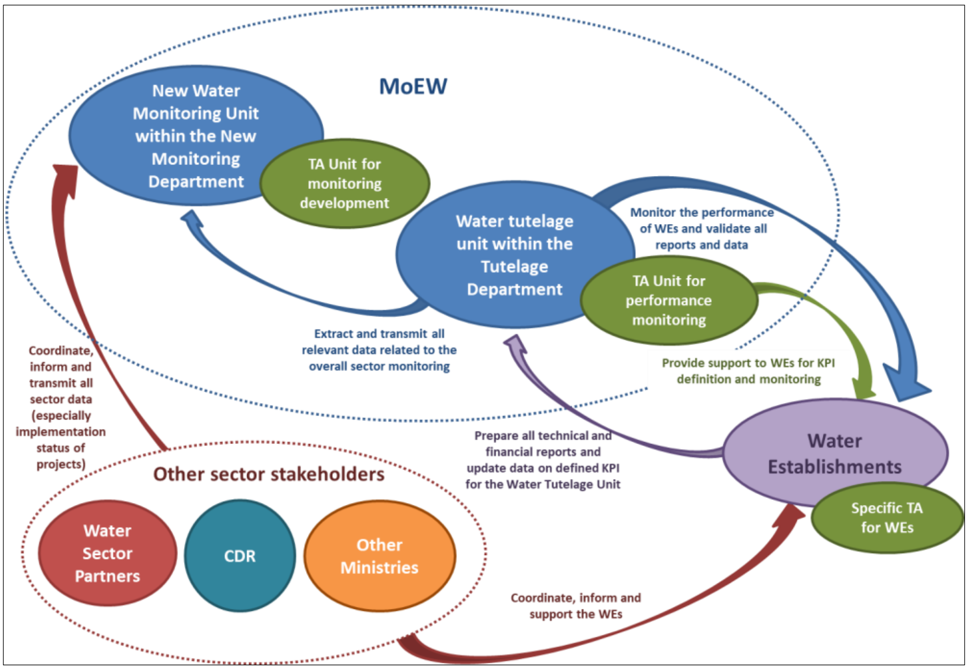


Figure 5 Proposed overall structure of the sector-monitoring framework

- To enhance transparency and proper communication, it is important to establish a unified database to include all sector monitoring data and ensure it is regularly updated (including the WE KPI): This database shall include all specific sector data on water resources, water quality, water uses, management of water, wastewater and irrigation services (as part of the WE KPI to collect and harmonize within this unified database managed by the Ministry), status of infrastructure projects and on financing tools of the sector.
- Setting up an annual sector review involving the main local and international stakeholders and partners is a key element of transparency.
- Regular reporting (annual report, financial report, commercial report) will ensure a transparent flow of information between WEs and MoEW.
- Communication with users is a key element for service sustainability through assessing existing tools and communication strategies at MoEW and WEs, while coordinating with other programs aiming to support the WEs and MoEW in their communication with users.
- A strong and clear coordination platform will be developed to improve the coordination between the CDR, MoEW and the WEs for all projects related to the water sector involving any of these institutions. This would avoid duplication of works and reduce the cost of investments and O&M of the projects at hand.
- The structuring and enhancement of the private sector involvement is a priority of this strategy and will start by reviewing existing contracts with private operators and gradually developing a new contracting framework and performance-based contracts.

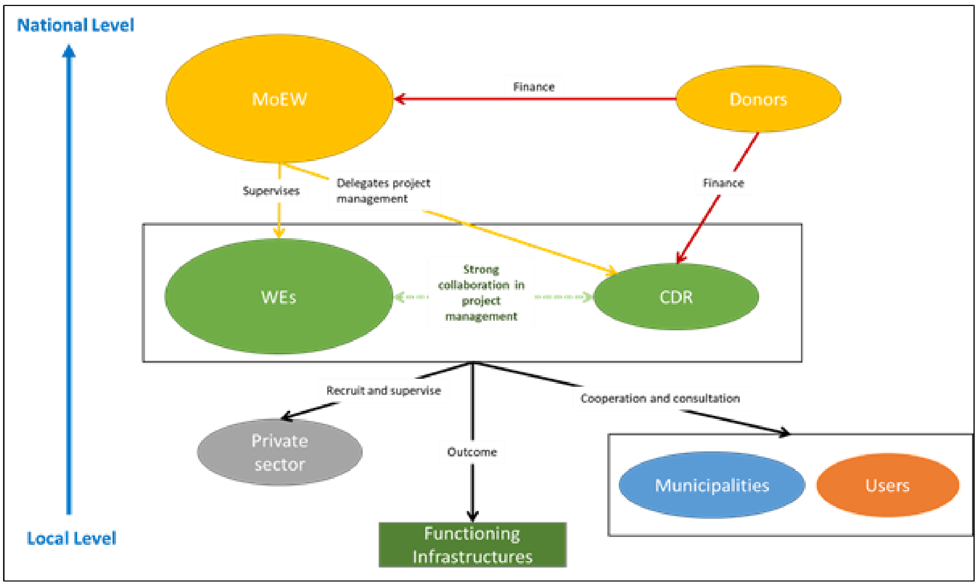


Figure 6 WE involvement according to Law 221 and the NWSS

According to Law 221 and the National Water Sector Strategy, WEs should play a central role in project planning and management, alongside MoEW & CDR.

Under this arrangement, the donors finance both the CDR and the Ministry, then the latter provides guidance to both the WEs and CDR.

The WEs and CDR should be responsible for ensuring the infrastructure functions correctly by monitoring the private sector and by working with municipalities and communicating with users.

2.1.4 Component 4: The financial and commercial frameworks

2.1.4.1 Challenges

- In the financial field, the key issues refer to the absence of International Financial Reporting Standards for all WEs together with an annual audit of the financial statements and ledgers by an international independent audit firm. Such a gap obstructs the transparency of financial statements and the ability of MoEW to properly monitor the utilities and fairly compare the WEs performances.
- The current service pricing system is not adapted to the needs of the WEs to ensure a financial balance and achieve basic performance in the service delivery across all sectors mandated by WEs (water, wastewater and irrigation).
- The gauge system is inaccurate and produces side effects both on the technical side (no measurement of Non-Revenue Water (NRW) and over consumption) and on the financial side (efforts made for keeping control of NRW is not financially rewarded). The gauge system and the associated flat rate billing system do not allow to spot the over consumption of water. Such systems lead to wasting of water and draining of the financial resources of the WEs.

Table 2 Overview of the WEs (2020)

	NLWE	BWE	BMLWE	SLWE
Est. population of the service area	1,716,000	750,000	2,907,000	1,200,000
Nbr of villages	457	250	533	385
Nbr of subscribers/subscribed households (2018)	124,793	86,761	592,835	176,000
Est. Population supplied (est. 4.5 persons per HH)	561,569	390,425	2,667,758	792,000
Est. population tapping the water from unknown origin	1,154,432 (67 %)	359,576 (48 %)	239,243 (8 %)	408,000 (34 %)
Nbr of actual employees	637	403	782	236
Nbr of autonomous sub-systems	8	11	6	7
Est. length of the networks (km)	1,839	4,384	9,000	5,000
Est. Unaccounted for water (%) (1)	46 %	48 %	35 %	55 %
Nbr of water meters	56,266	38,400	185,960	N/A
Volume produced (Mm^3/Y)	106	68	171	113
Est. collection rate	63 %	32 %	79 %	51 %
Nbr of WWTP under the WEs jurisdiction(2)	27	14	19	26

Note s: (1) Unaccounted for water % as per verbal communication from the WEs.

(2) This is the total number of existing WWTP or under construction, under the jurisdiction of the WE, and operated either directly by the WE, by CDR, or other.

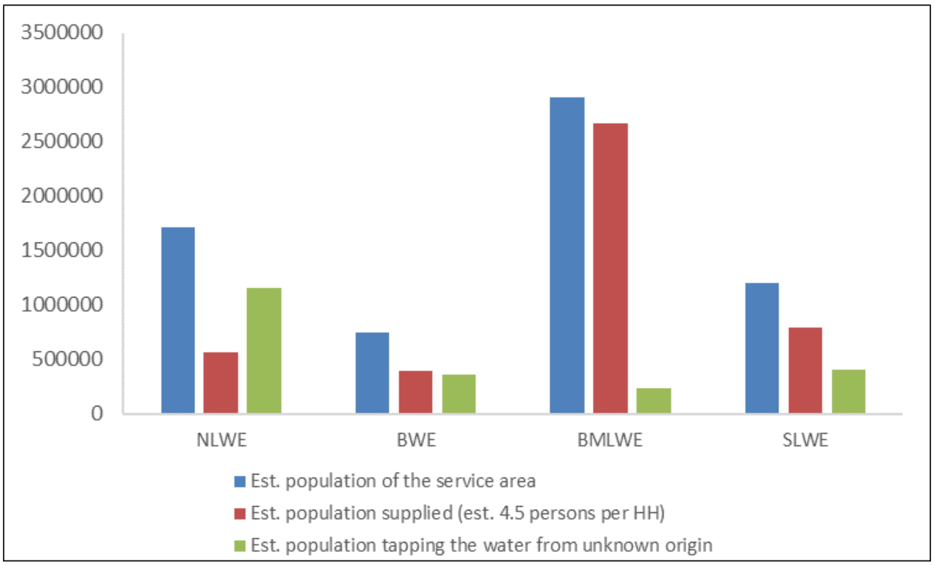


Figure 7 Population supplied vs overall population (2020)

- WEs have installed water meters in order to start implementing consumption-based tariffs but many are not read and the staff need training and support for the water meters' management.

- Tariff level and tariff settings are set differently by each WE with considerable discrepancies among the 4 WEs. Such differences should be justified based on the operating models of the WEs (gravity supply v/s water pumping, treatment v/s spring water), but they are not. In addition, the billing computation corresponding to water meters differs from one WE to the other. Table 3 shows the annual water tariff for 1 m^3/day subscription for houses connected to the wastewater networks.

Table 3 Annual water tariff In LBP for a 1 m³/day subscription (2020)

	NLWE		**BWE**		**BMLWE**		**SLWE**	
	Gauge	Meter	Gauge	Meter	Gauge	Meter	Gauge	Meter
Tariff for 1 m^3/d	228,000	228,000	180,000	NA	275,000	321,000	216,000	216,000
Maintenance	12,000	24,000	20,000	NA	10,000	50,000	25,000	35,000
IT/Computerization	NA	NA	5,000	NA	3,000	3,000	5,000	5,000
WW Subscription	20,000	20,000	60,000	NA	40,000	40,000	30,000	30,000
Subtotal	260,000	272,000	265,000	NA	328,000	414,000	276,000	286,000
VAT (11%)	28,600	29,920	29,150	NA	36,080	45,540	30,360	31,460
Stamp	1,000	1,000	1,000	NA	1,000	1,000	1,000	1,000
Round	400	80	850	NA	920	460	540	640
Bill/Year	**290,000**	**303,000**	**296,000**	**NA**	**366,000**	**461,000**	**308,000**	**319,000**

Table 4 Status of water meters in WEs (2020)

WE	Number of water meters	Percentage of subscribers	Comments
NLWE	56,266	45%	Individual meters are not read and are billed on a flat basis. Seems that only big consumers water meters are actually read.
BWE	38,400	44%	Approximately 38,000 meters have been installed, but billing made on a flat rate. Only 3,000 meters are read for monitoring purpose.
BMLWE	185,960	31%	Metering is a success and even smart meters have been installed. Management is willing to increase the number of meters.
SLWE	NA	NA	Metering is not commonly encountered.

- On the Commercial side, customers' databases (for the potable water services) are not comprehensive and WEs deal with a large gap between the number of official customers (listed in the databases) and the actual population tapping from the network. The current situation demonstrates that lot of households/dwellings are supplied from unknown origins, and this refers to private wells or multiple connections, or even wrong allocation within the database down to illegal connections.

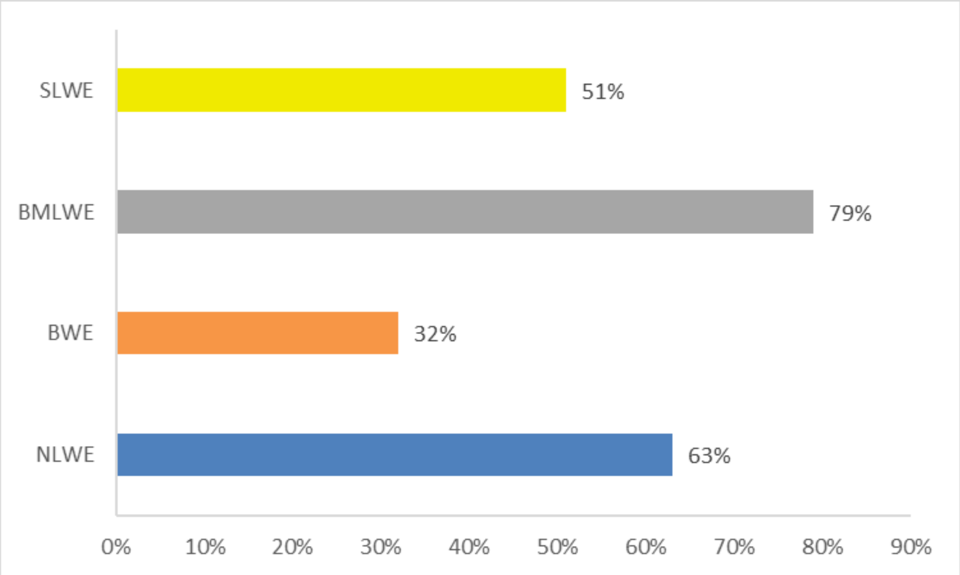


Figure 8 Estimated collection rate (2018)

- Users' databases for the wastewater management services have not been developed yet. Users of the services need to be identified and registered in specific databases as in some regions not all users of wastewater services (households connected to sewage networks and ultimately to treatment plants) are subscribers to the water service of WEs. According to the Water Code, a wastewater fee must be paid by non-connected houses to the sewage network as a sort of "pollution tax" for damaging the environment. Today, the WEs are charging the fees shown in the above table but this fee is not sufficient to cover the O&M of wastewater systems.

Table 5 Yearly sewage fee (LBP) (2020)

	Connected to the Waste Water System	
	yes	no
NLWE	20,000	10,000
BWE	60,000	15,000
BMLWE	40,000	25,000
SLWE	30,000	15,000

Such fee has to be elaborated soon to become proportional to the actual water consumption. The pollution tax for non-subscribers would be a low tax when a properly designed septic tank exists and high when such a system does not exist.

2.1.4.2 Recommended Reforms

Water demand and supply management initiatives, such as decreasing NRW, controlling produced and consumed volumes through the installation of bulk flow meters at source and district levels along the water systems, as well as improving collection rates and financial performances of the WEs, restructuring the general billing system and the water-meter readings are all important and priority objectives and require the following specific actions:

1. To optimize the cost of production of water and increase the supplied volumes, the primary objective is to decrease NRW through initiatives such as:
   a. Removal of illegal connections and the reduction of technical losses: The Government's political support, when it comes to removal of illegal connections, is crucial to allow for an effective enforcement of the law on all territories. In parallel, installing bulk flow meters at the sources and district meters along water systems shall be considered a top priority, as this would allow to measure the volumes of water produced, as well as the volumes wasted in the systems, and to calculate the cost of production, leading to a proper evaluation of the targets and the tariff. Eventually, this action plan would yield in an increased volume of water supplied to subscribers, and installation of water meters at household level becomes feasible and efficient, knowing that the target of this strategy is to introduce water meters on a large scale targeting 100% of households by the end of 2035.
   b. Installation of bulk flow meters at the sources and district meters along water systems: this is considered a top priority for it allows to measure the volumes of water produced and those wasted in the systems, take the necessary action to control the water, and to calculate the cost of production, leading to a proper evaluation of the tariff. Eventually, this action plan would yield in an increased volume of water supplied to subscribers, and consequently, the installation of water meters at household level becomes feasible and efficient, knowing that the target of this strategy is to introduce water meters on a large scale targeting 100% of households by the end of 2035.
   c. Upgrading the irrigation systems: as discussed later in the document, irrigation networks need to be upgraded from earth channels to concrete canals or piped systems, as judged feasible. Although concrete channels reduce the natural recharge of aquifers, yet they are more efficient in delivering the supplied volumes of water to the irrigable lands. Two additional elements are needed here: 1) the application of an adequate tariff that is socially and economically appropriate to farmers, and that allows WEs to maintain and rehabilitate channels and supply the needed water quantities, and 2) the use of water-efficient irrigation systems with the support of the MoA.
   d. Bridging the gap between the number of official customers as existing in the various customer databases and the actual population tapping from the network: The main recommendation is to conduct a customer census campaign (each WE in its jurisdiction) to detect and attract potential new customers and include them in the customer database and billing system. Expected output is to increase revenues of the WEs with no real additional operating cost and to reduce the commercial losses.
2. Financial reforms and changes in the water tariff structure, closely accompanied with increasing the number of subscribers and collection rates are primordial actions, and should be complemented with a communication campaign, reaching out to local citizens, informing them about the importance of paying their dues for the sustainability of the WEs services, encouraging those who are not subscribed to legalize their status, motivating them to save water and to installing water meters.

3. An increase in the Water tariff, the application of a Wastewater tariff, and a change in the tariff structure are top priorities and will be based on a tariff restructuring study. Once the tariff restructuring study is undertaken, blocks of tariffs with specific rates will be introduced where the first block of tariff will have a fairly low rate to account for the socially vulnerable tranche, and will increase gradually with increased consumption. Eventually, a new category of customers targeting big consumers (Industrials, Hotels, others to be identified) should be gradually introduced with specific tariff levels.

   This should be economically justified and would require the enforcement of the International Financial Reporting Standards (IFRS) concept and the introduction of an annual audit carried out by independent firms of international reputation.

   Table 6 below represents the scenario of the targets set by MoEW and the WEs in the "Recovery Plan of the Water sector 2022-2026" to reach equilibrium and financial recovery. This scenario tackles the increase in subscriptions and collection rates, reduction of non- revenue water (through the customer census and district metering) and the increase of the tariff accordingly. The tariff restructuring is not shown here, but will be included once the tariff study is undertaken.

   These targets are illustrative, and are based on the economic and financial context of Lebanon early 2022; therefore, the final packaging might be different depending on the National Economic Recovery Plan, and the corresponding Business Plans of the WEs. These targets are subject to yearly modifications depending on the overall situation of the country.

Table 6 Typical baseline scenario for financial recovery of WEs

	2021	2022	2023	2024	2025	2026
Subscribers increase rate	0%	0%	4%	4%	3%	4%
Collection rate increase rate	0%	0%	3%	5%	5%	5%
Average tariff increase rate	0%	330%	150%	170%	0%	120%
Average tariff proposed (LBP)	320,000	1,000,000	1,500,000	2,500,000	2,500,000	3,000,000
Average tariff proposed (USD) (nominal 20,000 LBP/USD)	15	50	75	125	125	150

Table 7 Results of the recovery scenario if applied to WEs (2022 – 2026)

WE	Subscription increase From – To	Non-Revenue Water reduction From – To	Collection rate increase From – To
SLWE	60% to 70%	58% - 25%	54% - 80%
NLWE	50% to 70%	46% - 25%	51% - 80%
BWE	37% to 70%	29% - 25%	46% - 80%
BMLWE	60% to 70%	5% - 5%	69% - 80%

4. To complement the second step, and to encourage citizens further, WEs should set a financial plan to allow payments of arrears, subscriptions fees and yearly fees to be settled through periodic instalments.
5. Municipalities have a special role to play in the water sector, and although their inclusion has gained momentum in the past few years, it is proving important to strengthen the relationship between WEs and municipalities in order to achieve financial and commercial targets (such as increased collection and subscription rates and decreased NRW water), as well as proper O&M and swift interventions by WEs on the ground.
6. Introducing a wastewater fee proportionally to the water consumed and defining a specific wastewater fee for households that are not subscribing to the WEs (as stated by the Water Code 192/2020) are very important steps especially that WEs have started taking over operational WWTP's. For the wastewater management, users of the services need to be identified and registered in specific databases. It is essential to be able to cross-reference the database of subscribers to the WEs with the database of users of wastewater services. A specific system of pricing and collection of the sanitation fee will have to be applied to those who are not yet WEs subscribers.
7. To decrease the cost of wastewater treatment, AFD/EU Technical Assistance team calculated the dry cost (not including profit, contingencies and supervision costs) of operating the major treatment plants. This estimated cost can be a benchmark for WEs when tendering operations of WWTP's. Energy consumption of the plants should be optimized by introducing Renewable Energy sources where feasible. At the same time, the types of contracts with private operators should be gradually upgraded to PBC to optimize performance and cost of service. Note that an assessment of all existing WWTP's is being conducted to identify the gaps obstructing their full performance, the actions required and the estimated cost of their rehabilitation/upgrading. Such works would optimize the cost of operations.

The above action points are priority and major elements towards a sustainable management and financial stability.

Sustainability of service delivery and proper management of the water sector is a medium term process expected to last between 3 to 5 years, backed by political consensus. With the adoption of the updated NWSS, the ratification of the revised Water Code (law number 192/2020), the technical assistance programs financed and supervised by different Donors, the most imminent of which being the AFD/EU program and USAID's Water, Sanitation and Conservation program, and the willingness and involvement of the WEs, progress towards a sustainable management of services is considered to be set on the right track.

2.1.5 Component 5: Operation and maintenance

2.1.5.1 Challenges

The operation and maintenance of facilities and services are key factors for developing the sector and strengthening the sustainability of services. Three main axes form the basis for the proper and sustainable management of facilities and provision of services:

1. The High Operating Cost:

   High energy consumption, inefficient design of facilities, inappropriate repair and maintenance, and inefficient contractual modalities are some of the reasons behind the high operating cost borne by WEs.

2. The Private Sector Involvement

   WEs have contracts with private operators for operating water and wastewater facilities, but they lack an efficient and effective contractual framework and internal technical skills to properly supervise private operators.

   Law 48/107 was ratified in 2017 to encourage public-private partnerships in various sectors including the water and the wastewater sectors. The PPP modality is expected to attract financing of large projects and service provision as identified in this strategy, especially when implementation of reforms starts bearing the intended positive results.

   Law 192/2020 has allowed the private sector to participate in various activities at the WEs, particularly regarding customer relations, customer data-base management, communication, billing and water meter reading. A public-private partnership in the water sector allows it to move towards achieving SDG 17: Partnerships for Goals which involves Strengthening the means of implementation and revitalizing partnerships for sustainable development.

3. The Fragmented Wastewater Management Framework

   This is a challenge on its own and a high priority for the sector sustainability. Although stakeholders agree on the institutional framework that mandates the WEs to manage the wastewater systems; however, the effective framework for wastewater management is not clear and needs to be refined. Several actors are involved in wastewater management (WEs, CDR, municipalities, and private operators), and, therefore, the identification of modalities of involvement and financing mechanisms need to be defined.

2.1.5.2 Recommended Initiatives

To overcome the above challenges, the following initiatives are recommended:

1. Developing a specific strategy to control the energy costs of the facilities and a national plan to introduce Renewable Energy sources at water and wastewater facilities known to be energy consuming (such as pumping station and treatment plants). This initiative is the water strategy's contribution to **SDG 7** (Affordable and Clean Energy), with the aim of limiting carbon emissions generated by the water sector operations.

2. Defining guidelines to ensure that design of facilities is efficient and adapted to the capacity of WEs to cover operating costs and provide proper maintenance.

3. Structuring and enhancement of the private sector involvement by reviewing existing contracts with private operators and developing a new contracting framework based on performance and target achievement.
4. Identifying the activities to be outsourced and the outsourcing arrangements to be adopted.
5. Adopting a shared wastewater management framework: A specific study should be carried out to:
   - Analyze the current wastewater facilities management arrangements and wastewater financing tools (fee added to the water bill, municipal tax, etc.).
   - Conduct a full cycle analysis for each wastewater system currently operational.
   - Set benchmarks from successful frameworks used in Lebanon and abroad.
   - Coordinate between WEs, MoEW, CDR, donors and partners to conduct joint discussions.
   - Propose scenarios and an overall framework for wastewater facilities management and propose financial arrangements for O&M (in coordination with the tariff study that will be carried out in the framework of the water metering development).

2.1.6 Summary of reforms and action plans

Table 8 below shows the detailed Priority and Short Term Action Plan, the associated activities for the reform of the Water Sector and the timeline for implementation. This Action Plan extends over a period of 5 years, and will be implemented with the help of technical assistance programs financed by Donors of the Water Sector, starting with AFD's (Agence Française de Développement) Long Term Technical Assistance programme over a period of 4 years as of September 2020.

The budget estimates of these complementary studies together with other studies, and other plans such as the surface and groundwater management that should be conducted simultaneously with the priority and short term Action Plan in order to implement reforms and abide by the requirements of the legal, institutional and infrastructures frameworks of this updated NWSS 2020 are given under Sub-Section 4.1

Table 8 Priority and short term Action Plan

	Activity	Priority	Stakeholder: Lead	Stakeholder: Involved	Means to mobilize	Deadline	Indicators	Funding
RS-A.1. Sector Governance								
RS-A.1.1	**Implement the legal and regulatory framework reform (Water Code)**							
RS-A.1.1.1	Prepare, adopt and implement the Water Code bylaws as already listed	High	MoEW	WE, LRA, MoE, MoA	Recruitment of legal consultant	Phase 1 : Q1 2021 Revision : end 2025	Adopted Decrees	INT
RS-A.1.1.2	Draft revised WE organisation bylaws, support the approval process and follow up on their enactment	High	MoEW	WE	Recruitment of legal consultant	Phase 1 : end 2020 Revision : end 2025	Adopted Decrees	INT
RS-A.1.1.3	Draft the new code of irrigation	High	MoEW	WE, LRA, MoE, MoA	Recruitment of legal consultant	Phase 1 : end 2020 Revision : end 2025	Adopted Decrees	INT
RS-A.1.1.4	Draft the decrees allowing the Ministry of Energy and Water to define the performances of the Water Establishments and audit them based on their efficiency	High	MoEW	WE	Recruitment of legal consultant	Phase 1 : end 2020 Revision : end 2025	Adopted Decrees	INT
RS-A.1.1.5	Draft a legal text related to the competence of the Tutelage	High	MoEW	WE	Recruitment of legal consultant	Phase 1 : end 2020 Revision : end 2025	Adopted Decrees	INT
RS-A.1.2	**Rationalise the tutelage framework with a view for clear dispatching between operational and regulatory activities**							
RS-A.1.2.1	Restructure the Ministry's supervisory functions and introduce a substitute function in the event of WE failure (incl. direct procurement of external audit if not conducted by WEs and cost deduction from their budget)		MoEW		Recruitment of legal consultant	End of 2020	Revised Decree	INT
RS-A.1.2.2	Review the organisational decrees by focusing them on defining guidelines for WEs organisation and streamline specific procedures	High			Recruitment of legal consultant	Phase 1 : end 2020 Revision : end 2025	Adopted Decrees	INT
	a. Define guidelines for the WEs' HR recruitment and organisation structures / simplify the organisation chart validation procedure			WE				
	b. Streamline the HR recruitment process and make it possible to enhance recruitment outside the public service procedures			WE				
	c. Raise the expenditure and procurement validation thresholds		MoEW	WE, MoF				
	d. Define guidelines for WE performance monitoring			WE				
	e. Define guidelines for pricing services and simplify the validation procedure			WE				
	f. Define guidelines for procurement management and the management of performance-based contracts			WE				
RS-A.1.2.3	Conduct an assessment of the administrative supervision department roles and capacities and develop a specific staff capacity-building plan	High	MoEW		Recruitment of consultants / experts (water services management, HR, capacity-building)	Assessment : End of 2020 Implementing the capacity-building plan : End 2025	Assessment and CB plan validated by MoEW and activity reports of the supporting activities	INT
RS-A.1.3	**Develop proper mechanisms for performance monitoring**							
RS-A.1.3.1	Set up a unit in charge of performance monitoring within the MoEW administrative supervision department	Short Term	MoEW		Recruitment of technical assitants (to 2 Experts in water services management and performance monitoring)	Recruitment : End 2020 TA until end 2025	*Standardized reports prepared by WEs *Conduction of external annual audits starting in 2021 *Production of KPI *Performance contracts between MoEW and WEs	INT
RS-A.1.3.2	Standardise the structure of annual reports incl. financial and business reports	Mid Term	MoEW	WE				
RS-A.1.3.3	Define the monthly activity report submission and validation structure and procedure	High	MoEW	WE				
RS-A.1.3.4	Develop the framework for the annual external audit and evaluation of WE	High	MoEW	WE				
RS-A.1.3.5	Define key performance indicators to be monitored in the short, medium and long term (in alignment with the WE monitoring capacities)	High	MoEW	WE				
RS-A.1.3.6	Establish performance contracts between the MoEW and WE	High	MoEW	WE				
RS-A.1.3.7	Set up the performance monitoring committee as required by law 221	High	MoEW	WE, MoF				

Table 8 Priority and short term Action Plan (continued)

Activity		Priority	Stakeholder Lead	Stakeholder Involved	Means to mobilize	Deadline	Indicators	Funding
RS-A.2. Financial and commercial								
RS-A.2.1 Conduct a customer and user census								
RS-A.2.1.1	Identify customers connected to piped water and convert unknown customers tapping into the network into legal users	High	WE	MoEW	Recruitment of consultants (technical experts and census experts) - Census to be conducted for all customers / estimated to 1 500 000 of households (price: $3 for 1 household)	Phase 1 : End 2020 Complete census : Beginning 2021	Census reports and updated WEs' consumers database	INT
RS-A.2.1.2	Identify users of collective wastewater services (network or network+WWTP) / identify those who are / are not WE customers (cross-reference with the water supply customer census) in order to define specific approaches for tariff-setting	High	WE	MoEW	Recruitment of consultants (technical experts and census experts)	Complete census for zone 1 by mid 2021	Census reports and updated WEs' wastewater services users database	INT
RS-A.2.1.3	Ensure the take over of new customers/users by WEs and their inclusion in the customer/users database for the billing/collection cycle		WE	MoEW	if needed support from specific TA	Beginning 2022	Increasing subscribers base	INT
RS-A.2.2 Implement consumption-based tariffs for water service								
RS-A.2.2.1	Streamline the water meter billing procedure		MoEW		Recruitment of financial and water tariff expert(s)	Mid 2022	Harmonized guidelines and procedures for water meter billing	INT
RS-A.2.3 Revise the tariff structure for sanitation services								
RS-A.2.3.1	Conduct a proper cost analysis of facilities O&M		MoEW		Recruitment of technical and financial experts on wastewater management	End 2020	Adoption and implementation of new tariff policy for wastewater management	INT
RS-A.2.3.2	Base the tariff on the cost analysis and, as a minimum, cover O&M costs		WEs			Mid 2021		

Table 8 Priority and short term Action Plan (continued)

	Activity	Priority	Stakeholder Lead	Stakeholder Involved	Means to mobilize	Deadline	Indicators	Funding
RS-A.3. Reporting and monitoring								
RS-A.3.1 Enhance sector monitoring								
RS-A.3.1.1	Create a Monitoring Department within the Ministry		MoEW		Recruitment of legal consultant	End of 2020	Revised Decree or Amendment to the Law 247	INT
RS-A.3.1.2	Establish a unified database to include all sector monitoring data and ensure it is regularly updated (incl. the WE KPI)		MoEW		Recruitment of water sector monitoring (part-time assistance) and 1 IT expert (full-time assistance)	Mid 2021	*TA recruitment *TA activity reports *Establishment and regular update of the sector database	INT
						Mid 2022	Database	
RS-A.3.1.3	Set up an annual sector review involving the main stakeholders and partners		MoEW		Organisation of annual sector workshop	Mid 2020	Workshop / annual review and annual sector review report	National
RS-A.3.1.4	Set up the process for monitoring the Strategy implementation status		MoEW		Analysis of sector data	Mid 2025	Strategy implementation status report	National
RS-A.3.2 Enhance sector transparency								
RS-A.3.2.1	Ensure a transparent flow of information between WEs and MoEW through regular reporting (annual report, financial report, business report)		MoEW		Reports production and publication / TA support	Continiuous activity	Meeting minutes, reports	National
RS-A.3.2.2	Publish annual WE reports (incl. results of audits performed by independent auditors)		WEs		Recruitment of external auditors	starting from mid 2021	Annual WEs' reports publication	National
RS-A.3.2.3	Prepare financial reports based on IFRS book-keeping standards		WEs		Reports preparation with TA support if needed	starting from mid 2021	Financial report	National and INT TA
RS-A.3.2.4	Publish the main sector indicators, ensuring these are updated on a regular basis		MoEW		Update of sector indicators (with TA - see C.1.1)	starting from mid 2021	Publication of main sector indicators	National and INT
RS-A.3.2.5	Publish the breakdown of the water bill		WEs		Publication and communication support	starting from mid 2021	Publication by each WE of the water bill breakdown	National
RS-A.3.3 Enhance sector coordination								
RS-A.3.3.1	Improve coordination between CDR and WEs on infrastructure project planning and management		MoEW		Regular meetings, MoEW follow-up on coordination, support from donors and sector partners	Continiuous activity	Participation of WEs in the projects design and implementation	National
RS-A.3.3.2	Organise an annual sector review involving all stakeholders and partners		MoEW		Organisation of annual sector workshop	Mid 2020	Workshop / annual review and annual sector review report	National
RS-A.3.4 Enhance communication with user								
RS-A.3.4.1	Develop a communication strategy for MoEW and WE		MoEW		Recruitment of communication experts	End 2020	Communication strategy, tools and supports	INT
RS-A.3.4.2	Design and launch a national communication campaign on the water sector		MoEW			Beginning 2021		

Table 8 Priority and short term Action Plan (continued)

Activity		Priority	Stakeholder Lead	Stakeholder Involved	Means to mobilize	Deadline	Indicators	Funding
RS-A.4. Capacity-building								
RS-A.4.1 Strengthen the MoEW monitoring capacities								
RS-A.4.1.1	Appoint specific technical assistance to the MoEW to help develop monitoring		MoEW			***Covered under item C.1.1***		
RS-A.4.1.2	Support the MoEW in defining sector key performance indicators		MoEW					
RS-A.4.1.3	Support the MoEW and the WEs in developing a performance monitoring framework		MoEW			***Covered under item A3***		
RS-A.4.1.4	Identify the MoEW staff to be trained and supported in monitoring activities		MoEW					
RS-A.4.2 Streamline and structure WE internal organisation and management								
RS-A.4.2.1	Conduct an overall internal audit in each WE (organisational, HR management, financial - assets, commercial, technical), propose measures and guidelines for streamlining internal WE organisation		WEs		Recruitment of the following experts: institutional, O&M of water utilities, capacity-building and HR management, water and wastewater	Beginning 2021	Audit report validated by MoEW and the four WEs	INT
RS-A.4.2.2	Prepare a handbook of jobs in the WEs with minimum skills required per position and standard training / capacity-building plan to be implemented		WEs			*Beginning of 2022 for the hanbook validation *End of 2025 for implementing the capacity-building plan and TA support	*Handbook *Capacity-building plan *TA activity reports and specific studies	INT
RS-A.5. O&M of facilities and services								
RS-A.5.1 Improve operating cost control								
RS-A.5.1.1	Develop a specific strategy to control the energy costs of the facilities (based on ongoing studies)		MoEW		Recruitment of technical and financial experts	End of 2021	Validated reports and strategic guidelines	INT
RS-A.5.1.2	Define guidelines to ensure that facilities design is adapted to the capacity to cover their operating costs		MoEW		Recruitment of technical and financial experts (coordinate with other financial and technical studies)	End of 2021	Publication of guidelines	INT
RS-A.5.2 Enhance private sector involvement								
RS-A.5.2.1	Review existing contracts with private operators and develop a new contracting framework and performance-based contracts		WEs		Recruitment of institutional, legal and technical experts in overseeing water facilities O&M contracts	Mid 2021 for pilot contract for wastewater facilities management End of 2025 to assess the contracts and revise the framework (if needed)	Implementation of performance-based contracts Assessment report of the efficiency and ownership by WEs of this framework and propose improvements	INT
RS-A.5.2.2	Identify the tasks or activities to be outsourced and the outsourcing arrangements to be adopted		WEs		Recruitment of the following experts: institutional, O&M of water utilities, capacity-building and HR management, water and wastewater	Mid 2021	Reports and validation of the proposed framework by WEs and MoEW	INT
RS-A.5.3 Adopt a shared wastewater management framework								
RS-A.5.3.1	Address the issue of the organization(s) responsible for managing the WW network and treatment plants (WEs, municipalities, private operators.) and determine the financing method		MoEW		Recruitment of institutional, financial and technical experts in wastewater facilities operation and management	Mid 2021	Publication of the wastewater management framework	INT

2.2 PILLAR 2: INTEGRATED WATER RESOURCES MANAGEMENT

2.2.1 Integrated water resources management, basin schemes and the water code

Under Chapter 2 "Organizing and Managing Water Resources", Articles 16 to 23, Law 192/2020 provide extensive details on the methodology to set an IWRM Master Plan for Lebanon. The geography shall be divided into basins and each basin water resources would be evaluated; plans would then be set for the development of each basin as a separate unit and organized on the basis of the principle of the integration of the management of water resources in accordance with the social, economic and environmental development plans. The law clearly states that the IWRM Master Plan shall be based on Watershed or Basin Schemes and specifies the requirements for the development of such schemes. The IWRM Master Plan and the Basin schemes are closely interrelated and feed into one another.

The available data till date does not allow yet the MoEW to update its planning based on the IWRM requirements of the Water Code. However, this strategy update will be the cornerstone that will allow the Ministry and the WEs to set Basin Schemes and eventually develop its strategies based on an IWRM. Two important elements are missing and hinder the development of an IWRM strategy:

1- Unavailability of an economic and social development plan: so far, the Government of Lebanon has not adopted an economic plan that clearly identifies the sectors it wants to prioritize, and that would accordingly guide the MoEW towards a proper water allocation plan based on resource availability and GDP targets per sector.

2- Unavailability of data: water resources in Lebanon are not well monitored, public wells and springs lack periodic monitoring, while river flows monitoring is incomplete. No solid data on the extraction levels from private (licensed and unlicensed) wells can be obtained due to their large numbers and randomness, and the lack of law enforcement. The lack of data results, among other impediments, in estimated/approximated projections of supply and demand, and does not allow for the formulation of a measured national water balance.

Therefore, under Pillar 2, the updated NWSS 2020 aims at highlighting the importance and criticality of creating Integrated Hydrological Information System (IHIS) that consists of data measurement at all types of water resources and the establishment of a data center at MoEW, interlinked with data centers at the level of the WEs (more details under Sub-Section 2.2.5).

2.2.2 Available data on water resources

The available water resources in Lebanon for potable and irrigation purposes are:

- Groundwater (springs and wells)
- Surface water (rivers)
- Surface storage (dams)

It is rightly believed that if properly managed, the available water from the above sources would cover the needs of the country well beyond the horizon of the present study. As such, Pillar 2 aims first at identifying the available resources based on the existing data till date (collected from different stakeholders LRA, WEs, etc.). Second, at identifying the allocation of water resources per sector and per source in 2020 till 2035 to set the ground for a proper integrated management that focuses on Lebanon’s conventional and non-conventional resources taking into account all the challenges, and third, at achieving **SDG 13: Climate Action** (taking urgent action to combat climate change and its impacts), as all the sections described below have one goal in common, which is: how to sustainably manage our water resources to make them available for future generations..

Groundwater appearing at surface – Major Springs

Table 9 below shows the list of the major springs tapped for potable water purposes by each WE, sorted by Caza. The situation may be summarized as follows:

- The total number of springs exceeds 2,000 with only 275 tapped ones. However, small springs are subject to progressive drought due to increasing urbanization and groundwater misuse.
- The estimated yearly Average yield of springs exceeds 2,050 Mm^3, and the maximum available yield in dry months is approximately 200 Mm^3.
- The WEs are currently tapping almost 90% of the exploitable water resources from springs. Therefore, little future optimization is expected (less than 10 %).
- It should be noted that over extraction from groundwater through unlicensed wells affects the flows available from springs. Public and licensed private wells are subject, prior to development, to a hydrogeological study that identifies their potential impact on springs flow.

Surface Water – Major Rivers

Table 10 shows the list of major rivers used for either irrigation or potable water. The yields and volumes shown are those measured at the reference gauging stations (where available) by the hydrological service at LRA. It has to be noted that when the gauging station is at the sea mouth, the volumes extracted upstream are not measured and measured flows also include the discharged volumes from springs. Thus, due to missing data and lack of accurate measurements, it is almost impossible to assess the total yield that would be available from those rivers. The yield of main and secondary seasonal rivers, wadis and in-between streams are those measured by LRA in addition to estimated yields from adjacent rivers' specific average flows. The total area of Lebanon was considered 10,400 km^2 same as of FAO 2008 report to ease calculation estimation. Based on available measurements, the estimated yield from rivers is 4,260 Mm^3/year divided into 2,210 Mm^3/year of surface water either remaining or leaving the country, and 2,050 Mm^3/year being the estimated springs flows discharging into rivers.

Table 9 List of major springs in use for potable water

Spring Name	Average Flow (m^3/d)	Exploited Flow for Domestic Usage (m^3/d)
BMLWE	**1,998,000**	**226,000**
Baabda		
Ain El Delbé	20,000	6,000
Daychounieh	39,000	6,000
Chouf		
Ain Dara before safa	47,000	
Barouk	83,000	9,000
Qah	20,000	9,000
Raayan	120,000	17,000
Safa	83,000	6,000
Jbeil		
Afqa	300,000	3,000
Rouaiss	265,000	1,000
Kesrouane		
Jeita	370,000	120,000
Nabaa El Aassal	75,000	7,000
Nabaa El Laban	89,000	
Nabaa El Madiq	86,000	10,000
Metn		
Fouar Antelias'	207,000	19,000
Kashkoush	176,000	13,000
Saltaneh	18,000	
BWE	**1,507,000**	**337,000**
Baalbeck		
Laboue	77,000	1,000
Nabaa Yahfoufa – Es Sike	69,000	
Nabaa Yahfoufa – Bustan El Mirr	47,000	
Ras el Ain (Baalbeck)	17,000	
Yammouneh	97,000	
Yammouneh – El Arbaain	67,000	
Yammouneh – El Bawalih	28,000	
Yammouneh – El Mahkan	10,000	
Hermel		
Ain Ez Zarka	224,000	86,000
Ras El Mal	25,000	25,000
West Beqaa		
Ain el Hajar	22,000	22,000
Ain El Zarqa (West El - 30 -aste)	228,000	1,000
Ana spring	32,000	32,000
Nabaa el Khraizat	19,000	
Nabaa es Saalouk	20,000	20,000
Zahle		
Ain el Baida Spring – Kfarzabad	17,000	
Ammiq Spring	26,000	
Anjar Spring	164,000	58,000
Berdaouni Spring	156,000	2,000
Chamsine	18,000	18,000
Chtaura spring	37,000	
Qabb Elias – Ouadi El Delem	56,000	56,000
Ras El Ain (Chtaura)	51,000	16,000

Spring Name	Average Flow (m^3/d)	Exploited Flow for Domestic Usage (m^3/d)
NLWE	**736,000**	**146,000**
Akkar		
Ain Aamas	11,000	
Bebnine Spring	13,000	
Nabaa es Safa	75,000	11,000
Batroun		
Dalle and Ghouaouit	43,000	12,000
Bcharre		
Mar Challita	24,000	3,000
Nabaa El Haddad	9,000	1,000
Qadisha	89,000	3,000
Ras En Nabaa (Mashour)	10,000	1,000
Koura		
Abou Halka	37,000	30,000
Nabaa el Haab	35,000	35,000
Miniyeh-Daniyeh		
Ain el Arbaain	35,000	
Ain el Bire	22,000	
El Sekkar	62,000	5,000
Nabaa El Breissa	27,000	1,000
Nabaa El Qseim	17,000	3,000
Nabaa Ez Zahlane	30,000	1,000
Oyoun El Samak	11,000	10,000
Ras El Ain	18,000	1,000
Zgharta		
El Kadi	25,000	2,000
Rachiine	143,000	27,000
SLWE	**1,042,000**	**100,000**
Hasbaiya		
Hasbani	169,000	5,000
Sreid – El Mairi Bridge	59,000	
Wazzeni	180,000	6,000
Jezzine		
Aazibi Springs	27,000	
Ain al Kabire spring	12,000	7,000
Jarmak Spring	26,000	
Jesr el Habayeb Spring	28,000	
Jezzine Spring	63,000	8,000
Joun Spring	25,000	
Nabatieh		
Aalman Spring	22,000	10,000
Nabaa el Tasse Spring	31,000	30,000
Ghelle	230,000	
Saida		
Qasmiye – Ain Abou Abdallah	86,000	
Sour		
Rachidiye springs	17,000	12,000
Ras El Ain springs	67,000	22,000
Total of 275 tapped springs	**5,500,000**	**814,000**

Table 10 List of major rivers in use for potable water or irrigation.

River	Watershed Area (km²)	Average Annual Volume (1990 – 2013) (Mm³)	Specific Average Flow (l/s/km²)	Reference Gauging Station
Abou Ali	481	218	14.4	Abou Samra
Arka	121	49	12.7	Hakour
Assi	1764	390	7.0	Sea Mouth
Awali	302	433	45.5	Saida
Bared	281	127	14.3	Sea Mouth
Beirut	222	78	11.2	Daychounieh
Damour	293	183	19.8	Sea Mouth
El Ghadir	52	9	5.6	Sea Mouth
El Jouz	180	57	10.0	Sea Mouth
El Kabir	300	432	45.7	Sea Mouth
El Kalb	258	190	23.4	Sea Mouth
Hasbani	526	151	9.1	DS Wazzani Spring
Ibrahim	336	335	31.7	Sea Mouth
Litani	1288	223	5.5	Joub Jannine
Litani	2163	215	3.2	Sea Mouth
Ostouane	161	71	14.0	Sea Mouth
Sainiq	108	11	3.3	Sea Mouth
Zahrani	109	18	5.1	Sea Mouth
Perennial rivers	7,656	3,189	13.2	
Main wadis*	1,223	448	11.6	
In-between and secondary seasonal rivers	1,522	623	13.0	
Grand Total	10,400	4,260		

*Main wadis : Antelias, El Asfour, Wadi Abou Assouad, Wadi Abou Zeble, Wadi Awik, Wadi Bachta, Wadi Barsa, Wadi El Minie, WadI Fidar, Wadi Ghazir, Wadi Iklim Kharroub, Wadi Izziye, Wadi Jounieh, Wadi Kfarkouk, Wadi Madfoun, Wadi Marjhine, Wadi Mouhnane, Wadi South Saida, Wadi Tabarja

2.2.2.1 Public and Private Wells

The total number of public wells is estimated to be 1,615 distributed over the different WEs as shown in the below. A much larger number of private wells is in service, for domestic, industrial or irrigation purposes. Some are legal, but many are not. The exact total volume extracted from public and private wells is impossible to assess with an acceptable margin due to poor data availability from WEs, lack of comprehensive data measurement and collection campaign, absence of data on private wells and unknown number of operation hours due to recurrent power cuts. Despite these uncertainties, the total extraction is estimated at approximately 990 Mm^3/year and was calculated based on the following assumptions for each type of wells:

- Extraction from public wells by WEs elevates to 350 Mm^3/year based on 12 hours/day operation (except for SLWE 14 to 16 hours/day) under actual conditions and to 558 Mm^3/year based on 24 hours/day operation for all WEs with an additional 77 Mm^3 for the 2035 horizon from the proposed public wells; hence a total of 635 Mm^3.
- Extraction from 85,000 private wells (10% for irrigation and 90% for domestic) is estimated to be 640 Mm^3/year: 315 Mm^3 are extracted for irrigation purposes and 325 Mm^3 are extracted for domestic usage.
- Total current extraction from public and private wells elevates to 350 + 640 = 990 Mm^3/year.

The above figures are as accurate as possible; they are not based on actual measurements, but on data related to the installed pumps, assumptions made on the pumping hours and extracted volumes. No comprehensive data measurement and collection campaigns were conducted. Also the number of hours of operation of the boreholes, due to recurrent power cuts, is unknown, which adds to the uncertainty of the figures put forward. However, the numbers clearly show that groundwater aquifers are being exploited beyond their capacity, causing the water tables to drop tremendously, sea water to intrude further, and natural aquifer recharge to be insufficient to reverse the damage caused.

It should be noted that the Water law 192/2020, article 37, encourages citizens who have an unlicensed well to settle their infringement and legalize their situation within a period of two years, the penalty of not doing so being the closure of the well. The realistic implementation of this article should be accompanied by the formation of a committee or unit at MoEW (including, at least, a hydrogeologist, a legal advisor, a representative from the concerned WE) that assesses the applications presented by citizens, the impact of the well on the aquifers and other sources, and the ability of the WE to provide water. The aim of MoEW and the WEs is to eventually supply sufficient amounts of safe and affordable water to all citizens and economic sectors such that the need for individual water security is reduced to a minimum, and this can only be achieved after implementing the reforms and infrastructure projects identified in this strategy.

Table 11 Number of public wells, sorted by WE and status (2020)

	BMLWE	BWE	NLWE	SLWE	Total
Status					
In service	273	293	232	395	1,193
Out of service	165	53	78	126	422
Proposed 2035	35	32	110	6	183
Total	473	378	420	527	1,798
Flow (m^3/d)					
In service	474,500	355,600	325,000	372,800	1,528,000
Proposed 2035	54,400	31,800	87,600	38,200	212,000
Total	529,000	387,400	412,600	411,000	1,740,000

2.2.2.2 Dams

A number of dams/hill lakes is currently operational or under construction in Lebanon, as shown on Table 12.

Table 12 Total dynamic storage capacity of existing dams

Dam	Static Storage (Mm^3/y)	Dynamic Storage (Mm^3/y)	Dam Height (m)	Status	Usage
BMLWE					
Chabrouh Dam	9	11	65	Operational	Potable/Irrigation
Ballout Lake	0.5	0.5	15	Operational	Potable/Irrigation
Qaysamani Lake	1	1	15	Operational	Potable
Janneh Dam	38	95	-	Under const.	Potable/Irrigation/Hydropower
Boqaata Dam	6	12	71.5	Under const.	Potable
Bisri Dam	125	125	73	On Hold	Potable/Irrigation
	180	**245**			
NLWE					
Kouachara lake.	0.4	0.4	11	Operational	Irrigation
Brissa Dam	0.8	0.8	35	Needs repair	Irrigation
Mseilha Dam	6	12	35	Under Const.	Potable/Irrigation
Balaa Dam	1.2	2.2	35	Under Const.	Potable
	8.4	**15.4**			
BWE					
Yammouneh Lake	1.45	1.45	7	Operational	Irrigation
Assi Dam – Phase I	-	63	10	On Hold	Irrigation
Qaraaoun Dam	220	300	62	Operational	Potable/Irrigation/Hydropower
	221.45	**364.5**			

Total storage capacity at country scale: Static = 410 Mm^3/y - Dynamic = 625 Mm^3/y

2.2.3 Water balance and data quality

Several studies and projects have tried to develop an annual water balance of the Lebanese water resources but failed to deliver a long term estimation which considered all the components. For example, UNDP 1970 study of Lebanese groundwater missed to include snow contribution as no monitoring stations were installed above 2000 m altitude back in that time. FAO 2008 AQUASTAT country profile report didn't calculate the evapotranspiration; however, it was adopted by the 2010 NWSS with an unjustified estimation of the evapotranspiration at 50% of the total precipitation. UNDP 2014 assessment of groundwater resources in Lebanon estimated the water balance components for only two hydrological cycles (2010-2011) and (2011- 2012) without estimating the surface and groundwater flows to adjacent countries and the flow of submarine sources. Nevertheless, UNDP (2014) advanced a serious calculation of the real evapotranspiration using Turc (1961) method over 71 meteorological stations across Lebanon with an estimation ranging between 16% and 26% of the total precipitation.

The 2020 NWSS annual water balance updated the 2010 NWSS based on the review of FAO 2008 components to include the total losses as deficit of runoff (evapotranspiration and other losses) estimated at a ratio of 30% equivalent to 2,579 Mm^3 closer to UNDP 2014 real evapotranspiration figures between 16% and 26% of the total precipitation, but less than the 50% ETP values adopted by FAO 2008 and the NWSS of 2012. The same figures of FAO 2008 were adopted for the water outflow leaving Lebanon, with the total surface water outflow estimated at 735 Mm^3/year, of which 160 Mm^3 to the sea and the total groundwater outflow leaving Lebanon estimated at about 1,020 Mm^3/year of which 740 Mm^3 to the sea. Hence, the water resources remaining in Lebanon are 4,225 Mm^3 /year of which 700 Mm^3 as dynamic groundwater reserves, 2,050 Mm^3 as springs discharge and 1,475 Mm^3 as surface runoff, estimated from the average flows measured by LRA hydrometric service between 1990 and 2013 and other private hydrometric records.

In summary, the real evapotranspiration is estimated at 30% of total precipitation, total surface runoff inside and outside Lebanon about 25% and groundwater infiltration about 45%.

It should be noted that the annual water balance was included for information only and should not be adopted for water management plans at national scale. Rather, water management plans should be based on water balances estimated at the watershed scale as part of the IWRM approach. The updated national water balance is presented in Figure 9 below. *(More details in Annex II, Section A).*

Despite all these estimations, a complete and inclusive long term annual average water balance is still missing for Lebanon and requires further knowledge and studies especially regarding real evapotranspiration estimation, groundwater resources leaving Lebanon either to adjacent countries or to the sea through submarine springs with estimations dating back to 1970's. In addition, the new information collected on snow cover contribution during last decade should be seriously integrated into the annual water balance.

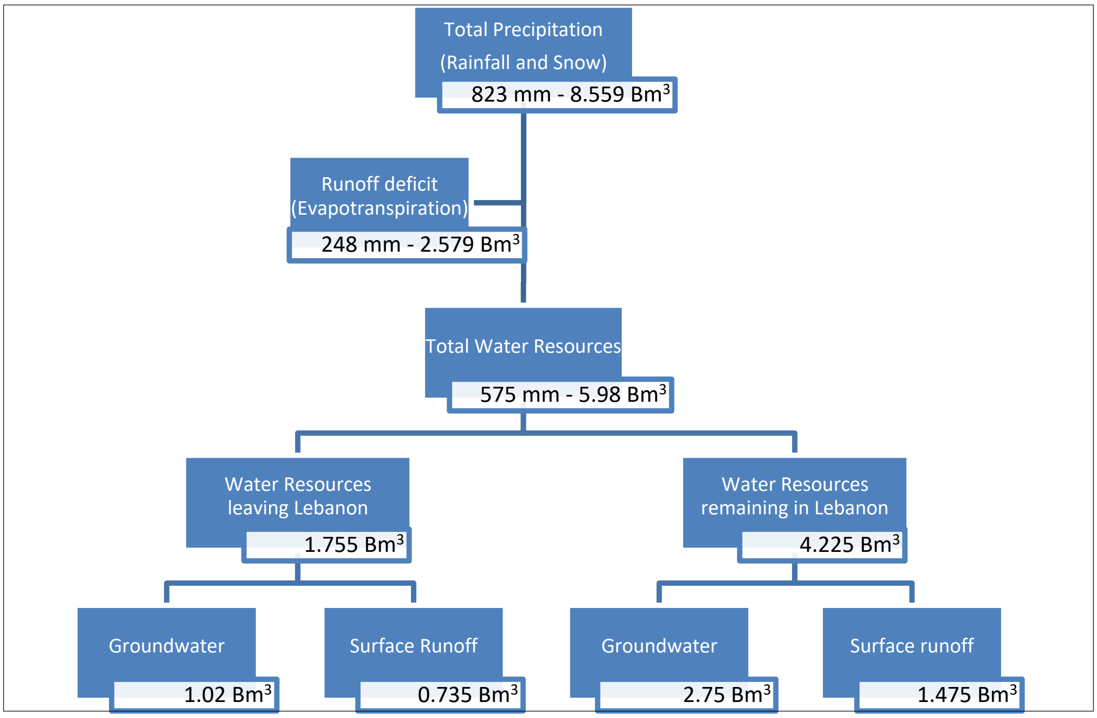


Figure 9 Simplified annual water balance diagram
(Developed based on MEW 2010, FAO 2008 and UNDP 2014 reports)

In fact, Figure 9 is a simplified diagram. The annual water balance distribution should be detailed furthermore to show each component distribution especially groundwater resources and the resources leaving Lebanon to adjacent countries or to the sea. Exploited water resources by different WEs and authorities could also be added to the diagram. A detailed diagram is suggested in Figure 10 which shows approximate values of all the components for an adequate water resources management, which requires:

- Implementing adequate and comprehensive coverage of the Lebanese territory with meteorological and hydrometric networks, which would provide reliable data about surface water. This is addressed in detail in *Annex II Section B*.
- Carrying out required comprehensive geological and hydrogeological studies all over the Lebanese territory, in order to properly assess the groundwater capacity (static reserves), and also to properly assess how the volumes lost by "groundwater seepage to the sea" are affected by the exploitation of the sea cost aquifers. Groundwater management is addressed in detail in *Annex II Section II C*.
- Conducting studies to set up Watershed management schemes.

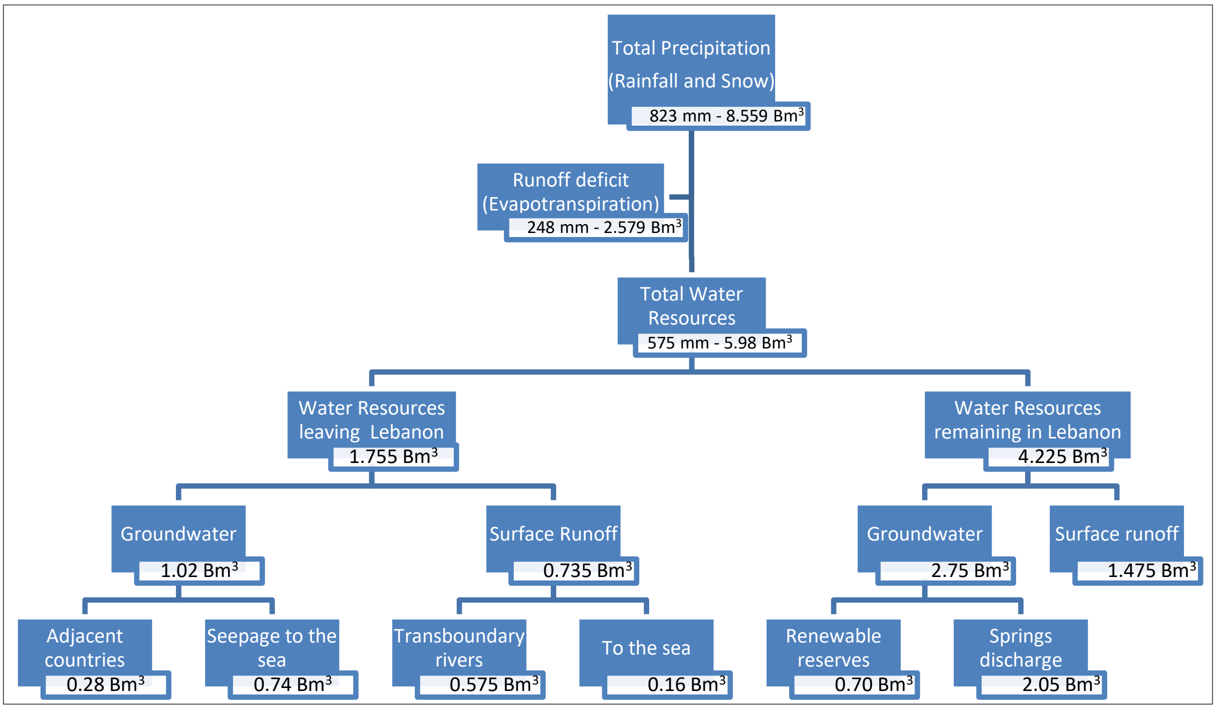


Figure 10 Suggested detailed annual water balance diagram

2.2.4 Impact of climate change

2.2.4.1 Climate change in Lebanon

The Second and Third National Communication (SNC[1] and TNC[2]) to the United Nations Framework Convention on Climate Change (UNFCCC) developed by the MoE in 2011 and 2016 presented the expected climate change effects in Lebanon obtained from university research programs and scenarios that have been developed for Lebanon through the application of the PRECIS RCM model (SNC) and MENA CORDEX RCM (TNC).

The analysis of precipitation time series have shown a stable trend without any clear variation in the past decades. However, it was confirmed that minimum temperatures in Beirut have an increasing trend with an estimated 3°C over the past 140 years.

On the other hand, the main results of key climate variables in Lebanon as simulated by PRECIS were presented as changes of the respective periods of the near and distant future compared to the “control” period the last 20-30 years or the “recent past/ present”. According to PRECIS model and in relation to the present climate, by 2040 temperatures will increase from around 1°C on the coast to 2°C in the mainland, and by 2090 they will be 3.5°C to 5°C higher. Comparison with Lebanese Meteorological System LMS historical temperature records from the early 20th century indicates that the expected warming has no precedent. Rainfall is also projected to decrease by 10% to 20% by 2040, and by 25% to 45% by the year 2090. This combination of significantly less wet and substantially

[1] MoE/UNDP/GEF, (2011)
[2] MoE/UNDP/GEF, (2016)

warmer conditions will result in an extended hot and dry climate. Temperature and precipitation extremes will also intensify. In Beirut, hot summer days (Tmax > 35°C) and tropical nights (Tmin > 25°C) will last, respectively, 50 and 34 days more by the end of the century. The drought periods, over the whole country, will become 9 days longer by 2040 and 18 days longer by 2090.

In terms of seasonal changes, temperatures will increase more in summer and precipitation will decrease more in winter, while positive changes are predicted for autumn.

While the actual considered resolution is 25 km, the SNC authors pointed out the need for a finer modelling resolution to help decision makers defining Lebanon's optimal commitments on mitigation and adaptation measures facing Climate Change. Hence the importance of the application of recent RCM models considering new CMIP5 scenarios similar to the ones applied in the Med-CORDEX project which do not rely on downscaling the GCM.

The TNC included the analysis results of the projected climatic changes in Lebanon and their impacts on natural resources based on the generation of dynamically downscaled regional climate modelling projection covering the Arab/Middle East North Africa (MENA) domain in accordance with the CORDEX program under RCP4.5 and RCP8.5 scenarios. These projections were carried out through the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources in the Arab Region (RICCAR) led by the United Nations Economic and Social commission for Western Asia (ESCWA). The projections were then linked to two regional hydrological models to specifically analyze the impact of climate change on the region's freshwater resources.

In Lebanon, the projections by the end of the century compared to the baseline period of 1986-2005 results showed an increase in temperature by up to 3.2°C with an increasing warming trend reaching up to 43 additional days with maximum daily temperature higher than 35°C. It also showed a decrease in precipitation by 4% under RCP 4.5 and 11% under RCP8.5 with trends towards drier conditions with an increase in number of consecutive dry days (when precipitation < 1.0 mm) which indicates the extension of dry summer season. This combination of significantly less wet and substantially warmer conditions will result in hotter and drier climate[3]. (*More details in Annex II Section A*).

2.2.4.2 Climate change impact on water resources

In what follows, we discuss the impact of climate change on water resources and consequently on SDG 6, SDG 2, and SDG 15.

2.2.4.2.1 Impact on SDG 6: Ensure availability and sustainable management of water and sanitation for all

The SNC and TNC included a climate change impact assessment on Lebanese water resources taking into consideration the effect of precipitation and temperature variation on surface water and groundwater availability from direct runoff, infiltration, and snowmelt. The assessment covered the variation of precipitation during wet season including snow cover, and losses through ETP increased by temperature increases during dry season. This assessment faces multiple challenges mainly the limited recorded data and lack of meteorological and hydrometric stations.

[3] ESCWA, (2015)

The expected increase in temperature as described in previous section has a considerable impact on the snow cover, main source of freshwater resources in Lebanon. It was estimated that a 2°C increase in temperature would cause a decrease of 50% in snow depth in addition to a significant reduction in the maximum volume of snowpack from 1,200 Mm^3 to 700 Mm^3; a 4°C warming would further reduce it to 350 Mm^3. The altitude of sustained snow cover would also shift upwards from 1,500 m to 1,700 m for a 2°C warming, and to 1,900 m for a 4°C warming (Najem, 2007).

These findings were confirmed by the analysis of satellite images that have shown a noticeable spatial and temporal decrease between 1990's and 2000's of the dense snow cover surface by 350 km^2 and residence time by 20 days (Shaban, 2009).

This has consequently major impact on the stream flow regimes of major rivers and springs. Drought periods would occur 2 to 3 weeks or even a month earlier for a 2°C and 4°C temperature increase, and peak flows would shift from the end of April to the end of March and river flows would increase during winter months while demand is low. Upon the recharge of most springs' aquifers, early snowmelt will reduce the available water supply for irrigation during summer and increase floods by up to 30%. This will have adverse impacts on rivers and groundwater recharge and will affect water availability during summer season and drought periods. The main consequence would consist in a decrease in spring and stream discharges towards the end of the dry season.

Aquifer recharge conditions, however, remain less predictable, as one cannot easily forecast whether early precipitations would efficiently recharge the aquifers or simply contribute to fast runoff.

In the absence of proper water storage structures, a considerable proportion of this water would be lost. From April to June, while the demand for irrigation water for agriculture is higher, the reduction in snowpack will not allow to sustain river flows.

These results highlight the increasingly difficult challenges that water sector is actually and will be facing in the future, particularly with respect to water supply, as a result of the expected increase in population and demand per capita, coupled with longer periods of water shortage. Drought's impacts on groundwater usage for agriculture are considerable. It increases irrigation demand, which is met almost entirely by groundwater abstraction during dry seasons. Also, large agricultural areas depend on spring systems, while the discharge of these springs fluctuates in response to climate affecting changing snow cover and precipitation. While autonomous adaptation through changing of sowing dates is possible in the agriculture sector, the shortening of the season when aquifers and springs recharge will necessitate the construction of surface and underground storage reservoirs that can store enough water for the longer dry season (Hreiche et al., 2007; Najem, 2007).

2.2.4.2.2 Impact on SDG 2: End hunger, achieve food security and promote sustainable agriculture

The impact of climate change not only affects the flow regime of water, but also menaces Lebanon's food security if lower quantities of water are available for agriculture. Therefore, it is primordial that: i) the Government of Lebanon identifies the crops it considers important for the country's food security, and ii) the MoA identifies the lands dedicated for these crops, so that MoEW and the WEs can properly plan their resource allocation and their infrastructure plans to cater for food security needs.

2.2.4.2.3 Impact on SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Changes in water availability directly and negatively impact biodiversity. Increase in temperatures and extreme hot weather events increase risks of forest fires, cause desertification and impact the water cycle in general, resulting in further changes to the climate. Forest fires also require water points be made available in proximity of forests, which requires planning and capital expenditures that should be decided on at a national level.

2.2.4.3 NWSS Impact on climate change

This chapter has discussed till now the impact of climate change on water resources and their availability. In this section it will discuss the probable impact of the strategy on local and global climate including the adopted objectives and proposed projects (dams, infrastructure, etc.) and actions.

The strategy is developed in the context of the Sustainable Development Goal 6, in particular target 6.4 “By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.” It also implicitly takes into consideration the SDG 13 “Take urgent action to combat climate change and its impacts” through the adoption of the IWRM as main background framework with all the proposed governance measures, sector reform and projects.

The adoption of the IWRM at the river basin level as main approach with all its implementation principles in particular the principle of sustainable development will optimize the water resources distribution according to its availability now and in the future taking into consideration the climate change scenarios discussed previously (Principle of sustainable development : According to which water resources management must meet the environmental needs of the present without compromising the ability of future generations to meet their own needs). The potable water balance estimation at the distribution system level in each district has detected the deficit and surplus of available water resources and suggested corresponding development projects accordingly. This exercise could be considered as first step towards complete IWRM at the river basin level once necessary data will be collected and water balance models developed using appropriate software (*WEAP software detailed in Annex II Section B*). The optimized water balance shall ensure sustainable withdrawals and address water scarcity issues.

The suggested projects are diverse and range between municipal, district and national level. Their impacts are also diverse some are local like wells and springs intake and can only affect the concerned aquifers and streams and other have larger impacts like dams that can affect the microclimate and the ecosystem.

Dams and corresponding lakes can induce altered microclimate due to increased humidity and cooling in the area, they will also induce greenhouse gas emissions because of decomposing matter submerged by the flooding. To mitigate those effects, every removed tree can be compensated by another and the ecosystem restored in an adjacent area of the dam.

2.2.5 Integrated Hydrological Information System

To overcome the multiplicity of studies and estimations, and to mitigate the impacts of climate change on water resources, it has become crucial to implement an IHIS that would act a strategic tool for decision making in the water sector.

Such a system will provide real, scientific data to allow for proper planning of infrastructure, and shall provide public and private stakeholders' access to reliable information to build a holistic management approach. Decisions on integrated water resource management, flood and drought management, locations and feasibility of dams, groundwater extraction, rainwater harvesting and water allocation among economic sectors can only be made in light of data availability and reliability and proper analysis. It will also support Lebanon's decision regarding global agendas, such as the United Nations SDGs, the United Nations Framework Convention on Climate Change (UNFCCC), the Global Framework for Climate Services (GFCS), etc.

Probably the most successful design of an IHIS in Lebanon would reside in the combination between LMS's (Lebanese Meteorological System) climatic zoning, LRA's distribution on catchment scale and completed by Lebanese Agricultural Research Institute LARI's agrometeorological network for agricultural areas. Each network would be monitored by its corresponding institution but in coordination with the IHIS office. This distribution ensures that each catchment microclimates are well covered (coastal areas, plains, lowlands and mountains), rivers specific hydrological regimes are taken into consideration (snow influence, spring contribution, etc.) and land cover characteristics are covered by LARI's network for evapotranspiration estimation. Also of utmost importance is the monitoring of groundwater aquifers based on aquifer delimitation of 1970 and the findings of other relevant hydrogeological and geological studies, as this should be an important element included in the IHIS. The cost estimate of the IHIS implementation including the upgrade and expansion of networks included are listed in Sub-Section 4.2 *(More details are described in Annex II Section B).*

Nevertheless, some gaps are still to be covered to complete this integrated system. The main gaps in the existing networks are briefed here below.

- Hydrogeological aquifers are main contributors to river flow regimes and especially karstic formation (cave and submarine springs); they should be well monitored by expanding both meteorological and hydrometric networks to detect each aquifer contribution from and into surface flows.
- The hydrometric network should be expanded to cover more streams, connections and sub-catchments;
- Snow cover makes up to 25% of Lebanese water resources. Autonomous snow monitoring stations should be installed to cover the mountainous regions above 1500 m and estimate correctly the snow contribution into river flows.
- Groundwater monitoring wells should be installed across the coastal and inland aquifers. Public wells should be quantitatively and qualitatively monitored by installing volumetric bulk meters to measure the exploited volumes of groundwater, data loggers and water level sensors to monitor the fluctuations of the groundwater static, and dynamic water levels and other sensors to monitor the quality of the extracted groundwater.

- Major springs should be monitored because they constitute the biggest portion of water supply and should be linked to the IHIS system, along with the rehabilitation of the springs catchment structures.

- All the natural reserves and forests should be covered by expanding MoE network and include it in the integrated network.

- Water volumes along infrastructure shall be monitored and should cover the following infrastructures:

    - Dams and hill lakes: surface storage shall be monitored at the water inlet and outlet of the reservoirs. Water quality shall be also monitored in dams and main hill lakes for potable water.

    - Water supply: transmission lines, pumping stations, distribution networks should be equipped with metering systems.

    - Wastewater collection networks and treatment plants, as well as stormwater drainage networks, should be equipped with metering systems.

- Data management and valorization needs improvements. A data management protocol which unifies the data sharing methodology and reliability should be set up.

- Geographical Information System (GIS) platform should be activated for an interactive and dynamic assessment and follow-up of all existing networks.

- Knowledge of global climate change impact on Lebanese water resources for better adaptation strategies should be improved;

Setting up of the IHIS data center to record, check, analyze and archive all the collected measurements improves the quality and reduces the time for water balance estimation, water allocation simulations, prediction and planning. An Implementation Coordination Team of the IHIS shall be formed to elaborate and implement the strategic plan for developing the IHIS over the next period.

	Duration (months)	**YEARS** 1	2	3	4	5	6	7	8	9
A- Recommended studies for IHIS implementation	**84**									
Assessment studies	12									
Update and Analysis of the NLUMP	12									
Lebanese Data Rescue Project	24									
Design studies for IHIS implementation	16									
Integrated water resources management studies	60									
Flood risk Management Plan	84									
B- Networks Expansion	**60**									
LMS + LRA Meteorological Network	40									
LARI Meteorological Netwokr	12									
MoE Metworological Network	24									
LRA Hydrometric Network	60									
C- IHIS implementation	**36**									
IHIS Implementation	12									
IHIS Operation and Supervision	24									
WEAP Implementation	6									

Figure 11 Recommended studies, networks expansion and IHIS implementation timescale

In addition, studies related to drought mitigation plan and rainwater harvesting program shall be carried out as complementary to the IHIS. *(More details in Sub-Section 2.2.9 and 2.2.10).*

2.2.6 Groundwater resources management and monitoring

2.2.6.1 General

Water scarcity has been a redundant problem in Lebanon for the past decades due to the mismanagement of water resources which has been causing the disparity between supply and demand. Balancing between supply and demand requires the need for a sustainable IWRM, especially with the growing population.

Groundwater resources including springs and wells constitute around 45% of annual precipitation in Lebanon. For a sustainable use of water resources, an improved and forward-thinking groundwater management is necessary. Therefore, valid and accurate information on groundwater quantity and quality, its renewability and the hydrogeological structure of the underground are necessary (BGR, n.d.).

The two most prominent factors affecting groundwater availability are population growth and climate change. The study done by the UNDP in 2014 confirmed the relationship between population size and groundwater availability. It showed that stressed aquifers are located in urban areas (such as Beirut, Tyre and Tripoli), and in areas where the demand for irrigation is high (such as in the Beqaa plain and Akkar plain).

Lebanon is currently going through a critical phase in managing its natural resources. Particularly in the water sector, the socio-economic evolution of the population from one side and the Syrian refugees' crisis on the other, greatly added to the stress on available resources and will exacerbate the expected 10-20% decrease in precipitation volumes by 2040, related to climate change (SNC – MoE 2011).

The current situation of groundwater extraction can be described as follows:

- In coastal and urban areas, the number of existing drilled water wells is extremely high putting the tapped aquifers under stress and consequently preventing a full material replenishment. This uncontrolled situation has led to the draining of the groundwater resources and to their contamination by seawater intrusion.
- In the remaining areas, most of the groundwater aquifers are being overexploited by private wells which are extracting large volumes of water without any restrictions or monitoring.
- The uncontrolled number of unlicensed private wells and the uncontrolled extraction of groundwater from these wells decreased dramatically the flows discharged by many springs, which water is primarily used for domestic supply and irrigation.
- No detailed groundwater balance studies have been made on the identified aquifers since 1970.
- No monitoring on the extracted water volumes from public and private wells is made.
- No monitoring of the fluctuations of the water levels in the wells is being made.

- No monitoring of the quality of the extracted water from the wells is being made.

There is, therefore, a great necessity to sustain a serious groundwater resources management plan to avoid a water crisis in the near future.

2.2.6.2 Recommendations

The increased fluctuations in precipitation and extreme weather events will directly affect the availability of groundwater and our dependency on it. For example, during long periods of droughts, rivers and springs will become almost dry to the point where people will increasingly rely on wells to secure their water demand, resulting in a higher risk of aquifers depletion or contamination by seawater intrusion. In other cases, such as flooding events, the rate of surface runoff will be very high resulting in a lower infiltration rate which leads to a lower recharge rate and eventually a higher risk of aquifers depletion.

In addition to what was mentioned in the previous section which recommends that “Groundwater monitoring wells should be installed across the coastal and inland aquifers” and that the collected data would be integrated in the IHIS, it is also necessary to build up a strategy that would enforce the management capacities of the MoEW and WEs by:

- Recruiting specialized staff in the fields of geology, hydrogeology and water resources;
- Refreshing and completing the detailed geologic mapping of Lebanon at scale of 1/20,000;
- Assessing the sea-water intrusion in the major coastal aquifers.
- Refreshing the 2014 UNDP water resources study by performing in stages hydrogeological studies and producing hydrogeological reports on the identified hydrogeological basins in the North, Central, South, North Beqaa valley, South Beqaa valley and Eastern Lebanon mountain chain area;
- Drilling deep reconnaissance water wells to detect the presence of new potential aquifers in some specific areas and proceed with their water testing;
- Enhancing the Artificial Recharge of some selected aquifers;
- Refreshing the water budgeting of all aquifers progressively;
- Performing progressively the modelling of the karstic, saline and porous aquifers.

The detailed activities (studies, investigations and works) to be performed and their sequence in time are shown in Figure 12. The cost estimates of these studies without expropriation and reforms is detailed in Sub-Section 4.3 and covers the implementation of a project management unit at the MoEW, the cost of general geological and hydrogeological studies, and the cost of drilling of new exploratory wells.

	Activities and Projects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Time in years														
1	**Setting up a PMU team in the MoEW**															
1.1	PMU team inlementatipn															
1.2	Staff recruitment for the Hydrogeological Department of the MoEW															
1.3	Procurement of vehicles, working tools, softwares, computers, etc… to the benefit of the MoEW															
1.4	Review the licensing procedures of the MoEW for drilling and exploiting private water wells															
1.5	Review of all existing data in the MoEW Data Center, and collection of existing geological and hydrogeological studies. Including continuous data entry in the database															
2	**Water Resources monitoring**															
2.1	Continuously monitor the flow and water quality of the majority of the public wells in operation, in collaboration of the WEs; Knowing that all the wells in operation will be equipped with flow and water level monitoring devices															
2.2	Continuously monitor, in collaboration of the WEs where relevant, the yield and water quality of springs which low water flow exceeds 80 l/sec															
2.3	Monitor the rivers yield, in collaboration with the Rivers Flow Monitoring Department of the MoEW															
3	**Implementation of Hydrometric Stations**															
3.1	Carry out detailed studies for the implementation of hydrometric stations on selected sites along the major rivers in Lebanon taking into consideration the hydrologic, geologic and hydrogeologic prevailing conditions															
3.2	Construction of the Hydrometric Stations															
4	**Geological Mapping**															
4.1	Geological survey at 1/20,000 scale of Central area															
4.2	Geological survey at 1/20,000 scale of Bekaa and Eastern area															
5	**Hydrogeological Mapping**															
5.1	Production of hydrogeologic maps at a scale of 1/50,000 and hydrogeologic report on the identified hydrogeologic basins/aquifers of Beirut and Mount Lebanon area															
5.2	Production of hydrogeologic maps at a scale of 1/50,000 and hydrogeologic report on the identified hydrogeologic basins/aquifers of the North Lebanon															
5.3	Production of hydrogeologic maps at a scale of 1/50,000 and hydrogeologic report on the identified hydrogeologic basins/aquifers of the South Lebanon															
5.4	Production of hydrogeologic maps at a scale of 1/50,000 and hydrogeologic report on the identified hydrogeologic basins/aquifers of the Northern and Southern Beqaa areas															
5.5	Production of hydrogeologic maps at a scale of 1/50,000 and hydrogeologic report on the identified hydrogeologic basins/aquifers of the Eastern Lebanon															

Figure 12 Detailed activities to be performed

	Activities and Projects	Time in years														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	**Aquifer Artificial Recharge**															
6.1	**Berdaouni (A10 site) pilot area**															
6.1.1	Proceed with the preparation of the detailed design of the AAR pilot project facilitied in Berdaouni (A10 site)															
6.1.2	Implement the construction works of the Berdaouni AAR facilites															
6.1.3	Follow up the AAR of the Berdaouni aquifer															
6.2	**Damour Aquifer**															
6.2.1	Detailed design of the AAR facilities of Damour															
6.2.2	Construction of the AAR facilitied of Damour															
6.2.3	Follow up of the AAR of Damour aquifer															
6.3	**Mejdlaya - Abou Ali aquifer**															
6.3.1	Detailed design of the AAR facilitied of Mejdlaya - Abou Ali site															
6.3.2	Construction of the AAR facility of Mejdlaya - About Ali															
6.3.3	Follow up of the AAR of Mejdlaya - About Ali aquifer															
6.4	**Hadath-Hazmieh lower Cenomenian limestones aquifer**															
6.4.1	Detailed design study of the AAR of Hadath-Hazmieh aquifer															
6.4.2	Construction of the AAR facilities of Hadath-Hazmieh aquifer															
6.4.3	Follow up of the AAR of Hadath-Hazmieh aquifer															
6.5	**Daichounieh Jurassic limestones (J4) aquifer**															
6.5.1	Detailed design study of the AAR of Daichounieh aquifer															
6.5.2	Construction of the AAR facilities of Daichounieh aquifer															
6.5.3	Follow up of the AAR of Daichounieh aquifer															
6.6	**Akkar plain aquifer**															
6.6.1	Detailed design study of the AAR of Akkar plain alluvial aquifer															
6.6.2	Construction of the AAR facilities of Akkar plain alluvial aquifer															
6.6.3	Follow up of the AAR of Akkar plain alluvial aquifer															
7	**Drilling & Testing reconnaissance and exploratory wells:**															
7.1	in Hadath-Hazmieh (3 wells)															
7.2	In Damour (3 wells)															
7.3	In Daichouniye (2 wells)															
7.4	In Akkar plain (5 wells)															
8	**Groundwater vulnerability mapping**															
8.1	Perform groundwater vulnerability mapping and delineation of protection zones 1 and 2 for springs whose low water flow exceeds 100 l/s															
8.2	Perform groundwater vulnerability mapping and delineation of protection zones 1 and 2 for springs whose low water flow is less than 100 l/s															
9	**Aquifers' modelling**															
9.1	Modelling of fractured and karst aquifer systems															
9.2	Modelling of porous, permeable aquifer systems subject to saline water intrusion															
10	**Refresh the water budget studies of the identified aquifers**															

Figure 12 Detailed activities to be performed (continued)

2.2.7 Water quality monitoring

Water quality monitoring in Lebanon should be strengthened, as data registered from samples taken by WEs are collected but not extensively analyzed. In 2021, UNICEF, in coordination with SLWE, NLWE and BWE, conducted a water quality mapping that presented findings on the physico-chemical and bacteriological parameters from water analyses done by these WEs during a period of one year on several sampling points. This assessment also related the effects of land use, climate and urbanization on water quality. In conclusion, it was shown that the water quality in general is not bad, sampling and analysis must be done more regularly and exhaustively sampling points must be unified and coded, and water quality monitoring automated as applied by SLWE.

The Ministry will take necessary measures to protect potable water from contamination as also indicated in the Water Code. Such a plan is only possible through (a) designing and implementing a comprehensive surface water, groundwater, and irrigation water quality monitoring network, (b) developing and implementing pollution prevention measures for recharge zones, and (c) centralizing data to ensure better customer service.

2.2.7.1 LIBNOR Standards

Earlier in 2019, LIBNOR standards for water quality published in 1999 were revised (edition 2016) and sent to MoEW and the WEs for application *(More details in Annex II Section D).* However, the laboratories at the WEs are not well equipped to analyze the newly introduced parameters in the revised edition, such as heavy metals. As such, the revised standards will not be considered applicable before laboratories are equipped with the necessary equipment and staff is recruited and/or trained. It is recommended that Standard Operating Procedures (SOPs) be written for all WEs under normal and emergency situations covering water sampling procedures and laboratory practices.

2.2.7.2 Water Safety Plans and Protection Zones

The Water Safety Plan concept (Step-by-step risk management for potable water suppliers 2009) is described in the WHO guidelines of 2017 and an outline for developing a Water Safety Plan in 11 steps is set. It is also a requirement of the Lebanese Water Code 192/2020.

In 2019, UNHCR and IHE-Delft university, in close coordination with MoEW, and based on Law 192/2020, conducted trainings for the teams of the WEs on Water Safety plans. The aim of these trainings was to familiarize the teams with the concepts of WSP's, accompany them in drafting such plans on pilot areas, and eventually assist them in setting WSP's for all water sources in their geographical mandate. Unfortunately, this training program was stopped due to shortage of funds, and to the multiple crises that started in Lebanon by end of 2019.

MoEW considers Water Safety Planning as a priority activity in the determination of sources of pollution relative to water sources, and one that enforces coordination among different stakeholders, ministries, public institutions, civil society and others.

Water Safety Plans, accompanied with regular and automated water analyses, should be fed to a data management system at each WE and at MoEW, allowing them to analyze information and extract reports easily and as needed. Such data allows the identification and delineation of protection zones and implementation of land use restrictions in the watersheds of main water resources.

The WSP's should be reviewed whenever a change happens to the water system such as a new activity in catchment occurs, new treatment infrastructure, industries or health facilities are built, and improvement plans are implemented in the catchment area. The review period should therefore not exceed 5 years.

Accordingly, the Updated NWSS 2020 is proposing the adoption of an operational water quality monitoring program (including parameters, locations, frequency of testing), the publishing of the updated 161:216 LIBNOR drinking water quality standards, and the implementation of Water Safety Plans by the WEs.

Table 13 Water quality gaps and solutions in Lebanon

Current Problems	Problems solutions	Timeline (From – To)
The 161:2016 LIBNOR water quality standards have not been published	Equipping all laboratories with the necessary tools to be able to abide by the new standards (see Annex II Section D.4)	2023-2025
No monitoring plan	Implementation of Water Safety Plan methodology including operational and compliance monitoring The plan should be strictly implemented by all WEs	2023-2024
Lack of resources, unaffordable costs	Prioritization of parameters that should be tested regularly. Keeping the list relevant and short Certain parameters should only be tested after an exogenous event.	Q1-Q2 2023
Water treatment	Chlorination system should be functional for all resources, and treatment plants should be installed where needed.	2023-2024
Unorganized or unavailable water quality data	Creation of Data management system (Database) that is centralized in each WE, and is updated on regular basis.	2023-2025[i]

2.2.8 Existing wastewater systems

Table 14 below shows the location of operational wastewater treatment plants, their design capacity and the actual treatment capacity.

Table 14 List of operational wastewater treatment plants

Status of WWTPs	Number	Design capacity (m^3/d)	Actual capacity (m^3/d)
Existing	75	397,757	292,918
Operational (subset of existing)	53	385,918	292,918
In the Pipeline	11	130,000	-
Proposed	182	1,196,875	-
TOTAL	268	1,770,389	292,918

The currently treated wastewater volumes make up only 30% of the wastewater generated volumes. The effluent treated at secondary and tertiary levels make up 25% of the treated effluent and just 8% of the total generated WW volume.

If the operational WWTP's function at maximum or design capacity, they will exceed by 30% the total wastewater generated volume.

Wastewater treatment plants located on the coastal zone are the largest because they serve the urban areas concentrated on the western part of the country, mainly around the coast. Plants such as Tyre, Nabatieh, Ras Nabi Younes, Ghadir, Jbeil, Selaata, Chekka, and Tripoli (among others) cover a large population and discharge their effluent into the Mediterranean Sea. Therefore, upgrading them to secondary treatment stages and ensuring their proper and sustainable operation are crucial to respect the international conventions that Lebanon has signed up to, such as Barcelona's Convention for the protection of the Mediterranean Sea against pollution and to the achievement of SDG 14 which calls for the Conservation and sustainable use of the oceans, seas and marine resources for sustainable development. Plants serving the inland urban areas are also significantly large and discharge their (un)treated into adjacent rivers. Continuity and upgrade of operations alleviate pollution of surface water sources and feed into the achievement of several SDG's. Therefore, MoEW counts on the implementation of the reforms identified in this strategy, namely tariff adjustment and collection of fees, to ensure sustainability of the wastewater sector.

Indicators from WWTP's such as treated volumes, influent and effluent parameters and analysis, generated sludge quantities and quality and means of disposal, and energy expenditures should be reported periodically and linked to a centralized data management system and SCADA system at the WEs, with a right of access to MoEW for proper monitoring.

2.2.9 Disaster risk management

As part of surface water management, it is necessary for the MoEW to put in place management plans for disasters related to the water sector in coordination with the Disaster Risk Management unit of the Presidency of the Council of Ministers. Floods, drought and forest fires are the main threats that require the Ministry's intervention and preparation.

2.2.9.1 Flood risk management

A flood risk management plan for each of the 20 major Lebanese rivers which watershed area exceeds 100 km² would include a conceptual and legal framework, a program of measures, early warning protocol and organizational frameworks.

The preparation of such study includes the following tasks:

- Topographical and urban surveys of the river and its floodplains.
- Hydrological study
- Hydraulic study and flood mapping
- Risk analysis

- Social risks management plan including conceptual and legal frameworks, a program of measures, early warning protocol, organizational framework.

2.2.9.2 Drought risk management

The recent study carried out by IWMI on drought vulnerability mapping and identification for the water and agriculture sectors in Lebanon has identified the stakeholder needs to improve drought risk management. These include the themes of policy-settings, financial systems, institutional coordination, drought management plans and institutional capacity to deliver them, extension services and cropping calendar planning, water management regimes, and underpinning science and information, governance, and policy implementation support.

Drought mitigation actions are investments in managing drought risk, requiring resources and effort to implement. Appropriate mitigation actions, however, can save money and effort during drought periods by reducing the economic impacts of drought and reducing the costs of relief and response efforts. Thus, drought mitigation would include the following tasks:

- Institutional development, including the formulation of legislation, policies, strategies, methodologies, plans, instruments and budgets;
- Data collection including historical drought events
- Establish indicators and thresholds for drought classification based on climate change scenarios
- Develop a program of measures, mitigations and recommendations for a nation scale strategy
- Information sharing and raising awareness about managing drought risks.
- Monitoring and analysis, to support drought early warning and the design, timing, targeting, and evaluation of drought actions
- Establish organizational framework for the production, implementation and update of the drought mitigation plan.

Many mitigation actions also offer co-benefits to other economic and social goals. Reducing groundwater over-abstraction, for example, can also support environmental sustainability, broad-based economic growth, and access to drinking water as well as strengthening drought resilience.

2.2.9.3 Forest fires

The MoEW shall be included in the inter-ministerial committee, responsible for the implementation of Lebanon's National Strategy for Forest Fire Management which establishes a comprehensive Risk Management Framework for forest fire management known as the 5Rs, Research, Risk modification, Readiness, Response and Recovery. It shall be more involved in Research with the help of the meteorological monitoring network, the IHIS functioning as early warning service and in Readiness through locating water reservoirs and increasing water availability near forests.

2.2.10 Non-conventional water resources

With the increasing challenges facing water availability continuously along the year starting from climate change and seasonal variability, anthropogenic activities and not ending at lifestyle evolution, it is actually crucial to rely on nonconventional resources to fill the deficit gap of the water balance where possible and ensure sustainable sector management. Artificial Aquifer Recharge, wastewater reuse and rainwater harvesting have been found to be the most efficient non-conventional resources, and their adaptability to the Lebanese context should be studied, as identified under this strategy.

2.2.10.1 Artificial aquifer recharge

There are significant unexploited runoffs during the rainy season and especially during snowmelt. Injecting part of it in the aquifers would have a positive impact on the potential groundwater availability and would reduce seawater intrusion into the coastal aquifers. AAR has a great potential to increase the renewable resources and ease the water stress in Lebanon and should be subject to further studies and piloting to assess its success in karst geology. (*Refer to Annex II Section C 3.8 for more details on the advances of AAR and the remaining needed steps)*.

2.2.10.2 Wastewater reuse

The reuse of treated wastewater was one of the main nonconventional resources that the NWSS 2010 has assessed and set to increase to 50% in 2020. However, only Ablah WWTP in Beqaa was equipped with a reuse system for the irrigation of 20ha of grapes that replaced irrigation from individual wells.

Wastewater treated to standards can be a precious non-conventional source of water for irrigation, especially that agriculture is the biggest water consumer with a minimal impact on the national GDP. Reusing wastewater for irrigation helps achieve water efficiency and conservation, reduces the need for pumping from private wells, saving on energy and decreasing the cost of crops, and positively impacts the livelihood of farmers. A plan identifying the potential use of treated wastewater across the country will be developed once the LIBNOR standards are published.

The list of all available wastewater facilities in Annex III Section A shows that the majority of treated wastewater are discharged to the sea, while the actual annual flow of treated wastewater suitable for irrigation was estimated to only 17.5 Mm^3/year from 28 WWTP. Hence, wastewater reuse will remain a priority target for nonconventional resources in this NWSS for the horizon 2035. (*Refer to Annex II Section E 2 for more details*).

2.2.10.3 Rainwater harvesting program

Rainwater harvesting was identified as a promising adaptation technology for Lebanon. It includes the construction of hill or earth lakes, collecting runoff in urban areas, and from roofs. Exploring the full potential of rainwater harvesting is limited by a low agricultural water tariff, the irregular distribution of rainfall, inadequate urban planning, poor storm water collection infrastructure, and a lack of awareness. Rainwater harvesting through its different applications requires a national or regional plans, accompanied with awareness campaigns on the potential savings generated from rainwater harvesting initiatives. The study of such a program would include the following tasks:

- Define the conceptual and legal framework, methodology

- Data collection
- Hydrological assessment of the rainwater harvesting potential
- Determination of the harvesting methods and potential implementation sites
- Development of an implementation strategy and program considering climate change scenarios.

2.2.11 Wastewater reuse and sludge management

2.2.11.1 General

Data on influent and effluent wastewater quality and volumes is dispersed among several actors: CDR, WEs and Municipalities and the operators of the WW systems under each party's responsibility. Data on sludge quality and possible applicability are not collected and analyzed.

In Lebanon, there are no regulations, guidelines and standards for the reuse of treated wastewater and sludge for different purposes. Two propositions for Lebanese Guidelines on Sewage Sludge Use in Agriculture and for Lebanese Wastewater Reuse Guidelines were prepared by FAO in 2010, in coordination with the MoEW and MoA.

Currently, LIBNOR is preparing separate standards for the reuse of wastewater in irrigation and for sludge management in coordination with relevant stakeholders, such as ministries, CDR, WEs and academic researchers working on specific subjects and that act as a scientific support to the standards. The FAO standards of 2010 are used as supporting documents for LIBNOR's current work.

It is also worth noting that a National Master Plan for Sludge Recovery/Disposal was set by CDR in 2003. In 2021, CDR, in a study funded by the World Bank, prepared a Sludge Management Master Plan for the Beqaa region. Recommendations from this study started to be implemented in Zahleh WWTP, where a solar sludge drying bed will be installed, and land for a regional landfill is being sought out as a final disposal location for the sludge generated by a number of WWTP's in the Beqaa.

Several obstacles hinder the wide adoption of wastewater reuse. These include the delays in the execution of WWTP projects, the lack of an adopted national standard for the reuse of treated wastewater effluent and sludge, inadequate capacities and absence of extension services at the involved Ministries and WEs, as well as the lack of needed infrastructure to transport the water from the plant to location of intended use. *(More details in Annex II Section E)*

Despite the many challenges facing wastewater reuse and sludge management, yet they remain very important objectives that MoEW is working towards achieving in the near future, based on the below recommendations.

2.2.11.2 Recommendations

1. MoEW aims at upgrading the management, performance and monitoring of the wastewater treatment systems as a preparation to the applicability of wastewater and sludge reuse.
2. Mitigation of health and environmental risks, requires that common norms and standards for the reuse of treated wastewater and sludge in Lebanon be elaborated. Therefore, LIBNOR is assisting

MoEW and the WEs in directing their priority initiatives for the implementation of wastewater and sludge reuse.

3. Based on these standards, the MoEW and WEs will set up plans for the reuse of treated wastewater and sludge reuse, be it for agricultural purposes or aquifer recharge, in close coordination with the MoA and MoE.
4. Sludge management, whether reused or disposed of, is a matter of priority for MoEW and MoE. Regional master plans are being developed (starting with the Beqaa) to adopt the most suitable alternatives for sludge disposal and reuse.
5. Water conservation by reuse, aquifer recharge, or industrial reuse of treated effluent should be practiced where it is cost-effective and where water resources are otherwise insufficient. Irrigation of agricultural lands by wastewater should be promoted provided water quality is monitored and health standards are maintained.
6. Wastewater and sludge reuse should be oriented to demand driven planning by focusing on projects that are committed to reuse.
7. A clear-cut sludge treatment technology and a disposal/reuse strategy should be considered an indispensable, integral part of any WWTP project.
8. The potential for sludge reuse should be investigated and regular analyses should be conducted in a scientific manner.
9. The following should be promoted:
   - Measures to minimize sludge volume, such as anaerobic sludge digesters, and solar sludge drying.
   - Measures to generate and utilize biogas for power generation.
   - Regional co-operation in sludge management should be assisted, since economy of scale can help in bringing down sludge disposal/reuse cost.

2.3 PILLAR 3: SERVICE COVERAGE

Updating the NWSS aims at identifying the projects that should be implemented to fill the gaps between what has been implemented and what remains to be executed to cover the needs of the population in terms of potable water supply, wastewater collection, and water for irrigation. The strategy targets the projected needs in year 2035. Therefore, it is necessary to assess future population and needs per capita at an acceptable level of accuracy in order to identify relevant solutions and propose cost effective projects.

Based on the Central Administration Statistics of 2019 and the World Bank 2021 figures on the populations residing on the Lebanese territories, it was estimated that around 6.9 million people are resident of Lebanon. Estimations on population growth and water demand are based on previous experience of the Consultants who contributed to this strategy and who have extensive experience in the water sector in Lebanon. The figures discussed in this section can be reliable enough to form a solid basis for the purpose of this strategy.

2.3.1 Water demand

2.3.1.1 Population and growth factor

The distribution of the total resident population of Lebanon in 2020 is shown in Table 15 below. The numbers for every district corresponding to year 2020 are detailed in the water balance tables of Annex II C.

Table 15 Population distribution in 2020

Year 2020	Lebanese	Palestinian Refugees	Displaced Syrians	Total
Resident Population	4,842,050	250,562	1,800,000	6,892,612

It's worth noting that the numbers at the district level varies from winter to summer (mainly in rural areas). This dynamic seasonal variation was taken into account in the water balance calculation of every distribution system for the proposed projects as the water demands must be ensured for all housing units all year long, hence the equivalent resident population of approximately 9 Million in 2020 and 11 Million in 2035. The equivalent resident population of the dynamic seasonal variation is shown in Table 16 below

Table 16 Population and equivalent population projection for 2020-2035

Year	2020	2025	2030	2035
Resident Population	6,892,612	7,392,376	7,892,139	8,391,903
Equivalent Resident Population based on housing units	9,083,471	9,742,088	10,400,704	11,059,321

The NWSS 2012 has estimated the growth factor at 1.75 %, which is a relatively high figure. However, recent field surveys[4] covering a number of municipalities showed that the demographic growth factor is much lower than that.

For the period 2020-2035, the following growth factors shall be considered for all of Lebanon:

- For Lebanese in rural areas: 1.5% (slightly lower than what was considered in 2012)
- For Lebanese in urban areas: 0.75% (one-point difference between 2020 and 2012 assumptions)
- For the districts under the jurisdiction of SLWE, a flat growth factor of 2% is used so that needs and gaps are consistent with the Master Plan conducted by SLWE. The same growth rate will be used for displaced Syrians and Palestinian refugees.

2.3.1.2 Potable water demand per capita

There is a lack of large scale data on measured water consumption. Therefore, as long as water consumption is not metered and billed correctly, the strategy cannot be designed to meet the “water consumed”, but rather the realistic “water demand” of 125 l/c/d resulting from a household survey that evaluated the real water consumption in activities such as showering, dishwashing, and others. The non-domestic consumption and physical losses shall be added to the basic domestic consumption. *(More details are provided in Annex III)*.

This is a significant revision of the water consumption figures adopted in the NWSS of 2012 having values of 180 l/cap/day in urban and 165 l/cap/day in rural zones. This revision is backed by the WEs aim to generalize water metering, abolish illegal connections, and reduce all types of NRW, which will result in a decreased consumption in 2035.

The strategic target of water demand per capita for 2035 is set as follows:

- Domestic consumption: 125 l/cap/day
- Non-Domestic = 20 % of the domestic 25 l/cap/day

150 l/cap/day

- Physical losses = 25 % of the total needs 50 l/cap/day

Total potable water needs 200 l/cap/day

- Produced wastewater flow = 80 % of the needs (excluding physical losses) = 120 l/cap/day

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[4] Bcharreh district; ELARD 2016 – Baadda Aley district; BTD 2018 – Kesrwan district; BTD 2019

- Wastewater infiltration = 10 %

As long as Lebanon hosts refugees and displaced populations, it is important to calculate their impact on the national water balance although their consumption is not accounted for in the water balances at district and system levels. The following assumptions are made:

- For displaced Syrians living in informal settlements, the allocated water supplied to on-site water tanks is: 50 l/cap/day
- For Palestinian refugees living in camps and displaced Syrians living outside informal settlements and benefitting from the public network, the allocated water is: 80 l/cap/day (including losses and non-domestic consumption).

2.3.1.3 Water requirements for irrigation

Based on the inventory of the irrigation schemes across the country, presently irrigated land area is around 100,000 ha.

Under the presently prevailing irrigation conditions, considering network losses and the irrigation practices, the irrigation efficiency is around 50 to 60%. The average irrigation water requirement for a representative hectare (ha) at the country level is currently around 8,400 m³/ha /year.

Table 17 Present irrigation water demands

WE	Irrigated area (ha)	Commonly used rates in Lebanon (m^3/ha/year)	Total needs Mm^3/year
NLWE	23,600	7,500 (most of the area is coastal)	177
BMLWE	5,835	6,500 (most of the irrigated area is at high altitude)	38
BWE	66,115	9,000 (most of the irrigated area is inland/dry weather)	595
SLWE	4,210	7,500 (most of the area is coastal)	32
TOTAL	~100,000	8,435 (Average irrigation water requirement for one representative ha at the country level	842

2.3.1.4 Future irrigation water requirements

Irrigation development in the future is conditioned by:

- Implementing new projects
- Securing new water resources (storage structures & water wells).

The construction of the proposed projects would allow for the irrigation of an additional 38,000 ha at the country level, as shown in Table 18.

Table 18 Proposed development of irrigable lands

WE	Priority	Proposed new irrigation projects	Irrigable Land (ha)
NLWE	3	Noura el Tahta &	
	2	Dar Baachtar Dam	4,200
	1-3	Hill Lakes	730
			4,930
BMLWE	2	Hill lakes	540
			540
BWE	1-2	Assi dams	6,000
	3	Massa Dam	1,600
	3	Younine Dam	1,200
			8,800
SLWE/LRA	1-2	Conveyor 800	13,250
	2	Khardale Dam	1,300
	2	Choumaryeh Dam	4,000
	2	Ibl Saki Dam	3,800
	2	Hill lakes	1,235
			23,585
Total (rounded)			**~38,000 h**a

Assessment of future irrigation water requirements is based on the following assumptions:

- Irrigated areas would reach in 2035 around 138,000 ha.
- Irrigation efficiency will be improved and will be upgraded from 60% to 75% by rehabilitating or constructing concrete or piped conveyance structures and catchment structures and by modernizing on-farm irrigation practices (micro-irrigation). Consequently, irrigation water requirement for 1 representative ha will drop from 8,400 m^3/ha/year to 6,720 m^3/ha/year (based on 5040 m^3/ha/year as a net water requirement, i.e. without water losses, then 5,040/0.75=6,720 m^3/ha/year would be the gross water demand per ha per year when overall system efficiency will reach 75%).

Based on the above, the present irrigation water requirement at the country level is 842 Mm³ and would reach 927 Mm³ in 2035, should the proposed project be implemented.

On the other hand, the Agricultural National Census of 2010 (MoA, 2010) reveals that only 50% of the irrigated area is supplied from natural surface water whereas the rest is supplied by “expensive” underground water or from hill lakes. In addition, it shows that 65% of the irrigated areas are permanently irrigated whereas the remaining 35% are partially irrigated. Therefore, it is estimated that around 75% of the current Irrigation water requirement, i.e. around 630 Mm^3, are presently sustained by available water for irrigation and reflect the actual/real Irrigation water consumption figure across the country. Out of these 630 Mm^3 it is estimated that 315 Mm^3 are covered by surface water and the rest by groundwater.

2.3.1.5 Projected water demand 2020 – 2035

The national water demand is calculated at a strategic level to allow for the calculation of the national water balance relative to the national supply. However, when proposing water supply and irrigation projects (as will be discussed later), the water balance of every system and every irrigation scheme is calculated separately to serve as a solid basis for the project development plan.

Based on water balance calculation at the distribution system level, the dynamic seasonal variation of the population, and using the above assumptions on irrigable land, the total annual demand amounts to 1,505 Mm^3/year for the year 2020 for a network efficiency of 75% (1,837 Mm^3/year for network efficiency of 50%). These figures are slightly higher than the predicted values in the NWSS of 2012 due to the seasonal variation of the housing unit on which the water balance was based on in this update. In details, the following figures are obtained:

- Domestic water demand makes up around 40% of the total demand and is estimated at around 580 Mm^3/year.
- Irrigation water demand makes up 55% of the total water demand and is estimated at around 842 Mm^3/year.
- Non Domestic including industrial and commercial water demand stands at 5% of the total and is estimated at about 83 Mm^3/year.

It is worth mentioning that current water demands of the economic sectors should be measured through a census of actual consumptions, and the projected demands should be based on a national economic development plan as this can guide better the water allocation per sector.

Table 19 Comparison of annual water demand estimates between NWSS 2012 and NWSS 2020

NWSS	2012	2020 (Based on WB*)
Sector		
Domestic (Mm^3/yr)	505	580
Non Domestic (Mm^3/yr)	152	83
Tourism (Mm^3/yr)	6	-
Agricultural (Mm^3/yr)	810	842
Total demand (Mm^3/yr)	1,473	1,505
Assumptions		
Population	4.43	6.9
Per capita consumption (L/d)	180	125**
Network efficiency	52%	75%
Irrigated area (ha)	90,000	100,000
Irrigation consumption (m^3/ha)	9,000	8,400
Commercial demand	30%	20%

* Water Balance at the distribution system level

** For network design purposes, the value 200 l/c/d should be used as it includes network losses and non-domestic demand.

Table 20 Projection of annual water demand estimates per sector for 2020 – 2035

Sector	2020	2025	2030	2035
Domestic (Mm^3/yr)	580	622	664	706
Non Domestic (Mm^3/yr)	83	89	95	101
Agricultural (Mm^3/yr)	842	874	902	927
Total	1,505	1,585	1,661	1,734

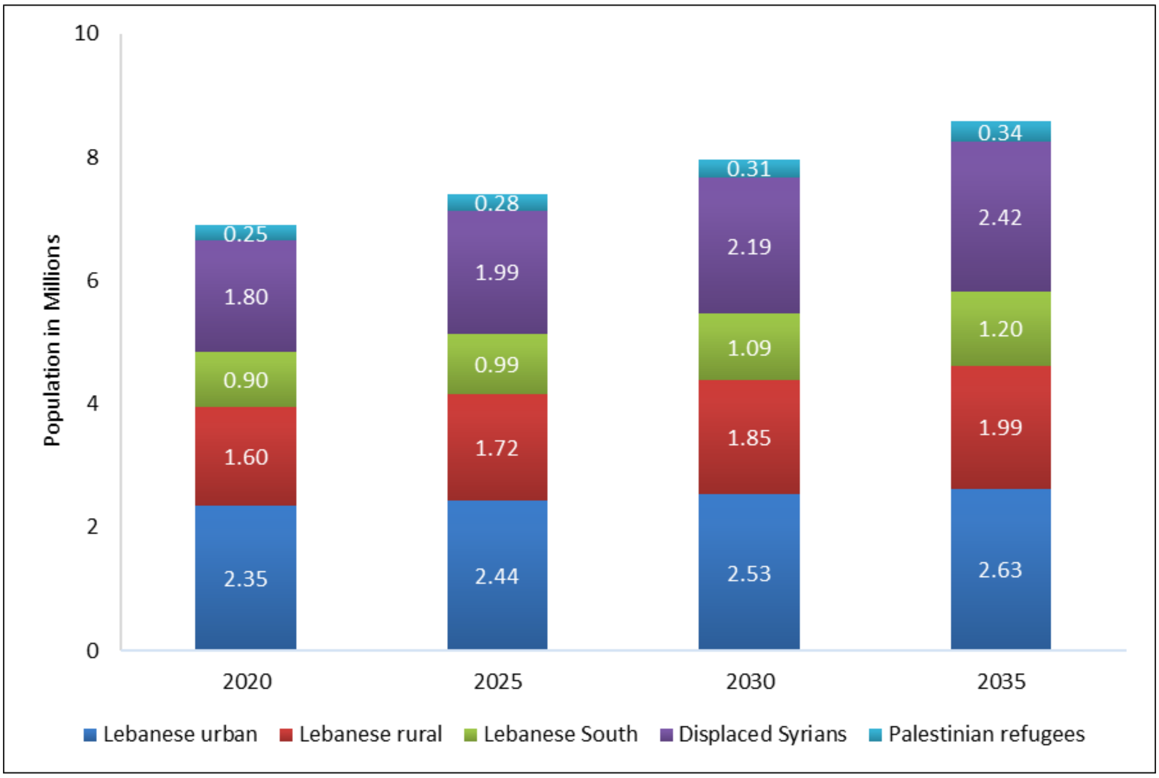

Figure 13 Lebanese Resident Population projection 2020 – 2035

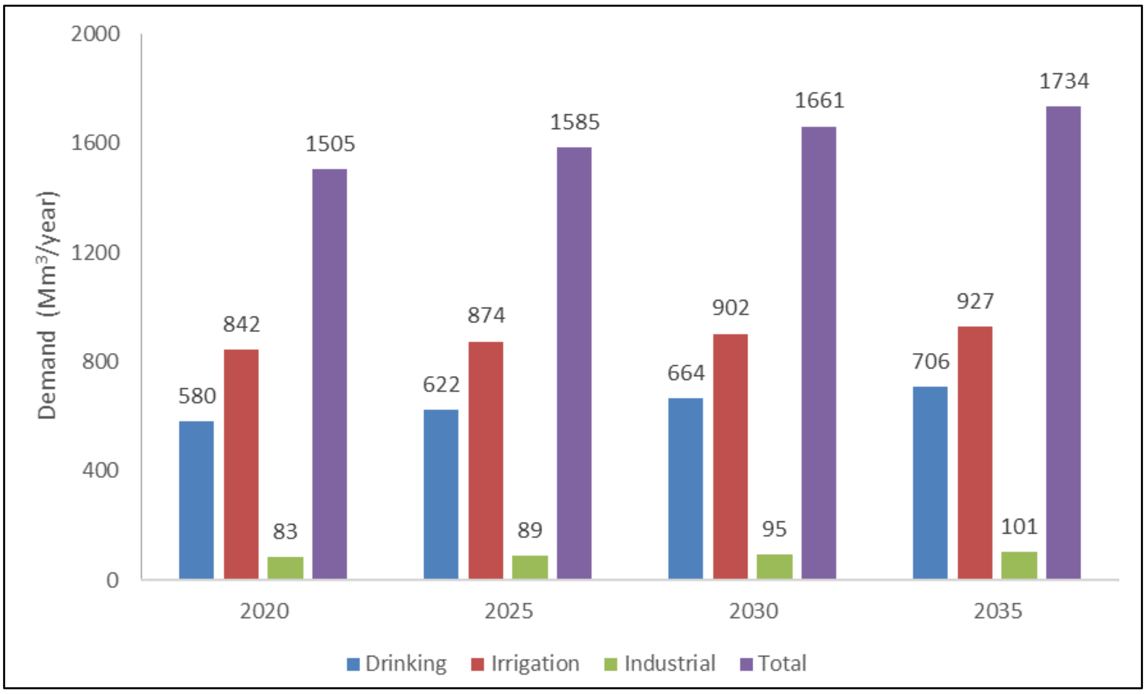

Figure 14 Total water demand projection 2020 – 2035

2.3.2 Total water supply

As shown previously in the estimation of the national water balance Sub-Section 2.2.3, the annual renewable available water volumes are estimated to be around 2,050 Mm^3 as springs, 1,475 Mm^3 as rivers, and 700 Mm^3 as aquifer reserves (public and private wells). As for the supply, they differ per exploited resources and per source type. It is worth noting that dams are usually filled from both surface water as rivers and groundwater as springs, and that aquifers are overexploited by approximately 300 Mm^3 per year. The table below summarizes these figures.

Table 21 Available and exploited water resources for 2020

Source	Available Resources (Mm^3/year)	Exploited Resources (Mm^3/year)
Rivers	1,475	14
Springs	2,050	594
Aquifer reserves (Public and Private wells)	700	990
Dams (Static)	-	314 (232)
Total	4,225	1,912

It is expected that exploited resources from springs will be optimized, from public wells will be increasing by 100 Mm^3 every 5 years as extraction from private wells will be gradually decreasing by 100 Mm^3 to reach its half in 2035, and dams' storage will be increasing according to the dams under construction only. Closure of private wells shall be accompanied by several actions:

1) Provision of drinking water supply in a continuous manner to allow for closure of private wells used for domestic purposes;

2) Organization of the irrigation sector under the WEs and coordination with MoA to develop and optimize sources of water for agricultural lands in order to decrease the need for private wells for irrigation purposes;

3) Conduct a national survey to identify locations and characteristics of private wells;

4) Installation of water meters and adjustment of domestic water and irrigation water tariffs to allow for a better control and monitoring. The water supply forecast is shown in Table 22 Below.

Table 22 Projected exploited resources by sources between 2020 and 2035

Source	Exploited Resources (Mm^3/year)			
	2020	2025	2030	2035
Rivers	14	14	14	21
Springs	594	617	656	656
Public wells	350	450	550	635
Private wells	640	540	440	320
Dams (Static)	314 (232)	314 (232)	410 (260)	625 (410)
Total Water Supply	1,912	1,913	2,009	2,257

2.3.3 Demand versus supply balance

Figure 15 below shows that the forecasted water supply with network efficiency of 75% exceeds the annual demand by 20% to 25% between 2020 and 2035. This gives the illusion that demands are always met despite the various pressures on Lebanon's water resources, be it due to the influx of displaced Syrians, the unstructured parallel market of water trucking, the impact of climate change or the excessive pollution of surface water and groundwater. However, due to the unbalanced geographical distribution of the available resources across the country and the mediocre maintenance of the infrastructure, the water resources management is challenging, and physical losses are considerable. Thus, with the current network efficiency of 50%, the supply versus demand chart overlaps perfectly.

Hence, if no effort is put to increase and optimize our resources, and properly manage our consumption, Lebanese will witness severe water shortage (see Figure 16 below). It is crucial that surface storage shall be enhanced, springs' catchments rehabilitated, and exploitable quantities optimized, groundwater extraction limited to only rechargeable volumes, and wastewater effluents (municipal, industrial waste, agricultural discharges and solid waste) treated and reused especially for irrigation.

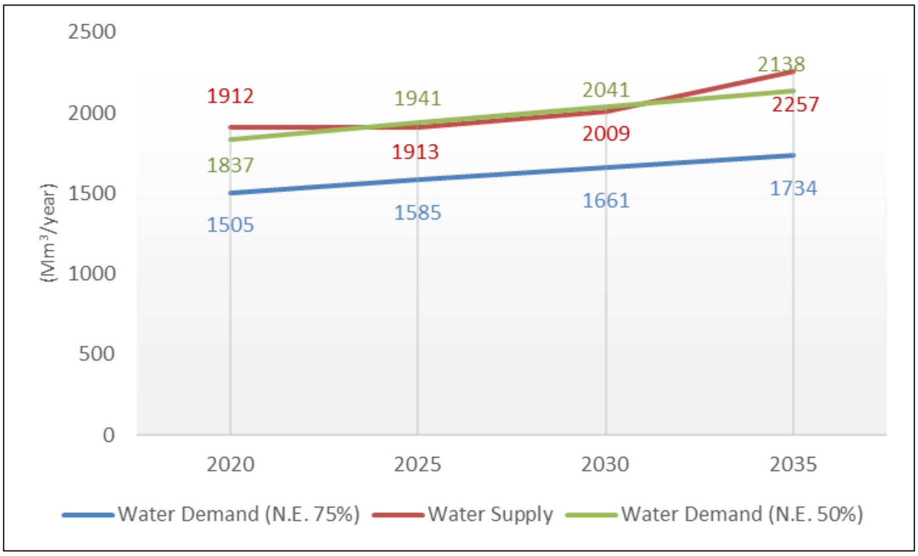

Figure 15 Demand versus supply forecast chart

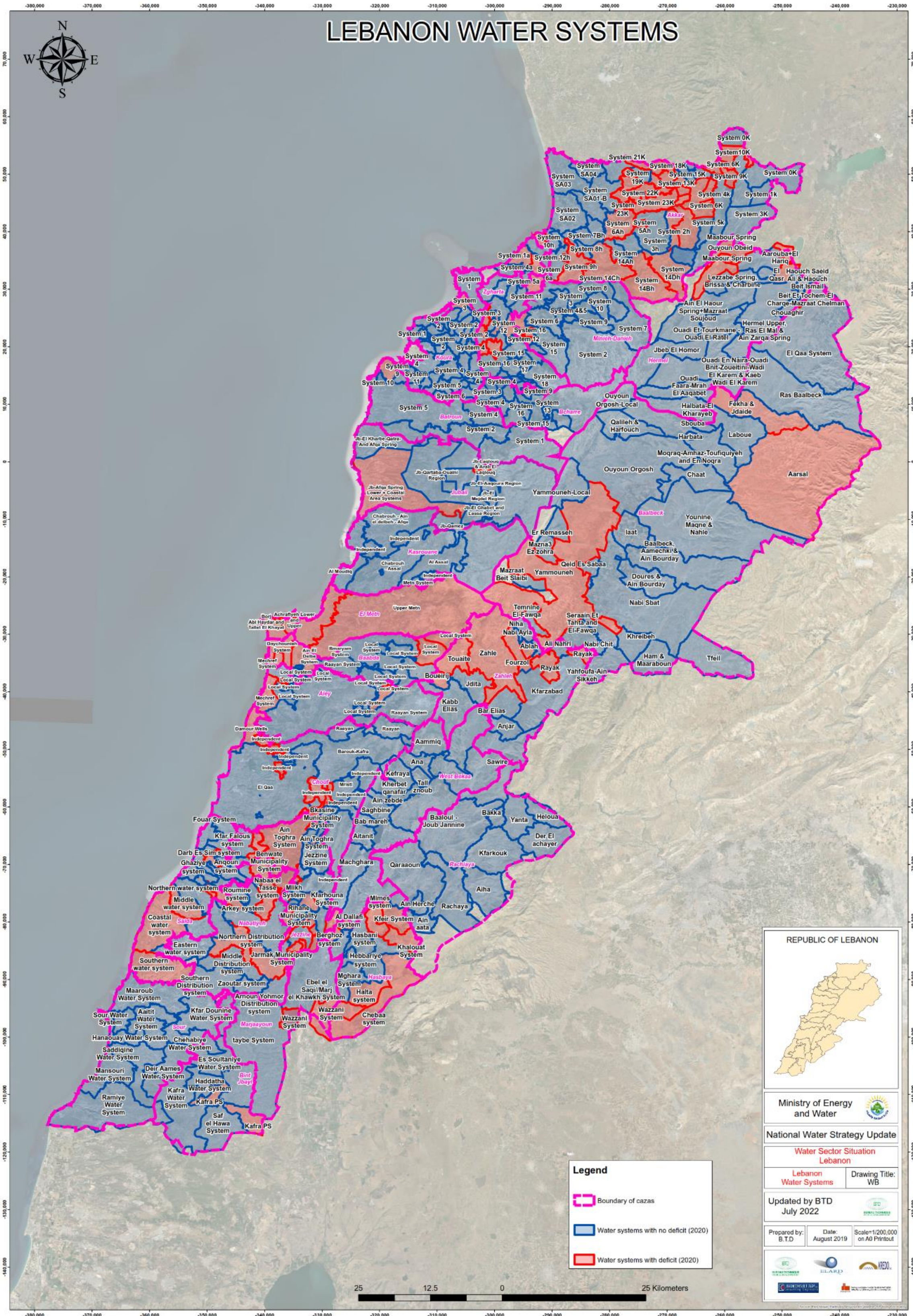

Figure 16 Excess (blue) and Deficit (red) of the Water Balance at the distribution system level

2.3.4 Proposed projects

2.3.4.1 General

The updated NWSS 2020 reviewed all the water, wastewater and irrigation needs across Lebanon; it assessed the existing operational systems and identified gaps that should be filled to cover the needs of all the citizens across the territory.

These gaps were then translated into projects in all three sectors prioritized by order of urgency and impact. Three levels of priority were used over the period of the strategy extending between 2020 and 2035; priority 1 being from 2020 to 2025; priority 2 from 2026 to 2030; and priority 3 from 2031 to 2035.

2.3.4.2 Surface Storage

Surface storage is still a strategic priority for resource exploitation under the updated NWSS 2020. Construction of storage facilities are recommended to be the first resort to compensate for water supply needs, on condition that they are financially, technically and environmentally feasible. Surface water flowing into rivers makes up an important portion of water resources in Lebanon and the only way to partially benefit from these volumes is through well-designed surface storage facilities. Dams and lakes provide water supply for irrigation and alleviate the pressure that irrigation is currently exerting on groundwater.

Exploiting rechargeable groundwater resources is kept for areas where surface storage is not possible or insufficient to cover the growing needs. On the other hand, non-rechargeable, deep groundwater resources are regarded as strategic reserves that should be saved for the next generations who will witness harsher climate change impacts.

This strategy provides an update on the status of the Dams identified in Lebanon's Surface Water Storage Strategy of 2011. Some of these dams were scheduled beyond the year 2035. Also, based on conducted feasibility or design studies, some of them were found to be geo-technically or financially not feasible and were disregarded. In other cases, the selected sites for dam's construction are not available anymore due to the expansion of private construction. Therefore, several sites for potential dams foreseen in the 2012 strategy are now dismissed. Table 23 below shows the list of dams considered in NWSS 2012 and their current status and Table 24 the list of selected dams in NWSS 2020.

Table 23 Present status of dams considered in the NWSS 2012

Dam Name	Caza	Project status in 2020
BMLWE		
Janneh Dam	Jbeil	Under Construction but put on hold
Chabrouh Dam	Kesrouane	In Use
Ballout lake	Metn	In Use
Bisri Dam	Jezzine	Tendered but put on hold
Boqaata Dam	Keserouane	Under Construction
Qaysamani Dam	Baabda	In Use
Aazounieh Dam	Aley	Tendered & budget secured since 2013; Expropriation should be completed.
Damour Dam	Chouf	Priority 2; after year 2026
Maaser El Chouf Dam	Chouf	Financially not feasible ($\$/m^3$> 26)
Laklouk Lake	Jbeil	Priority 1; design and funds should be secured soon because the lake will be used for Irrigation
El Manzoul Dam	Metn	Financially not feasible because of high expropriation cost
Ratiba Lake	Jbeil	Priority 1; design and funds should be secured soon because the lake is used for Irrigation

Table 23 Present status of dams considered in the NWSS 2012

Dam Name	Caza	Project status in 2020
NLWE		
Kouachra Lake	Akkar	Constructed (downstream irrigation system needs completion)
Bared Dam	Akkar	Priority 1; design and funds should be secured soon so that the dam is ready when the supply is needed in 2030
Adline Noura Tahta	Akkar	Priority 3; Tender Documents have to be reviewed in view of the water master plan of Akkar
Mseilha Dam	Batroun	Constructed but not yet in use
Balaa Dam	Batroun	Under Construction
Rahwe Dam	Batroun	Priority 2; after year 2026
Qarkaf Dam	Akkar	Technically not feasible
Dar Boochtar Dam	Koura	Priority 2; after year 2026
Iaal Dam	Zgharta	Technically not feasible; the site has been constructed by locals
Brissa Dam	Danniyeh	Constructed; needs concrete lining for which the funds are secured and works should start soon
Ouadi Chich – El Arz	Bcharreh	Financially not feasible ($/m3> 26)
Atolbe Lake	Akkar	Technically not feasible; the optimal site of the dam has been constructed by locals
Hadath el Jebbeh	Bcharreh	Priority 3; after year 2030
Kammoua Lake	Akkar	Priority 2; after year 2026 and/or when land ownership problems are resolved

Table 23 Present status of dams considered in the NWSS 2012

Dam Name	Caza	Project status in 2020
BWE		
Aassi Dam (Phase 1)	Hermel	Priority 1; design and funds should be secured soon because the dam is used for Irrigation
Aassi Dam (Phase 2)	Hermel	Priority 2; after year 2026
Ouadi Sbat Dam	Hermel	Site for potential surface storage facility if the need arises but has not been seriously considered so far.
Barhacha Lake	Zahle	Technically not feasible
Yammouneh Lake	Baalbeck	In Use
Younine Dam	Baalbeck	Priority 3; after year 2030 for irrigation purposes
Massa Dam	Zahle	Priority 3; after year 2030 for irrigation purposes
Rachaya – Ain Arab Lake	Rachaya	Site for potential surface storage facility if the need arises but has not been seriously considered so far.
Qaraoun Dam	West Beqaa	In Use

Table 23 Present status of dams considered in the NWSS 2012

Dam Name	Caza	Project status in 2020
SLWE/LRA		
Ibl es Saqi Dam	Marjayoun	Priority 2; after year 2026 for irrigation purposes
Kfarsir or Choumariyeh Dam	Nabatiyeh	Priority 2; after year 2026 for irrigation purposes
Khardaly Dam	Nabatiyeh	Priority 3; after year 2030 for irrigation purposes
Ansar Dam	Saida	These are sites for potential surface storage facilities if the need arises, but none has been seriously considered so far
Ain Baal Dam	Sour	
Khiam Dam	Marjayoun	
Chohour Dam	Sour	
Barich Dam	Sour	
Nabaa el Tasse – Jarjou	Nabatiyeh	
Lebaa Lake	Jezzine	
Kounine Dam	Bint Jbeil	
Jinsnaya Dam	Jezzine	
Aita el Chaab Dam	Bint Jbeil	
Balatet el Jamejem Dam	Saida	
Kfarwa Lake	Nabatiyeh	
Aazbieh Lake	Jezzine	
Jbaa Lake	Nabatiyeh	
Salaa Lake	Hasbaya	
Kfarhouna Lake	Jezzine	

The above list of dams considered under NWSS 2012 was reviewed under the NWSS 2020, and the below list was retained.

Table 24 List of selected dams in NWSS 2020

Governorate	Dam Name	Capacity (Mm^3)	Purpose	Nature of Works	Cost (M USD)
Priority 1					
Akkar	Bared	37	Water Supply	Dam, WTP, Transmission Lines and Reservoirs	196
Mount Lebanon	Azzounieh	4	Water Supply	Dam, WTP and Transmission Lines	65
		41			**261**
Priority 2					
North Lebanon	Dar Baachtar	7	Water Supply + Irrigation	Dam and Major Transmission Lines	50
South Lebanon	Ibl El Saki	50	Water Supply + Irrigation	Dam, Transmission Lines and Reservoirs	145
South Lebanon	Choumariye	28	Water Supply + Irrigation	Dam, Reservoirs, WTP and Transmission Lines	128
Mount Lebanon	Damour	42	Water Supply + Irrigation	Dam, WTP, Transmission Lines and Reservoirs	200
Beqaa	Assi 2	37	Irrigation	Dam, Power Generation and Lift Lines	150
		164			**673**
Priority 3					
Akkar	Noura El Tahta	35	Water Supply + Irrigation	Dam and WTP	150
Beqaa	Younine	5.8	Irrigation	Dam and Major Irrigation Lines	70
Beqaa	Massa	8	Irrigation	Dam and Major Irrigation Lines	37
South Lebanon	Khardale	128	Water Supply + Irrigation	Dam, Reservoirs, WTP and Transmission Lines	180
Mount Lebanon	Maasser El Chouf	2.2	Water Supply	Dam + WTP	53
		179			**490**
Grand Total		**384**			**1,424**

2.3.4.3 Water supply projects

The main objective of the proposed projects is to secure the required water resources i) to cover the projected needs of the populations supplied from all the studied water systems, with priority being given to regions suffering from severe water scarcity; and ii) to ensure adequate transmission, storage and distribution infrastructure.

It shall be noted that the development of any type of resource will be accompanied or preceded by:

- An effective reduction in NRW, resulting either from technical losses in the transmission and distribution networks or from illicit connections to those networks or due to any other cause.
- The installation of District Meters allowing to track of defaults along the water systems, taking immediate action where these are detected, optimizing the cost of production, increasing the volumes and the hours of water supply to the customers.
- The installation of water meters at household level becoming realistic and efficient at this stage.

Projects are selected and prioritized according to the following criteria:

- Priority 1:
  - Development and expansion of water resources to cover potable water demands, i.e., in water systems having a negative water balance in 2020
  - Provide adequate water storage capacities, i.e. in villages that currently have very small reservoirs compared to the required storage or in those that have very old reservoirs
  - Provide adequate main transmission lines by increasing the capacity of existing ones or replacing very old ones
  - Construction of distribution networks, mainly in villages that currently don't have a distribution network or in those that have very old one (i.e. > 30 years old)
  - Monitoring of the main transmission and distribution lines through the installation of bulk water meters, in order to better control and isolate leakages.
- Priorities 2 and 3:
  - Extension of existing distribution networks
  - Expansion of existing water storage capacities
  - Development and expansion of water resources to address future negative water balances, along with the construction of any related works (i.e. transmission lines, pumping stations and reservoirs).

It should be noted that due to the fine-tuning of the daily per capita demand in the updated strategy of 2020, and because the water balance was calculated at the level of every water source or village or group of localities, many of the water balances resulted in positive figures when projected till the year 2035. The cost estimates of proposed projects is given in Sub-Section 4.4.

Table 25 Summary of proposed transmission lines, distribution network, reservoirs, wells and pumping stations under NWSS 2020

WE	Transmission Lines (km)	Distribution Network (km)	Numbers of Reservoirs	Number of Wells	Number of Pumping Stations	Proposed Priority
BMLWE	421	-	139	36	17	1
	-	3268	-	-	-	2
BWE	483	-	169	110	16	1
	-	1072	-	-	-	2
NLWE	367	-	51	29	2	1
	-	803	-	-	-	2
SLWE	623	-	200	17	15	1
	-	1737	-	-	-	2
TOTAL	1894	-	559	192	50	1
	-	6880	-	-	-	2

2.3.4.4 Wastewater projects

The main objective of the proposed wastewater projects is to protect the environment and the health of the citizens by eradicating or at least minimizing the discharge of untreated wastewater into the environment or in waterbodies. The projects were selected and prioritized according to the following:

- Priority 1:
  - Implementation of new WWTPs and sewer networks in densely populated areas
  - Expansion and upgrade of major existing WWTPs if their treatment capacity isn’t enough to treat the influent wastewater (in 2020) or are operating at less than secondary treatment levels.
- Priority 2:
  - Implementation of new WWTPs and sewer networks in less densely populated areas
  - Expansion and upgrade of existing WWTPs if their treatment capacity isn’t enough to treat the influent wastewater flows in the near future.
- Priority 3:
  - Implementation of small wastewater treatment units in isolated villages/areas

The total cost of the wastewater projects by priority is given in Sub-Section 4.4.

2.3.4.5 Irrigation projects

Methodology

The following methodology was adopted to estimate the water demand for each irrigated scheme:

1. Estimation of the total agricultural area for each scheme and the main agricultural types;
2. Estimation of the irrigated areas per scheme using the intensification index of the agricultural land calculated from the MoA Agricultural Census of 2010 as the ratio between the irrigated area and the cultivated land by type (seasonal and permanent);
3. Characterization of seasonal and permanent crops obtained from the MoA Agricultural Census of 2010 based on the FAO classifications;
4. Definition of a cropping pattern for each Mouhafaza
5. Estimation of the water need for each type of crop in all Mouhafazas by elevation ranges;
6. Application of the water needs for latest agricultural areas of the existing schemes using the data of the Remote Sensing Center of the CNRS in 2017.
7. Re-categorization of the seasonal and permanent crops, based on crop types;
8. Delineation of the perimeters of the irrigated areas by irrigation type (gravity, sprinkler or drip).

Irrigation Water Balance

The water balance is thus the difference between supply and demand.

It should be noted that:

- A severe water deficit indicates the need for providing new water resources;
- A limited water deficit could be mitigated by network upgrade;
- A remarkable surplus due to a positive water balance indicates the need for water storage.

Negative values that appear in the water balance for the schemes indicate that either there are no sufficient data about public resources or that irrigation is assured through wells, private in general and illegal in many cases. Although this practice is compulsory to feed the need, it puts lot of stress on the Groundwater aquifers and cause depletions and salt-water intrusion for costal ones in the absence of good water management and sufficient storage of surface water.

Recommendations

Consequently, the target of this strategy is to address the following (the proposed projects – see Annex IV – are selected accordingly):

- Develop water resources by increasing water harvesting through promoting hill lakes and dams
- Rehabilitate and modernize existing irrigation infrastructure to reduce water losses and improve water efficiency by upgrading water catchment and deviation structures, and by repairing concrete broken structures and converting earthen channels into concrete one.

- Open channel systems to be eventually converted into pressurized piped system. This conversion will enhance modernization of on-farm irrigation systems.
- Accelerate execution of wastewater treatment strategies up to Irrigation acceptable standards and in conjunction with crops selection criteria.
- Perform detailed study for each existing irrigation scheme in order to assess the existing condition, and identify all necessary actions needed to upgrade and modernize the selected scheme.

Irrigation projects under SLWE and LRA jurisdiction

Prioritization of the projects was elaborated as follows:

- Priority 1projects include:
  - 1st phase of conveyor 800 Irrigation Distribution Networks Project (465 km). The first phase of this project is composed of the transmission system and Related reservoirs is presently under construction.
  - Saida-Jezzine Project – Replacement of 45 km of irrigation networks in the existing project.
- Priority 2 projects include:
  - Second phase of Conveyor 800 – Irrigation Distribution networks (1335 km).
  - Rehabilitation of existing local irrigation schemes in Bint Jbeil, Rashaya, Jezzine, Nabatiyeh, Saida, Sour districts.
  - Construction of 9 hill lakes: The projects are located outside the areas served by the main irrigation projects in order to provide additional water quantities. The locations of the hill lakes were determined in a conceptual manner. A feasibility study should be conducted for the final definition of these projects.
- Priority 3 projects include:
  - Phase II of Khardaleh Dam consisting of the construction of related irrigation distribution networks (1300 km).
  - Construction of Phase II of Ibl es Saqi dam scheme consisting of the construction of related distribution networks (380 km).
  - Rehabilitation and modernization of existing small-scale projects in 39 localities. The projects are located outside the areas served by the main irrigation projects (141 km).

The total proposed area to be irrigated based on the three priorities of projects is around 41,500 ha without taking into consideration the local schemes which constitutes around 80% of the agricultural lands.

Irrigation projects under NLWE jurisdiction

The results of the water balance estimation for Akkar and North Lebanon schemes show that the estimated water supply from rivers, springs and few identified wells is 328 Mm^3 ; the total crop demand is around 216 Mm3. The resulting water balance is a surplus of 128 Mm3.

Although the analysis concluded that the water balance is positive, this area is characterized by an overexploitation of groundwater, which caused a drop in its groundwater table. This implies that the water management practices are poor with the uncontrolled pumping.

Moreover, the surplus should be stored in the dams mainly recommended by the NWSS 2012 where feasible, for water supply during peak demand periods and to cut-off the illegal supply from wells.

Irrigation projects under BMLWE jurisdiction

The results of the water balance estimation for Mount Lebanon schemes show that the estimated water supply from rivers, springs and several wells is 241 Mm3; the total crop demand is around 58 Mm3. The resulting water balance is a surplus of 172 Mm3.

This water surplus is an indication of the importance of storing water in the dams mainly recommended by the NWSS 2012, for water supply during dry season.

Irrigation projects under BWE jurisdiction

The results of the water balance estimation for Beqaa and Baalbek-Hermel schemes show that the estimated water supply springs and several wells is 187 Mm3; the total crop demand is around 521 Mm3. The resulting water balance is a deficit of 345 Mm^3.

This water deficit could be attributed to the fact that this area relies heavily on well extraction. Unfortunately, most of these wells are unlicensed and non-monitored with flow meters. To add on it, the agricultural area is remarkable compared to the other mandates (BWE: 70,911 ha, NLWE: 33,555 ha and BMLWE: 7,251 ha).

Rationale for Project Selection

After estimating the water budgets of all schemes, several technical interventions could be concluded:

- Increasing canal conveyance efficiency by the rehabilitation of poorly maintained concrete canals and converting earthen canals into concrete;
- Optimizing the existing resources through water quality and quantity monitoring;
- Promoting the reuse of TSE for irrigation;
- Construction of Hill Lakes for rainwater harvesting;
- Construction of dams reassessed under this updated strategy;
- Promoting the use of drip irrigation and changing cropping patterns towards less water demanding crops.

These projects should be implemented hand in hand with strategic environmental assessment (SEA) and environmental impact assessment (EIA) studies to mitigate any environmental hazard.

Prioritized Projects and Cost Estimate

The recommended projects per scheme were organized over four levels of priority throughout the implementation timeframe of this strategy:

- Priority 1 Network upgrade (rehabilitation and/or improvement) for schemes with a negative water balance,
- Priority 2 Hill Lake system construction for schemes with a negative balance, in addition to other projects with a direct impact on the schemes.
- Priority 3 Upgrade and /or expansion of the network for schemes with a positive water balance. Construction of dams to serve adjoined schemes.

The cost estimates of the irrigation projects by priority is given under Sub-Section 4.4.

3 STRATEGIC ENVIRONMENTAL AND SOCIAL ASSESSMENT

3.1 BACKGROUND

The water sector in Lebanon is facing detrimental challenges, hindering the ability of the government to supply adequate and reliable water services while conserving Lebanon's water resources. Although the national coverage of water networks is around 80%, the quality of the supplied public water is questionable due to the lack of protection of water resources, insufficient water treatment at the supply level, deteriorated distribution networks, and the absence of continuous monitoring. Untreated wastewater, which accounts for around 70% of the total generated wastewater, is being directly discharged into the environment, thus polluting the groundwater and surface water resources that supply a significant portion of Lebanon's potable water. The pollution of water resources, in addition to the poorly managed water supply networks, have impacted the quality of water at the household level. An estimated 65% of the population does not have access to safely managed drinking water services. A reflection of this is the cholera outbreak in Lebanon; according to the World Health Organization (November 2022), since the first case was confirmed in early October 2022, more than 1,400 suspected cases and 17 reported deaths have been reported.

The absence of continuous Surface Water (SW) and groundwater (GW) resources quantity and quality monitoring, and adequate data collection and management in Lebanon translates into a lack of reliable national water balance that can be used for the development of effective water management plans. Estimates provided by the Ministry of Energy and Water (MoEW) suggest that the population relies mostly on GW supply (springs and wells), constituting 83% (~1,587 MCM/year) of the total supply, tapping on 58% (~1,595 MCM/year) of the total available GW on the national level. Private wells provide the highest percent supply (33%; ~631 MCM/year), followed by springs (31%; ~593 MCM/year) and public wells (18%; 344 MCM/year).

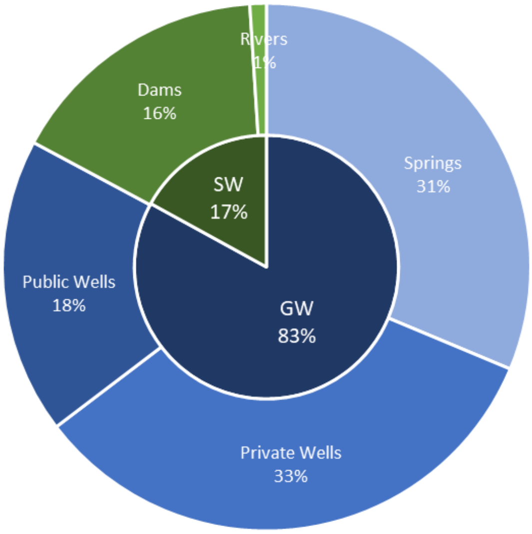

Figure 17 *Current Water Supply Mix (2020)*

The governmental authorities currently managing the country's water sector are the MoEW and the public water institutions: the four Regional Water Establishments (RWEs) (Beirut and Mount Lebanon, South, North and Beqaa water establishments) and the Litani River Authority (LRA). The four RWEs are not achieving cost recovery - a primary reason behind the insufficient provision of water services. The RWEs are being deprived of significant revenues considering that (1) the Non-Revenue Water (NRW) is more than 45% across Lebanon due to the lack of maintenance and presence of illegal connections, (2) customer-metered connections are around only 10% nationwide, (3) billing and collection rates are as low as 30% in some areas, (4) the flat tariff structure does not encourage a long-term water conservation behavior change among citizens, among other reasons.

To address structural changes in the water and wastewater sector and emerging challenges facing water resources management, the MoEW updated the 2012 National Water Sector Strategy (NWSS). In compliance with the Strategic Environmental Assessment (SEA) Decree 8213/2012 and funded by World Bank (WB) Lebanon – Lake Qaraoun Pollution Prevention Project, the Council for Development and Reconstruction (CDR) contracted ECODIT Liban (henceforth "ECODIT") to prepare, in collaboration with MoEW, a Strategic Environmental and Social Assessment (SESA) for the Updated NWSS-MoEW (2020).

The report seeks to satisfy the following objectives: (1) Assess the environmental and social impacts of the Updated NWSS-MoEW (2020) with the necessary stakeholder engagement and (2) Provide recommendations and high-level policy advice to MoEW to optimize the Updated NWSS-MoEW (2020) and mitigate potential adverse environmental and social impacts.

3.2 SESA METHODOLOGY

Although the SESA Report is considered as an update of the previous SEA (2015) for the NWSS-MoEW (2012), ECODIT applied a shift in its methodological approach to enhance the SESA's impact in influencing the decision-making process. ECODIT adopted a "hybrid" overall approach that combines "policy" and "impact-centered" SESA approaches. The methodological steps conducted by the SESA team are presented below:

1. Assessment of physical, biological, and socio-economic baseline conditions to understand the state of the environment and specifically the current situation of the water sector in Lebanon.
2. Review of legal, institutional and policy frameworks governing the water sector – including legislation and regulations, multilateral agreements and conventions – as well as relevant national and regional plans, programs and projects.
3. Stakeholder Engagement through two phases: (1) focused consultation meetings and (2) public consultation meetings.
4. Analysis of Alternatives identifying four water-supply mix alternatives that aim to enhance the scientific dialogue regarding Lebanon's water sector and narrow the gaps between policy making and public opinion. This analysis resulted with the selection of the most suitable strategic mix.
5. Assessment of the impacts of the Updated NWSS-MoEW (2020) based on specific and cross-cutting key themes (KT) (presented in the table below).

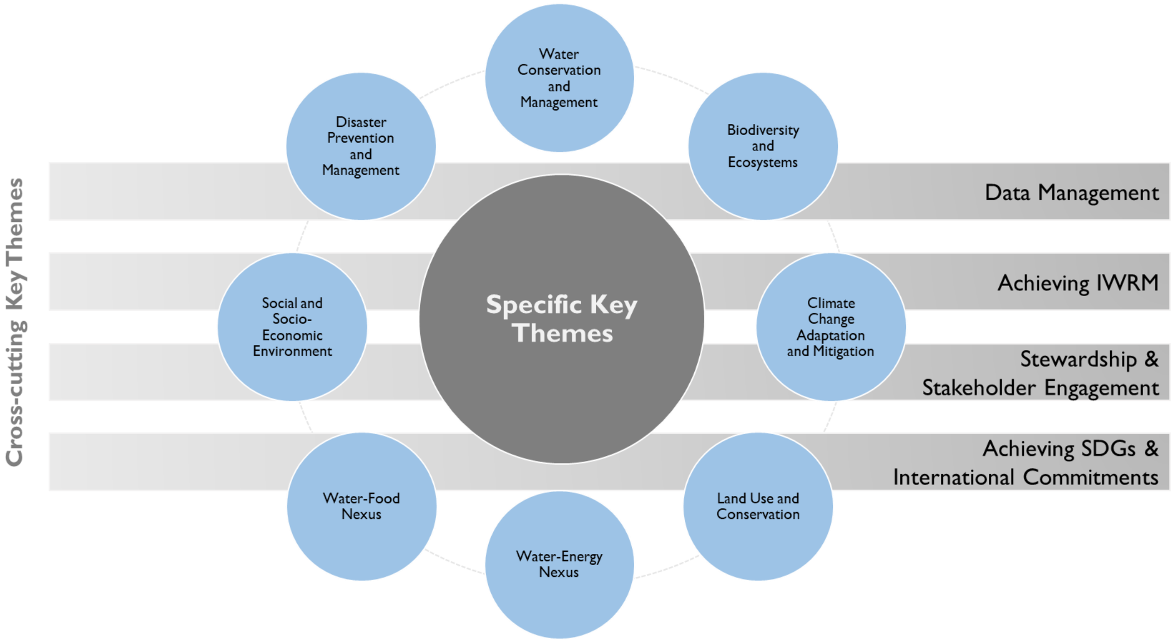

Figure 18 Specific and Cross-cutting SESA Key Themes

During the SESA preparation, ECODIT has been sharing with MoEW preliminary findings/recommendations to be integrated in the Updated NWSS-MoEW (2020). Accordingly, MoEW is reviewing the Updated NWSS MoEW (2020) in parallel to the SESA preparation and finalization.

3.3 STAKEHOLDER ENGAGEMENT AND CONSULTATION ACTIVITIES

In compliance with SEA Decree 8213/2012, ECODIT conducted an extensive stakeholder consultation process, through focused consultation meetings and public consultation meetings. The aims of these consultations were to (1) gain key insights and opinions on the water sector in Lebanon and the Updated NWSS-MoEW (2020) (2) enhance strategic recommendations, and (3) solicit feedback on SESA process and outcomes. ECODIT divided the SESA stakeholder engagement process into two phases:

3.3.1 Phase 1: Focused Consultation Meetings

The targeted stakeholders' meetings, which started in November 2021, involved virtual and in-person one-to-one or focus group meetings with more than 70 governmental and non-governmental stakeholders in the water sector, including water authorities and Ministries, active Non-Governmental Organizations (NGOs) and civil society, development and funding agencies, research centers and academic institutions, and other experts working in the field.

Stakeholders consulted in the focused consultation meetings provided diverse feedback regarding the Updated NWSS-MoEW (2020). Common technical concerns regarding the strategy were that it did not clearly tackle environmental components, particularly those related to the management of the wastewater sector and protection of resources. Out of the three strategy pillars, stakeholders tended to prioritize "Pillar 1: Implementing Reforms and Improving Sector Governance". Nevertheless, there was a common consensus that the three pillars of the strategy should be implemented in parallel, with focus on water resources management (data collection and storage, water demand management, and the protection of water resources) and institutional water sector reforms.

3.3.2 Phase 2: Public Consultation Meetings

In October 2022, ECODIT organized several stakeholders' consultation meetings to solicit the feedback of the general public on the Updated NWSS-MoEW (2020) and inform them about the results and recommendations of the SESA Report. To maximize the participation of stakeholders from citizens, government, local authorities, international organizations, research and academic institutions, and the private sector, ECODIT conducted four general consultation meetings divided by Water Establishment jurisdiction (Beirut and Mount Lebanon, North Lebanon, South Lebanon, and Beqaa).

Section 6 of the SESA compiles all information gathered from the stakeholder engagement process conducted.

3.4 ANALYSIS OF ALTERNATIVES TO THE PROPOSED STRATEGIC ACTION

Section 8 of the SESA identifies four water-supply mix[5] alternatives that aim to enhance the scientific dialogue regarding Lebanon's water sector and narrow the gaps between policy making and public opinion. In all alternatives, the percent reliance on GW is higher than that of SW knowing that not all available resources could be exploited as temporal distribution is not aligned with irrigation/agricultural season. At the international level, countries are implementing policies towards the sustainable use of water, reflected through the increase in surface water exploitation and storage, and management of groundwater over-exploitation to meet domestic, industrial and agricultural water demands[6]. The alternative scenarios are summarized below:

[5] The combination of water sources and supply schemes results in a national water supply mix. The water-supply mix analysis of alternatives exercise involves the modification in the proportional mix of water sources, while keeping the total volume of water supplied constant.

[6] (Semi)-Arid but also temperate example countries include: Spain ~ 78% SW; 22% GW (OECD,2011); Morocco ~ 80% SW; 20% GW (Hssaisoune et. al., 2020); Greece ~ 58% SW; 42% GW (EASAC, 2010), and France ~ 50% GW, 50% SW (Marechal & Rouillard, 2020).

Table 26 Summary of Scenarios Considered

Scenario		Description
Do Nothing Alternative (SW 22%; GW 58%)		The future baseline (2035 status) without the implementation of the Updated NWSS (2020).
Water Supply Mix Alternatives(*)	**Scenario 1: "Updated NWSS-MoEW (2020) Scenario"** (SW 29%; GW 71%)	Represents the general status of 2035 with the implementation of the Updated NWSS (2020): supply from SW 29% and from GW 71%.
	Scenario 2: "Updated NWSS-MoEW (2020) Scenario with Addition of Non-conventional Water Sources" (SW 29%; GW 65%)	Represents a duplicate of Scenario 1, with addition of non- conventional water sources (6% of the total mix) partially replacing GW (supply from SW: 29%, from GW: 65% and from Non-conventional Sources: 6% - noting that the supply from non-conventional sources cannot feasibly be brought higher.
	Scenario 3: "Updated NWSS-MoEW (2020) Scenario with increase in supply from SW sources" (SW 45%; GW 55%)	Represents a scenario where supply from SW accounts for 45% (considering that all the proposed dams in the Updated NWSS (2020) will be completed by 2035, thus supply from Dams amounting to 44%) and that from GW is 55%.
	Scenario 4: "Updated NWSS - MoEW(2020) Scenario with increase in supply from GW sources" (SW 20%; GW 80%)	Represents a scenario where supply from SW is 20% (considering that only the dams under construction will be completed and operational by 2035 (Janneh Dam, Mseilha Dam and Boqaata Dam) and that from GW is 80%.

(*) All assessed against the baseline scenario (i.e. the general status of 2020), where supply from SW (rivers and dams) accounts for 17% and that from GW (springs and wells) 83%

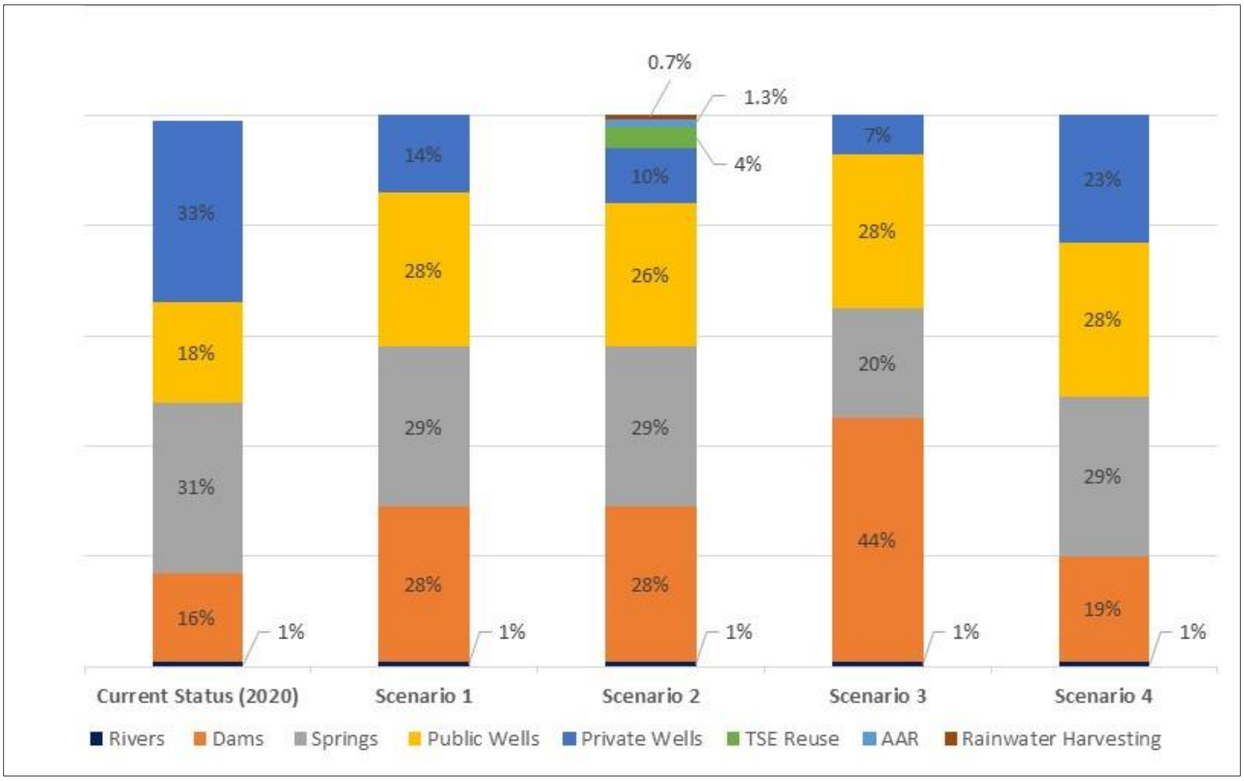

Figure 19 Specific and Cross-cutting SESA Key Themes

A rapid analysis of the scenarios, in terms of sustainability, reveals the following:

1. The “Do Nothing” alternative has extremely adverse social, economic, and environmental consequences, including the following:
   - Existing challenges with the proper and sustainable management of water resources to meet the national water demands will be further exacerbated.
   - Pollution of water sources will increase, and accordingly associated health risks (such as the recent Cholera outbreak).
   - Citizens’ reliance on private water sources (private wells, water tankers) will increase together with related health, financial and governance repercussions.

   Accordingly, without effective action to increase supply and improve water quality, Lebanon would be in danger of facing severe water shortages and increased public health deterioration in the near future.

2. Scenario 1 (Updated NWSS-MoEW (2020) Scenario) still relies heavily on GW (71%) which poses sustainability risks as it is allowing tapping into non-renewable ground water sources.

3. Scenario 2 (Updated NWSS-MoEW (2020) Scenario with Addition of Non-conventional Water Sources) decreases reliance on GW by 6%, which merits further investigation in terms of cost and technical feasibility, as well as supporting Research and Development (R&D) to further promote it.

4. Scenario 3 (Updated NWSS-MoEW (2020) Scenario with increase in supply from SW sources) is the most sustainable in terms of renewable source use since surface water storage will heavily reduce reliance on GW, thus bringing Lebanon closer to international best practice in terms of SW/GW reliance. It will also significantly reduce direct costs, incurred by citizens, and associated with securing water supply from private sources. It is to be noted however that in this scenario, surface water storage is mainly in the form of dams, many of which of the large scale (Bisri Dam, Janneh Dam and Assi Dam) and accordingly heavy on the government treasury (USD 2.12 Bn excluding Bisri Dam), and the ecology, let alone cost overruns. It is also important to highlight that while the need for surface water storage is very much justified for sustainability concerns, it is outside the scope of a SESA to assess proposed locations and engineering design of proposed dams.

5. Scenario 4 (Predominance of GW) will exacerbate over pumping from aquifers, which can lead to a drop in the groundwater level in most inland aquifers, seawater infiltration in coastal aquifers, and deterioration of the water quality.

Nevertheless, regardless of the adopted scenario, it is crucial to:

- Focus on increasing network efficiency to 75%, as this is a main assumption in the Updated NWSS(2020), which has a major impact on water demand and is a main condition for sustainable water management. While this will not offset the need for increased surface water storage (, it will reduce groundwater pumping
- Regulate abstraction from groundwater wells, including private ones. However, under the current circumstances, and until surface water storage is enhanced, water supply from private wells cannot be reduced to null as several agricultural schemes will still be relying on it.

- Promote additional R&D efforts to assess the potential of increasing reliance on non-conventional resources.
- Develop an integrated watershed management strategy prior to the implementation and completion of any dam. This will minimize and mitigate risks and damages and reduce expenses incurred by the citizen.

3.5 SELECTION OF THE «MOST SUITABLE STRATEGIC OPTION »

Based on the above, the water supply mix presented in the Updated NWSS-MoEW (2020) is currently, given the data available, the most logical alternative from an environmental and social perspective, in that it is a necessary strategy which there are no clearly superior available alternatives. However, the Updated NWSS-MoEW (2020) must remain flexible and can be greatly enhanced by researching and adopting other options and/or complementary measures for achieving the same goals.

More importantly, the strategy can be best improved by prioritizing the governance-related initiatives to strengthen the institutional capacities and ensure sustainability of projects. For these measures to unfold, it is important that MoEW 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 2020 when the Updated NWSS-MoEW (2020) was compiled but, rather, should adapt to the growing uncertainties and emerging opportunities in the water sector. However, it is recommended that the Updated NWSS-MoEW (2020) is implemented taking into consideration the mitigation measures and policy responses outlined in the "Framework to Optimize the Environmental and Social Effects of the Strategy" and "Recommendations for Integrating SESA Findings in the Updated NWSS-MoEW (2020)" sections of the SESA.

3.6 A FRAMEWORK TO OPTIMISE THE ENVIRONMENTAL AND SOCIAL EFFECTS OF THE STRATEGY

The SESA has compiled a list of policy responses and mitigation measures with responsibilities distributed among all stakeholders involved in the water sector, including the MoEW, MoE, CDR, RWEs, and others (listed in Table 10 of Annex II Section F). It also outlines other required responses, including:

1. Advance the IWRM implementation through strengthening political will, enhancing coordination between stakeholders, improving data and information sharing, and building capacity through IWRM-specific training. MoEW holds a major role in enhancing information sharing, communication, and coordination between the concerned stakeholders, including the public, on issues related to the water sector

2. Re-prioritize projects classified as Priority 1 to identify the projects which have the most significant positive impact and are required to achieve the projected development in the sector.

3. Strengthen the Environmental Impact Assessment (EIA)/In full (RMP) process as it is essential to ensure environmental compliance of the infrastructural projects proposed in the strategy.

4. Ensure that water resource allocation regime and water demand management take into consideration not only gradual changes in water availability due to climate change, but also sudden changes due unexpected climatic shifts.

5. Ensure that the MoEW develops a sector investment program, to ensure that viable financing is available for the implementation of the Updated NWSS-MoEW (2020) proposed projects and their operation.

In addition, Table 10 of Annex II Section F presents the mitigation strategies and policy responses recommended for the key themes discussed throughout the SESA report.

3.7 RECOMMENDATIONS FOR INTEGRATING SESA FINDINGS IN THE UPDATED NWSS-MOEW (2020)

ECODIT team attempts to highlight priority recommendations for integrating SESA findings in the Updated NWSS-MoEW (2020).

1. **Integration of Mitigation Strategies/Policy Recommendations into Updated NWSS-MoEW (2020)**
   It is advised to begin with the integration of the "priority" SESA policy responses and mitigation measures[7] into the Updated NWSS-MoEW (2020) and continue with the integration of all other SESA policy responses and mitigation measures in the upcoming revised/updated strategies.

2. **Oversight and Monitoring**
   There is an urgent need to clearly assign responsibility for oversight and monitoring of the Strategy.

3. **Research and Development (R&D)**
   Promote additional R&D efforts to assess the potential of increasing the reliance on non-conventional resources, as well as to address different water sector challenges.

4. **National Water Dialogue**
   Transparency and stakeholders' engagement is crucial for the successful implementation of the Strategy.

5. **Appraisal of the Updated NWSS-MoEW (2020) Implementation & Iterative Process for Revisions**
   There is a strong need for a "mid-term appraisal" of the Strategy through which lessons from experiences could be learned, targets and methodologies could be re-assessed, and SESA safeguards could be implemented. In particular, as stipulated in in the Water Code, the strategy should be revisited every 5 years.

[7] The "priority" mitigation measures/policy recommendations that could be integrated immediately into the Updated NWSS(2020) are highlighted in Table 10 of Annex II Section F

4 SUMMARIES OF COST ESTIMATES

4.1 WATER GOVERNANCE

Table 27 Summary of required water sector governance studies, financial, commercial, reporting & monitoring, capacity building, and operation and maintenance studies

RS-B Water Governance priority action plan			
1	RS-B.1	Sector Governance	1 465 000
1	RS-B.2	Financial and Commercial	6 750 000
1	RS-B.3	Reporting and Monitoring	1 257 500
1	RS-B.4	Capacity building	2 950 000
1	RS-B.5	O&M of facilities and services	660 000
		Total Water Governance priority action plan	**13 082 500**
		Out of which : Priority 1	13 082 500
		Priority 2	-
		Priority 3	-

4.2 HYDROLOGICAL NETWORKS AND IHIS IMPLEMENTATION

Table 28 Cost estimates for hydrological networks expansion and IHIS implementation studies

Priority	Project code	Description	Estimated cost (USD)
MH A. Meteorological and Hydrometric network expansions and improvements			
1	MH-A.1	LMS + LRA Meteorological Network Expansion Coastal Catchments: 9 Uncovered Catchments (+5 stations) 6 Semi-covered Catchments (+3 stations) Snow monitoring stations (+1 station per catchment above 2000m)	790,000
1	MH-A.2	LMS + LRA Meteorological Network Expansion Interior Catchments: 1 Uncovered Catchments (+5 stations) 3 Semi-covered Catchments (+3 stations) Snow monitoring stations (+1 station per catchment above 2000m)	200,000
1	MH-A.3	LARI Meteorological Network Expansion Maintenance instruments for 10 stations	100,000
1	MH-A.4	MoEW Meteorological Network Expansion Natural reserves and Forests	250,000
1	MH-A.5	LRA Hydrometric Network Expansion: Improvement of hydrometric stations as per LWP assessment report Hydrometric monitoring stations for stream connections coverage Hydrometric monitoring stations for hydrogeology coverage Main springs ADCP Installation Groundwater wells monitoring	4,726,000
		Total	**6,066,000**
		Out of which : Priority 1	6,066,000
		Priority 2	-
		Priority 3	-
MH-B. Integrated Hydrological Information System			
1	MH-B.1	Required studies for IHIS implementation: Assessment studies Update and Analysis of the NLUMP and annexed geodatabase Lebanese Data Rescue Project Design studies for the IHIS implementation Integrated water resources management studies Flood Risk Management plan Drought Mitigation plan Rainwater Harvesting plan	7,180,000
1	MH-B.2	IHIS implementation	2,000,000
1	MH-B.3	IHIS Operation for 24 months	288,000
1	MH-B.4	WEAP Operation and Implementation	80,000
		Total	**9,548,000**
		Out of which : Priority 1	9,548,000
		Priority 2	-
		Priority 3	-

4.3 GROUNDWATER STUDIES

Table 29 Groundwater management studies cost estimate

Priority	Code	Description	Cost
RS-B Implementation of a Project Management Unit for a 5 years period			
1	RS-B.1	Mobilisation of experts	6,700,000
1	RS-B.2	Purchase of cars, IT equipment, flow monitoring equipment, flow meters, manual dipmeters, misc working tools and required software	325,000
1	RS-B.3	Travel and transportation expenses	1,060,000
1	RS-B.4	Office expenses	420,000
		Total Implementation of PMU	**8,505,000**
		Out of which : Priority 1	8,505,000
		Priority 2	-
		Priority 3	-
RS-C General Geological and Hydrogeological Studies			
1	RS-C.1	Geology ang hydrogeology mapping and studies	12,200,000
3	RS-C.2	Refreshment of water budget studies of major hydrogeological basins	2,000,000
3	RS-C.3	Groundwater vulnerability mapping for springs Q > 10 l/s	1,600,000
3	RS-C.4	Modeling of major karst aquifers hydrogeological basins	3,000,000
3	RS-C.5	Modeling of major porous, saline aquifer systems	3,000,000
		Total Geology and hydrogeology mapping and studies	**21,800,000**
		Out of which : Priority 1	12,200,000
		Priority 2	-
		Priority 3	9,600,000
RS-D Drilling and testing exploratory wells			
1	RS-D.1	In Hadath-Hazmieh - 3 wells	1,500,000
1	RS-D.2	In Daichouniye - 2 wells	600,000
2	RS-D.3	In Akkar plain - 5 wells	2,500,000
3	RS-D.4	In Brak (Zahrani) - 1 well	500,000
3	RS-D.5	In Damour - 3 wells	1,050,000
		Total Drilling and testing exploratory wells	**6,150,000**
		Out of which : Priority 1	2,100,000
		Priority 2	2,500,000
		Priority 3	1,550,000

4.4 CONSTRUCTION PROJECTS

Table 30 Consolidated projects cost estimates, by WE
(in M USD, VAT and expropriation excluded)

	NLWE	BWE	SLWE/LRA	BMLWE	Total
Priority 1 projects					
Water	213.02	122.60	330.84	284.66	951.12
Wastewater	351.95	366.43	460.55	296.00	1 474.92
Irrigation	29.12	109.71	86.55	1.02	226.40
Dams	196.02	52.00	-	612.00	860.02
Hill Lakes	33.37	-	-	-	33.37
Aquifer Artificial Recharge **(*)**					3.65
Meteorological and Hydrometric networks **(*)**					15.61
General Studies and Investigations **(**)**					35.78
Total	823.47	650.73	877.95	1 193.68	**3 600.87**
Priority 2 projects					
Water	130.87	68.77	111.25	312.88	623.78
Wastewater	226.96	70.65	204.23	233.00	734.84
Irrigation	11.20	83.00	408.88	1.15	504.23
Dams	50.00	150.00	273.00	200.00	673.00
Hill Lakes	110.72	55.20	119.70	33.50	319.12
Aquifer Artificial Recharge **(*)**					11.60
Meteorological and Hydrometric networks **(*)**					-
General Studies and Investigations **(**)**					2.50
Total	529.75	427.62	1 117.06	780.53	**2 869.06**
Priority 3 projects					
Water	-	-	-	-	-
Wastewater	-	-	33.01	116.00	149.01
Irrigation	103.27	4.52	299.70	5.22	412.71
Dams	150.00	107.06	480.00	53.00	790.06
Hill Lakes	22.90	-	-	-	22.90
Aquifer Artificial Recharge **(*)**					16.50
Meteorological and Hydrometric networks **(*)**					-
General Studies and Investigations **(**)**					11.15
Total	276.17	111.58	812.71	174.22	**1 402.33**
Total Projects	1 629.39	1 189.93	2 807.72	2 148.43	7 872.27
15% Contingencies	244.41	178.49	421.16	322.26	1 180.84
Projects Grand Total	**1 873.80**	**1 368.43**	**3 228.88**	**2 470.70**	**9 053.11**

*** Including studies and implementation**
**** Including General geological studies + PMU and Governance**

Table 31 Consolidated projects cost estimates, by sector
(in M USD, VAT and expropriation excluded)

	Water	Wastewater	irrigation	Dams	Hill lakes	Total
Priority 1 projects						
NLWE	213.02	351.95	29.12	196.02	33.37	823.47
BWE	122.60	366.43	109.71	52.00	-	650.73
SLWE/LRA	330.84	460.55	86.55	-	-	877.95
BMLWE	284.66	296.00	1.02	612.00	-	1 193.68
Aquifer Artificial Recharge **(*)**						3.65
Meteorological and Hydrometric networks **(*)**						15.61
General Studies and Investigations **(**)**						35.78
Total	951.12	1 474.92	226.40	860.02	33.37	**3 600.87**
Priority 2 projects						
NLWE	130.87	226.96	11.20	50.00	110.72	529.75
BWE	68.77	70.65	83.00	150.00	55.20	427.62
SLWE/LRA	111.25	204.23	408.88	273.00	119.70	1 117.06
BMLWE	312.88	233.00	1.15	200.00	33.50	780.53
Aquifer Artificial Recharge **(*)**						11.60
Meteorological and Hydrometric networks **(*)**						-
General Studies and Investigations **(**)**						2.50
Total	623.78	734.84	504.23	673.00		**2 869.06**
Priority 3 projects						
NLWE	-	-	103.27	150.00	22.90	276.17
BWE	-	-	4.52	107.06	-	111.58
SLWE/LRA	-	33.01	299.70	480.00	-	812.71
BMLWE	-	116.00	5.22	53.00	-	174.22
Aquifer Artificial Recharge **(*)**						16.50
Meteorological and Hydrometric networks **(*)**						-
General Studies and Investigations **(**)**						11.15
Total	-	149.01	412.71	790.06		**1 402.33**
Total Projects	1 574.90	2 358.77	1 143.34	2 323.08		7 872.27
15% Contingencies	236.23	353.82	171.50	348.46		1 180.84
Projects Grand Total	**1 811.13**	**2 712.59**	**1 314.84**	**2 671.54**		**9 053.11**

*** Including studies and implementation**
**** Including General geological studies + PMU and Governance**

4.5 WATER AND WASTEWATER WORKS COST PER CAPITA

Table 32 Ratio of projects cost per capita

Project	Cost M USD	Population capita	Ratio USD / cap
NORTH LEBANON WATER ESTABLISHMENT			
Drinking water projects			
NL-W A. District of Batroun	23.72	93 578	254
NL-W B. District of Halba	72.07	377 776	191
NL-W C. District of Koura	31.92	171 508	186
NL-W D. District of Minieh	30.91	167 742	184
NL-W E. District of Ed Danniyeh	32.83	121 074	271
NL-W F. District of Zgharta	48.75	139 251	350
NL-W G. District of Tripoli	30.79	483 451	64
NL-W H. District of Qobayate	72.89	179 838	405
		Average ⟶	**238**
Wastewater projects			
NL-WW A. District of Akkar	361.73	635 838	569
NL-WW B. District of Koura	17.19	171 508	100
NL-WW C. District of Minieh	99.89	167 742	595
NL-WW D. District of Zgharta	50.97	139 251	366
NL-WW E. District of Batroun	49.13	93 578	525
		Average ⟶	**431**
SOUTH LEBANON WATER ESTABLISHMENT			
Drinking water projects			
SL-W A. District of Nabatiye	85.72	353 107	243
SL-W B. District of Jezzine	39.36	51 764	760
SL-W C. District of Sour	82.46	558 503	148
SL-W D. District of Zahrani	54.74	216 393	253
SL-W E. District of Saida	72.52	331 772	219
SL-W F. District of Bint Jbeil	60.39	146 685	412
SL-W G. District of Marjaayoun & Hasbaya	46.91	120 903	388
		Average ⟶	**346**
Wastewater projects			
SL-WW A. District of Nabatiye	67.15	353 107	190
SL-WW B. District of Sour	78.62	558 503	141
SL-WW C. District of Bint Jbeil	217.86	301 366	723
SL-WW D. District of Jezzine	123.09	51 764	2 378
SL-WW E. District of Saida	30.05	317 202	95
SL-WW F. District of Marjaayoun	106.08	136 057	780
		Average ⟶	**718**

Table 32 Ratio of projects cost per capita (continued)

Project	Cost M USD	Population capita	Ratio USD / cap
BEIRUT & MOUNT LEBANON WATER EST.			
Drinking water projects			
BML-W A. District of Beirut	142.60	643 059	222
BML-W B. District of Jbeil	64.13	218 128	294
BML-W C. District of Baabda Aley	115.93	1 198 485	97
BML-W D. District of Keserwan	49.95	464 480	108
BML-W E. District of Chouf	125.46	409 006	307
BML-W F. District of Meten	99.49	1 064 429	93
		Average ⟶	**187**
Wastewater projects			
BML-WW A. District of Beirut	50.00	643 059	78
BML-WW B. District of Jbeil	111.40	218 128	511
BML-WW C. District of Baabda Aley	277.20	1 198 485	231
BML-WW D. District of Keserwan	23.70	464 480	51
BML-WW E. District of Chouf	71.40	409 006	175
BML-WW F. District of Metn	111.30	1 064 429	105
		Average ⟶	**192**
BEQAA WATER ESTABLISHMENT			
Drinking water projects			
BQ-W A. District of Baalbeck	74.54	586 316	127
BQ-W B. District of Hermel	39.85	107 820	370
BQ-W C. District of West Beqaa & Rachaiya	44.09	199 929	221
BQ-W D. District of Zahleh	32.89	543 011	61
		Average ⟶	**195**
Wastewater projects			
BQ-WW A. District of Baalbeck	191.91	586 316	327
BQ-WW B. District of Hermel	123.70	107 820	1 147
BQ-WW C. District of Zahleh - West Beqaa	32.57	665 560	49
BQ-WW D. District of Rachaya	88.89	77 380	1 149
		Average ⟶	**668**