Rehabilitation and Extension project for Ablah Water Reuse System, Bekaa Lebanon

ReWater MENA Output 2:
Design of two local reuse models in Lebanon

International Water Management Institute

Contributors

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ABBREVIATIONS AND ACRONYMS

ACCBAT	
BCR	Benefit-Cost Ratio
BOD5	Biological Oxygen Demand
BWE	Bekaa Water Establishment
CAPEX	Capital Costs
CBA	Cost Benefit Analysis
CDR	Council for Development and Reconstruction
CFU	Colony-Forming Unit
CM	Cubic Meter
COD	Chemical Oxygen Demand
CWR	Crop Water Requirements
DI	Ductile Iron
du	Dunum (= 1,000 SM)
EIA	Environmental and Social Impact Assessment
ELVs	Environmental Limit Values
EMP	Environmental and Social Management Plan
ETo	Potential Evapotranspiration
ETc	Crop Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization for the United Nations
FC	Fecal Coliforms
FTO	Farm Turn Out
GRP	Glass Reinforced Plastic
H	Head
ha	Hectare (=10,0000 SM)
HP	Horse Power
ICU	Institute for University Co-operation
IEE	Initial Environmental Examination
IWMI	International Water Management Institute

Km	Kilometer
kWh	Kilo Watt hour
L	Length
LARI	Lebanese Agricultural Research Institute
LRA	Litani River Authority
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoIM	Ministry of Interior and Municipalities
MoPH	Ministry of Public Health
NPV	Net Present Value
NSEQ	National Standards for Environmental Quality
O&M	Operation and Maintenance
OPEX	Operation and Maintenance Costs
Q	Flow
RKP	Rafik Khoury Partners
SIDA	Swedish International Development Cooperation Agency
SM	Square Meter
TN	Total Nitrogen
TP	Total Phosphate
TSE	Treated Water Effluent also used as treated wastewater
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USD	United States Dollars
VAT	Value-Added tax
WHO	World Health Organization
WWTP	Waste Water Treatment Plant

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1 INTRODUCTION AND OBJECTIVES

Although well-endowed in water compared to its neighboring countries, Lebanon suffers from water shortage, with surface water heavily exploited and groundwater already in overdraft (MEW 2012; MEW 2020; Eid-Sabbagh et al. 2022). Since the 1960's, high demographic growth, urbanization and expansion of agricultural areas, coupled to serious management problems have put high quantitative and qualitative pressure on water resources and the environment. Today, most of the country's river-basins are over-allocated especially during the summer when irrigation needs become high.

Among the many actions needed to improve water management, the reuse of treated domestic sewage has the potential to reduce the water supply gap. The need and relative acceptability of water reuse is demonstrated by informal reuse practices observed in many agricultural regions of the country. At many sites in the Bekaa, Mount-Lebanon, and North-Lebanon farmers intentionally or unintentionally tap into treated effluents discharged into waterways, or even resort to untreated sewage to supplement their water needs and/or reduce the costs of groundwater pumping (Eid-Sabbagh et al. 2022).

In the last decade, improving wastewater management, and developing water reuse in Lebanon were given increased attention both from national and international actors. The 2012 National Water Sector Strategy and its updated version in 2020 states that the expansion of water reuse is a national objective. In 2010, an FAO project developed guidelines for water reuse and sludge reuse in agriculture. In 2015, an EU project implemented an irrigation water reuse system supplied by Ablah WWTP (central Bekaa) to irrigate 20 ha of vineyards in the neighboring plain and replace pumping from depleting groundwater. More recently, another EU project collaborating with the Ministry of Agriculture is planning to develop a reuse system linked to Aitanit WWTP (south Bekaa) to supplement irrigation water needs from the Mashghara spring.

In 2018, the IWMI ReWater MENA project launched several activities to support the expansion of safe water reuse in Lebanon. A national scale study analyzed the potential of implementing water reuse from existing and planned WWTPs and laid a political economy analysis of the wastewater sector (Eid-Sabbagh et al.2022). The report mapped and collected a set of data for the 104 existing WWTPs. At the time of the study (2020-2021), 41 WWTPs were operational, 20 partially operational, 35 not operational and 8 under construction.

The study modelled a 'Reuse Potential Area' (in hectare) for each plant and calculated a 'Reuse Potential Score' based on treatment performance, water quality levels and existing cropping patterns. This was done for two scenarios, the 'Actual Potential scenario' considering current operational status and actual treated volumes and the 'Ideal Potential scenario' where all WWTPs are considered operational at their maximum design capacity. The calculated total Reuse Potential Area for each scenario is 2208 ha and 4993 ha respectively, while currently less than 10 ha are part of a reuse scheme (in Ablah). The study identified around 18 WWTPs having good Reuse Potential Area and Score (**Error! Reference source not found.**).

Another activity of ReWater Project consisted at designing two bankable reuse systems linked to Ablah and Zahleh WWTPs (Central Bekaa) selected in the early stages of the project as part of stakeholder consultation processes and later identified by the cited study as being part of the 18 WWTPs with relatively good reuse potential.

The two studies respectively include detailed technical and socio-economic feasibility studies, as well as an implementation and governance plan proposing the management structure of the two systems in compliance with the Lebanese institutional and legal framework and taking into consideration de-facto governance practices. Both reuse studies were developed in close consultation with the respective stakeholders based on ReWater MENA's adopted participatory approach.

The following report presents the summary[1] study related to Ablah WWTP, a small domestic, trickling filter-based treatment plant (2,000 m3/day) managed by the municipality of Ablah town, in Central Bekaa, Lebanon. The study presents a plan for the rehabilitation of an existing irrigation reuse system (20 ha/30 farmers) and its extension to supply 12.3 ha more lands.

It starts with an overview of Ablah's site within its geographic environment and explains the rationale of the project. The methodology is then presented with a highlight on its participatory component. The report then presents the proposed infrastructure including investment and operation costs, cost-benefit assessment and environmental impact. The final section presents the project's envisioned governance. It expands on the formal and informal governance of the water and wastewater sector in Lebanon and the increasing challenges faced both by state administrations and local institutions at this time.

Table 1: Summary numbers for water reuse potential in Lebanon and main sites with high potential

	MCM/year	MCM/Season	% of total
Total Municipal Wastewater generated	273.7 -328.5	164.2 -198.2	100
Total Treated Water produced	81.2	48.9	25-30%
Total Treated Water discharge to sea	60.2	36.3	18 -22%
Total Treated Water discharge to inland water body	20.9	12.6	6.3 -7.6%
Total direct reuse (2020)	0	0	0
Total indirect reuse	Indirect reuse is widely spread as water from rivers is persistently used for irrigation but cannot be quantified because of a lack of water use and water production data.		
Area potentially irrigable with treated water at present in ha	2208 (ha)		
Treatment Plants with high potential (Area and Score)	• Zahleh (527.2 ha), Aitanit (32.6 ha), Ablah (28.6 ha), Fourzol (21.3), Joub Jannine (138.9 ha) (Bekaa), • Chabriha (326.3 ha) (Sour), • Tibnine (23.9 ha) (Bint Jbeil), • Hebarriye (11.2 ha) (Hasbaya) • Ijbaa(87.5 ha), Aintourine (91.9 ha)(Ehden), • Nabaa el Safaa (22.0 ha), Bater (15.6 ha), Barouk (12 ha) Ammantour (9.7 ha) (Chouf), • Hammana (19.5 ha) (Metn), • Qobayat (12.2 ha) (Akkar)		

Source: IWMI forthcoming

[1] A full economic feasibility study developed by Ecosystem with the detailed scenario and cost-benefit assessment is available in a larger report (Ecosystem, 2022).

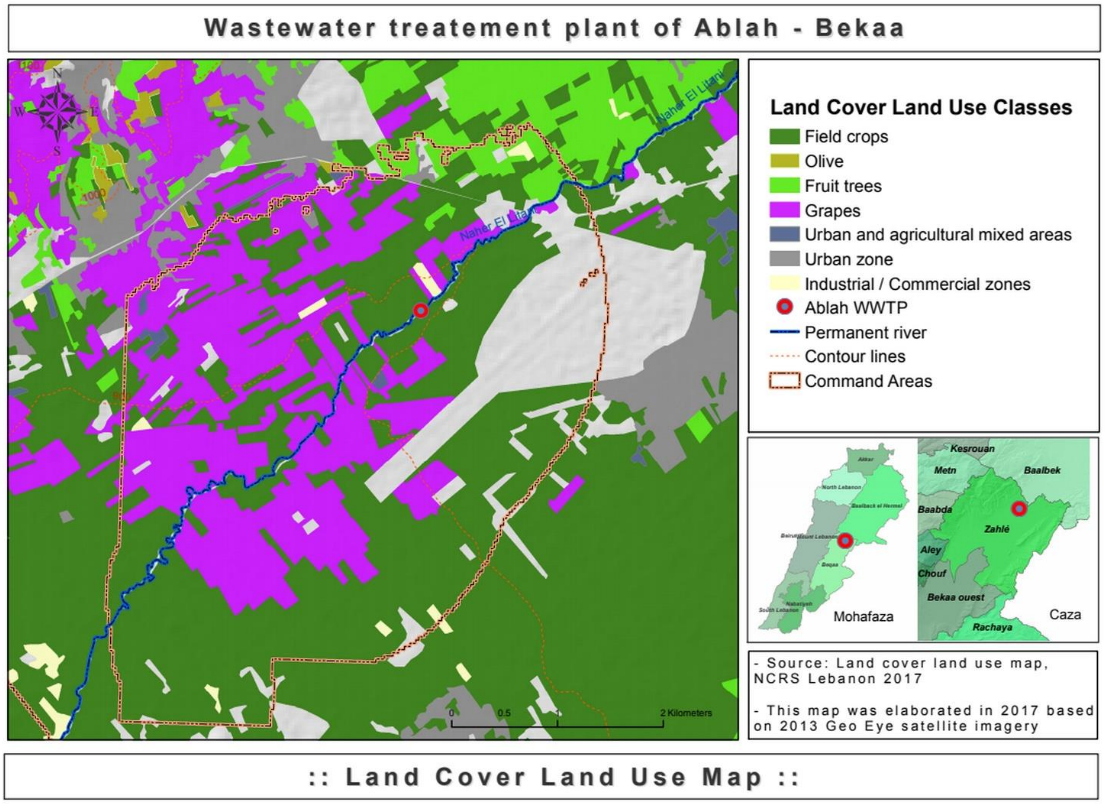
2 ABLAH SITE AND PROJECT RATIONALE

2.1 ABLAH TOWN WITHIN THE UPPER LITANI RIVER BASIN

Ablah is part of the Litani River Basin, the largest hydraulic basin in Lebanon, today's subject to serious problems of pollution and over allocation of both surface water and groundwater. Qualitative and quantitative pressure on water resources is evidenced by progressively alarming research (USAID-LRBMS, 2012; Molle et al. 2017; Shaban and Hamzé, 2018; Nassif, 2019) and experienced daily by its residents, especially in the summer months.

Ablah is a small agricultural town of Central Bekaa famous for grapevines production. According to recent data it has a total population of around 6,000 residents, and a total area of 6 Km2 (city-facts.com). Agricultural lands mostly cultivated with grapes occupy most of the town's area (Figure 1). There are around 100 farmers in Ablah and agriculture is considered a major source of income.

Figure 1: Ablah Land Use Map



Source: Eid-Sabbagh et al. 2022

2.2 WATER MANAGEMENT CONSTRAINTS

The main source of irrigation in Ablah is groundwater stored in the Quaternary aquifer, a layer of alluvial sediments underlying agricultural lands. Groundwater use from this aquifer started developing in the region and more generally in the Bekaa since the 1960's, first through superficial hand-dug wells, then with deeper tube wells as groundwater levels dropped with sustained abstractions and agricultural expansion (Nassif, 2016). Farmers use individual wells located at the level of their plots and use pressurized irrigation systems, drip and sprinklers depending on the crops. The Litani River is not a reliable or safe source of water. Diverted upstream, it completely dries out in the summer months and becomes a drain for untreated sewage (domestic, agricultural and industrial) discharged by upstream villages not connected to treatment facilities.

Groundwater levels are also dropping to more than 50 m (b.g.l) which incur high pumping costs on farmers (see below). Additionally, well yields in this aquifer are becoming significantly lower and some wells completely dry in the summer months with high impact on yields and crop health. It is common to see more than one well on the same plot, a strategy adopted by farmers as a response to yield decline (Nassif, 2016). The idea of a water reuse project around Ablah WWTPs stems from these constraints.

2.3 ABLAH WWTP

2.3.1 General description

Ablah WWTP is a small domestic wastewater treatment plant located on the right bank of the Litani River. It was built between 2009 and 2012 by a USAID funded project along with two other small WWTPs on the Upper Litani Basin. It has a treatment capacity of 2,000 m3/day and uses the trickling filter technique as a secondary treatment with additional chlorination. The effluent average daily volume from Ablah WWTP is 1,400 CM/day in summertime. A new wastewater line is currently under construction and will connect to the WWTP around 100 new houses in addition to the Antonine University. This line will expectedly provide some additional 100 CM of wastewater. The detailed drawing of Ablah WWTP is provided in Annex 1.

This treatment plant is the only WWTP in Lebanon that benefits from an irrigation reuse infrastructure. Built by an EU project (ACCBAT) in 2015, the system only operated for two irrigation seasons and was stopped due to a complaint deposited by a resident whose house was allegedly impacted by the collection reservoir located nearby. Today, most of the treated effluent is discharged into the Litani river and mixed with polluted water. Three farmers with plots located nearby the WWTP still benefit from the treated effluent through direct individual connections.

Figure 2: Location of the influent and effluent points of Zahleh WWTP

Source: Ecosystem, 2022.

2.3.2 Management and cost-recovery

The WWTP is owned and managed by the municipality of Ablah. Since its construction, it is operated by engineer an (Mohamed Boudaya) living in the neighboring town of Tibnine (North-Bekaa). He is helped by a Syrian technician, living in Ablah. The same engineer also operates Fourzol WWTP and was involved in the construction phase of these two plants that were built under the same donor funded program.

The costs of operation and maintenance (O&M) are paid by Ablah Municipality. In the first years of operation, the Union of Municipalities of the Caza of Zahleh (which Ablah Municipality is part of), used to contribute to these costs by settling the generator fuel bill (USAID, 2013). Until recently, the costs were entirely covered by Ablah Municipality. In 2012, The O&M costs in Ablah used to be around 64,000USD yearly in 2012 with energy representing 50% of the total costs (USAID, 2013). Since then, a change in the management of public electricity supply in Zahle caza[2] reduced the use of private generators and consequently the energy bill. According to the municipality, the total cost of O&M is now reduced to 50,000 USD/yearly.

At present, the WWTP is partially operational. Its operation depends on the hours of public electricity supply in the region, which is subject to rationing hours since 2021 when the Lebanese State stopped subsidizing fuel. In November 2022, electricity was provided only twelve hours a day (24 hours), interrupted twice a day for six hours. Furthermore, the municipal board is no longer active since the beginning of the year and the municipality is today under the administration of the Bekaa Governor, the 'Mouhafez'[3]. This makes the future of Ablah WWTP uncertain. This will be further detailed in section 5.

2.4 THE EXISTING REUSE SYSTEM

In 2015, an EU project (ACCBAT) partnering with the Italian University Co-operation, Lebanese Ministry of Agriculture (MoA), LARI and Ablah Municipality designed and implemented a reuse system supplied by Ablah WWTP's treated effluent. The system consists of an artificial hill lake (1500 CM) to which the effluent is pumped then distributed by pumping to 20 ha of plots planted with grapevines through underground pipes. At farm level, irrigation is done by drip lines also installed at the time of the project. The detailed system is provided in Annex and the existing equipment (to be rehabilitated as proposed by the present report) described in Section 4.1.

The objective was to reuse part of the effluent discharging into the Litani (and mixing again with polluted water) to irrigate plots planted with grape vines and mostly irrigated by individual wells[4]. The idea was to provide an alternative to groundwater use to decrease the cost of irrigation for farmers and preserve groundwater reserves. As mentioned in Section 2.2, the Quaternary aquifer is already scarce in this area,

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[2] The Lebanese government established a public private partnership with the company EDZ (Electricité de Zahleh) who ensures a better electrical supply than EDL (Electricité du Liban), the national company.

[3] In Lebanon, the 'Mouhafaza' is an administrative division constituted by different 'cazas', which in turn are divided by 'municipalities', the smallest administrative units. There are eight 'Mouhafaza' in Lebanon.

[4] Interviews showed that some of the vineyards in Ablah were rainfed.

and showing signs of depletion as exemplified by declining well yields and/or drying wells[5]. It was also envisioned that the reuse project would supply soil nutrients embedded in the treated water and reduce the need for fertilizers, a hypothesis that was verified by field experiments conducted by LARI with some farmers (Abi Saab et al. 2020).

2.5 Rationale for ReWater MENA proposed intervention

As presented below, Ablah WWTP was selected as one of the two local sites where there is potential for a reuse study around a potential technical intervention. First, the two years of the system's operation had revealed problems of water pressure at the tail end of the network which needed to be assessed and managed. Second, Ablah stakeholders proposed an extension of the network as Ablah was currently treating a larger volume of water that could benefit to more farmers currently using wells. This was verified within the IWMI's national assessment for reuse (Eid-Sabbagh et al. 2022) and later confirmed with field surveys showing that the current capacity of the WWTP can irrigate 12.3 ha additionally to its current command area.

Additionally, as per Ablah municipality, there was a need to put in place a long-term implementation plan including a governance organigram with a clear distribution of the different management tasks among stakeholders (Ablah municipality and farmers), and a cost-recovery mechanism for the reuse system's operation and maintenance.

The link to LARI's activities was yet another reason to select Ablah. The WWTP's effluents were used as one of the water sources in the scientific field experiment conducted in 2019 and 2020 by LARI under ReWater (Abi-Saab et al. 2022). The effluent's quality was regularly tested during the cropping seasons of 2019 and 2020 which was an opportunity to link both studies and provide data on water quality and its potential impact of crops and soil.

Finally, taking Ablah as one of the two case studies is an opportunity to take a closer look at the community-based model of wastewater treatment and irrigation governance and reflect on possible improvements of the current governance framework adopted by the State. While by law state administrations should manage WWTPs and irrigation networks (Law 221), municipalities were found to govern 66% of existing WWTPs and 60% of the functional (Eid-Sabbagh et al, 2022). On the other hand, local communities play an essential role in irrigation governance in Lebanon (Nassif, 2019). This indicates the relevance of State administrations building on local institutional arrangements to anchor and legitimize their territorial action. As a matter of fact, there are ongoing discussions at the central level around the relevance of establishing partnerships between State administrations and municipalities as a solution to the governance constraints faced by State administrations[6]. The present study case hopes to contribute to these discussions.

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[5] See Nassif 2016 for a study case about groundwater use in Fourzol where both the Quaternary aquifer and irrigation in the area have similar characteristics.

[6] Discussions around such partnerships were reported in the case of Aitanit WWTP between the Ministry of Energy and Water (MEW) and the Union of Municipality of Qaraoun Lake. More recently, two projects respectively funded by USAID and EU (Water Conservation Project and Madad fund) proposed to the Ministry of Energy and Water

3 METHODOLOGY

3.1 GENERAL METHODOLOGY

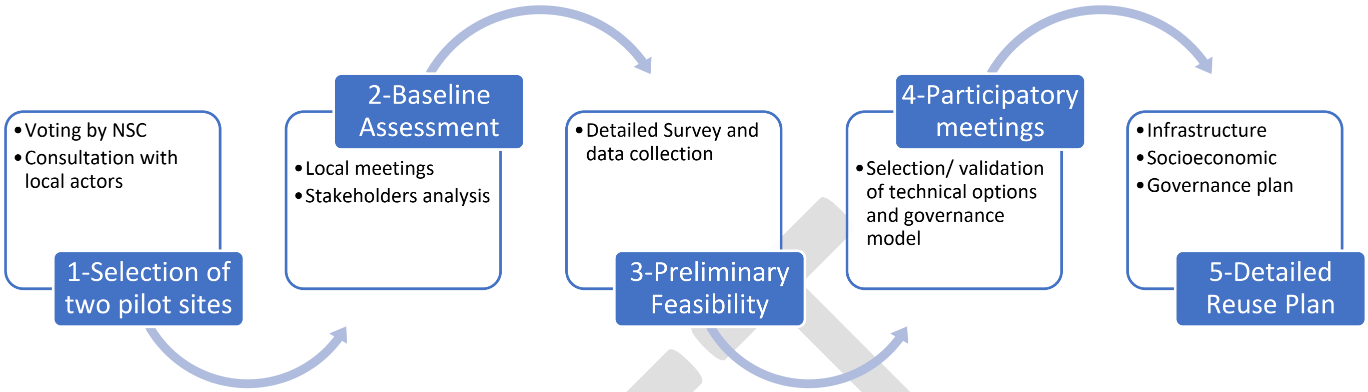
The design of the two reuse models in Ablah and Zahleh followed several steps and included a thorough local participatory process to ensure the integration of detailed local data (both technical and social), and tailor the reuse system on both environmental needs and socio-economic dynamics.

It started with the selection of two local sites based on consultation with local stakeholders and voting by the National Steering Committee (see 3.2.1). It was followed by a Baseline Assessment collecting data on the WWTPs and irrigation in the region, based on a template designed by IWMI researchers. The Baseline Assessment (BA) was supported by Lisode, a social enterprise specialized in participatory processes, and was progressively developed based on several field visits to the two sites and a stakeholder analysis exercise.

This was followed by a technical and socio-economic feasibility study developed by a local engineering company (Ecosystem) based on further technical assessments and surveys on irrigation in the region. This step was divided into a preliminary study where conceptual designs and implementation plans were discussed with stakeholders and then elaborated into detailed feasibility studies (Figure 3).

draft partnership agreements that allows the MEW to delegate several management tasks to municipalities. Those were not accepted by the MEW but the concept of delegation is not completely dismissed (Interview with a high-official at the MEW in November 2022).

Figure 3: General methodology for the local reuse studies



3.2 Public participation and co-design

3.2.1 Selection of the pilot sites

Stakeholders' participation was an essential component of ReWater MENA. Participatory processes were designed and facilitated by professionals in participation, using concepts rooted in the academic literature on public participation and tools demonstrated to foster inclusive project and policy designs (Dionnet et al. 2017) and more harmonious governance of reuse projects (Nassif and Tawfik, 2022). Representatives from the different public administrations with mandates in wastewater treatment management and agriculture were met several times in the inception phase of ReWater to develop the project's program. Some municipalities, private companies, and development agencies were also consulted.

3.2.1.1 The National Steering Committee

A National Steering Committee (NSC) (Annex 1) was formed in the beginning of the project and validated the different project activities, including the proposed design of two reuse systems. Eight sites, located in different Lebanese regions, were proposed by the project based on preliminary interviews and site visits and according to criteria of performance, proximity to agricultural areas, needs for additional water resources and social acceptance of reuse. In May 2019, each member of the NSC voted for two sites: Joub Jannine and Tyr (West-Bekaa, and Southern coastal area) but these two sites were later substituted after the Litani River Authority (LRA) changed its opinion. The Litani River Authority (LRA) changed its opinion and expressed its distrust in the performance of these two WWTPs and was reluctant to discuss a potential (partial) substitution of freshwater with treated effluents in the public schemes it manages (Canal 900 and Qasmieh Ras-El-Ain)[7]. The LRA later withdrew its participation to the project's meetings.

Zahleh and Ablah WWTPs were then adopted as the final pilot sites since they came as third and fourth choice of the NSC. They were also considered by ReWater MENA as useful pilots to comparatively analyze the two main governance models for collective wastewater treatment in Lebanon (State/Community-based). Opting for Zahleh and Ablah also allowed to diversify criteria of treatment capacity (respectively 25,000 m3/ day and 2500 m3/day), treatment technology (aerated sludge v/s trickling filters), existing irrigation sources (river-based v/s groundwater), modality of irrigation governance (collective/individual) and types of dominant crops (vegetables /fruit trees).

3.2.2 Stakeholders' participation in the study

In both Zahleh and Ablah sites, governmental and community stakeholders played an active role in designing both the system's technical layout and the way it would be managed and financially sustained. The Stakeholder Analysis supported by LISODE allowed to design a plan for stakeholder engagement throughout the process. In Ablah, the Municipality, as the direct administration managing the WWTP and reuse system closely followed the studies from the onset. The Bekaa Water Establishment (BWE) responsible according to the Law 221 for wastewater management was kept informed about the study and gave its consent on the final plans (see Sections 2.3.2 and 5 for more information on the governance framework).

In Ablah, Mr. Robert Semaan (President of Municipality) provided different information on Ablah's economy, agriculture, water and wastewater management and nominated the WWTP's operator Eng. Mohamed Boudaya to support the study. From 2019 to 2021, Mohamed Boudaya helped in further developing the study and liaising with farmers and community representatives. He provided the project with all technical information concerning both the WWTP and the existing reuse system. He facilitated technical assessments of the existing infrastructure, provided his technical advice on the network geographic extension and dimensioning, and gave insights on the modalities of future management. As a resident of Central Bekaa and having been involved in the design and management of both WWTP and reuse system, he also gave precious information on agricultural practices and social dynamics in the community.

Several farmers were consulted at the Baseline Assessment Stage (Step 2) and five farmers as part of the detailed survey (Step 3). In September 2021, the results of the Pre-feasibility study were presented to Ablah municipality and a group of farmers and residents (Table 2, Figure 4). The meeting allowed to validate the proposed extension of the system, and data adopted for both the system's design (e.g., irrigation requirements) and socio-economic feasibility study (e.g., production costs). The meeting was also an occasion to discuss aspects of the governance plan (Step 4).

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[7] The Litani River Authority (LRA) changed its opinion and expressed its distrust in the performance of these two WWTPs and was reluctant to discuss a potential (partial) substitution of freshwater with treated effluents in the public schemes it manages (Canal 900 and Qasmieh Ras-El-Ain). See Eid-Sabbagh et al. (2022) for more details on this case.

Table 2: List of participants to Ablah participatory meeting in September 2021

	Name	Position/Instituion
1	Robert Semaan	Mayor of Ablah Municipality
2	Youssef Jabbour	Mokhtar (town representative) and farmer
3	Alphone Abou Chehab	Farmer
4	Georges Semaan	Farmer and Physician
5	Robert Semaan	Farmer
6	Rizk Mehanna	Farmer
7	Georges Anis Semaan	Farmer
8	Mohamed Boudaya	Chief operator of WWTP
9	Marie-Helene Nassif	Coordinator of ReWater MENA in Lebanon
10	Antoine Slim	Ecosystem SARL

Figure 4: Final consultation workshop in Ablah, September 2021

Credit: Tony Slim

3.3 Hydraulic Design

The technical design of the rehabilitation and extension plan of Ablah reuse system was developed with the support of a Lebanese consultancy firm, ECOSYSTEM S.A.R.L. specialized in irrigation system design. Ecosystem and IWMI team performed several visits to the WWTP and collected records on treatment volumes and quality. Ecosystem performed full walk-through surveys on the existing irrigation system in collaboration with the operator. As a result of these surveys, an assessment of the technical status of Ablah's system was developed and a rehabilitation and extension plan were proposed. When studying the extension, priority was given to the plots located nearest the WWTP.

3.4 Socio-economic Feasibility and ESIA

3.4.1 Survey with farmers

A survey was conducted in 2021 with the objective to collect most data needed for the socio-economic feasibility study and the EISA. The survey was conducted with farmers already benefiting from the reuse system and potential new ones. It included qualitative and quantitative data on current livelihoods, agricultural practices, and willingness to use and pay for the treated effluent. The questionnaire was developed by IWMI researchers in collaboration with Ecosystem and Ablah WWTP's operator. It included questions needed for the cost-benefit assessment (CBA) and the Environmental and Social Impact Assessment (EISA). The survey also aimed to assess farmers' concerns about the impacts of treated effluents on their crops, soil and personal health. It included gender questions analyzed in ReWater MENA gender reports. The survey template is provided in Annex 3 and results are presented in Annex 5.

3.4.2 Cost-Benefit Assessment

The socio-economic feasibility study is based on the application of the cost-benefit theory and tools to the different options for a given intervention. The cost-benefit theory calls for the adoption of an option only if it satisfies certain investment criteria as detailed here below.

- Components of the discounted techniques of Cost- Benefit Analysis include:
  - ***Costs***
    The investment costs include estimates of construction of civil works, electro-mechanical works (pumping stations), pipes, turnouts, storage reservoirs and connecting pipes. With respect to recurrent costs, they include operation and maintenance. The maintenance costs are estimated at 3% of the investment cost per year for the pumping system, and at 0.5% for the storage and pipes. When calculating operation costs the labor cost of technician's support and pumping energy costs have been considered, with a pumping energy consumption for each type of suggested pumps during the proposed operation period (kWh for x month). These values were adopted by Declercq et al. (2020) for a similar reuse project in France: The average price of kWh was taken as 0.30$ referring to the price collected by small private generators in Lebanon in Summer 2021[8].
  - ***Benefits***

[8] Lebanon is facing an electricity crisis and currently relies on small generators for the provision of electricity and the situation is unlikely to change soon. This number represents the cost of Khw in 2021.

With respect to incremental benefits, farm gate prices for all crops and fertilizers are based on the results of the field survey and discussion with agriculture engineers experienced in fertilizations needs and practices in the Bekaa.

- ***Interest Rate (Discounted Rate)***
  Interest Rate: also called the discounted rate. It is the interest rate used to find present and future values, often equal to the opportunity cost of capital. It was taken as 10%.
- ***Life span of the project***
  The life span of the Project was taken as 15 years.

- The major criterion of the CBA used is the **Net Present Value (NPV)**. The NPV reduces a steam of costs and benefits to a single number in which costs or benefits projected to occur in the future are discounted. This implies that both incremental benefits and costs of the project should be discounted at the appropriate cost of capital in order to calculate the net percent value. In other words:

$$NPV = \Sigma \, discounted \; benefits - \Sigma \, discounted \; costs$$

A project is considered feasible if the NPV is greater than zero NPV ≥ 0. Project with highest NPV is best.

- The **Benefit-Cost Ratio (BCR)** was also calculated. The BCR is normally defined in terms of discounted values. It is calculated using the following equation:

$$BCR = \Sigma \, discounted \; benefits / \Sigma \, discounted \; costs$$

Project with highest BCR is best. BCR ≥ 1 is accepted

3.4.3 Project Boundaries Identification

The Project boundaries identification serves as an efficient tool for making decisions on the feasibility content of project work. For Ablah WWTP, the boundary adopted for the CBA is the command area of the reuse project including the proposed hydraulic extension. Potential impacts on the River Basin's environment and downstream users were only considered in the Environmental and Social Impact Assessment (EISA).

3.4.4 Environmental and Social Impact Assessment

Valuing the environmental and social impacts of a project raises complex and controversial issues. The environment is of value to the actual users, to potential users, and to those who do not use it but consider its existence to have an intrinsic value (perhaps to their "quality of life"). Clearly it is difficult to quantify such values. Nevertheless, attempts were made to semi quantify the environmental and social impacts of the proposed intervention. The parameters that were semi-quantified are listed in Table 3.

Table 3: Parameters used for the Environmental and Social Impact Assessment

Environmental parameters	**Social parameters**

• Impact on groundwater use/water conservation. • Impact on energy consumption. • Impact on pollution • Environmental risks in case of system breakdown	• Aesthetic and touristic impact • Impact on rural life and agriculture stability • Creation of job opportunities • Impact on social cohesion. • Health risks in case of system breakdown

The proposed intervention was assessed for its environmental and social impacts (such as magnitude, significance, acceptability, reversibility and severity) and then finally weighted on a scale that ranges from “Strongly Positive” to “Strongly Negative” where:

- 2P means Strongly Positive
- P means Positive
- 0 means Neutral
- N means Negative
- 2N means Strongly Negative

4 PROPOSED REUSE SYSTEM

4.1 HYDRAULIC DESIGN

Currently, part of the treated wastewater effluent from Ablah WWTP is being discharged into the Litani river and pumped by two neighboring farmers to irrigate their plots. The exact area currently supplied from the treated wastewater is around 1.4 ha.

IWMI’s ‘Analysis of Water Reuse Potential for Irrigation in Lebanon’ estimated the actual reuse potential area from Ablah WWTP at 28.6 ha based on an average of 1,200 -1,500 CM/day of treated wastewater (Eid-Sabbagh et al. 2022).The area was calculated by dividing the volumes produced by the WWTPs by an average gross irrigation requirement of the agricultural land cover within its command area. The irrigation efficiency was estimated at 55%.

However, as per Ablah WWTP operator, during the peak demand (July and August), the flow of the influent is ranging between 1,400 and 1,500 CM/day. Based on the actual cropping pattern, the area that can be irrigated exclusively from Ablah WWTP during peak demand is around 25 ha. The efficiency adopted in the current study is 75%.

The proposed irrigation zoning schedule shall be as per the table provided in Annex 5 and as shown in the drawings in Annex 6. The current 24 plots (22 formerly connected to the ICU network and two potential new ones) have a total area of 12.7 ha. The design accounts for 25 ha, consequently, there is still a potential to connect additional farms with a total area of 12.3 ha. It should be required that the farmers connecting to the treated wastewater have a drip irrigation system.

4.1.1 Rehabilitation works

Prior to any extensions works, the following rehabilitation works were found to be needed:

- Refurbishment of the two irrigation pumps and existing filters and reassembling of the latter filers of as per the standard engineering practices.
- A new booster set of 2 pumps and filtration station (70 CM/h each at 75m head) should be procured and installed to cover all the plots that can potentially be irrigated from the WWTP.
- The pump room should be replaced by a larger room (60 SM in surface).

4.1.2 Extension works

- A new pipeline (ranging from 125 to 160mm in diameter should be installed to cover the proposed extended area.
- A new pipeline (ranging from 125 to 160mm in diameter should be installed to cover the proposed extended area.
- A total length of 200 m of the existing main line should be replaced by a new one larger in size (160mm in diameter). The rest of the main line should be tested and rehabilitated as necessary.
- All existing main valves and manholes should be removed.
- New isolating main valves should be installed inside new manholes for the good operation of the network.
- At least 24 new FTO valves should be procured and installed.

4.2 Socio-economic feasibility

4.2.1 Investment costs

The investment cost for infrastructure works is estimated at 500,00 USD including the rehabilitation of the existing system (collection reservoir, pumps, distribution network and filtering station) and its extension. Details are provided in Table 4 below.

Table 4: CAPEX for rehabilitation and extension of water reuse from Ablah WWTP

Item description	**Unit**	**Cost in USD**

Trench Excavation and pipe supply, laying and testing. Re-instalment of asphalt paving, construction of reinforced manholes (around 14), supply and installation of gate valves, air release valve, installation of farmers' turnouts works 3,500 m of 160 mm OD HDPE pipe 1,000 m of 125 mm OD HDPE pipe 1,600 m of 110 mm OD HDPE pipe 50 m of 90 mm OD HDPE pipe 500 m of 63 mm OD HDPE pipe	Lump Sum	270,000
Civil and Electromechanical Works for Lifting, Pumping and Filtration Stations	Lump Sum	90,000
Retaining Wall (Length 80m, Height between 3m and 6m)	Lump Sum	97,000
Supply and installation of Geo-membrane (2mm thickness - average area 4.600 m^2)		43,000
TOTAL Cost excluding VAT		500,000

4.2.2 Economic Feasibility

The yearly operation and maintenance cost estimate for Ablah treated wastewater is 53,278 USD. The nominal volume of treated wastewater from Ablah WWTP being 1,500 CM/day over the irrigation period of 120 days, the O&M cost is 0.3 USD/CM of water. The NPV is negative and amounts for 1.80 Million US$ and the BCR is above 1 and amounts to 3.25. The analysis shows that the project is feasible at a discount rate of 10%. The adopted parameters are provided in Table 5 and the detailed results of the CBA results in Annex 8.

Table 5: Main parameters used in the financial analysis of Ablah Water Reuse Project

Investment Costs	500,000	US$
O&M Costs	53,278	US$/year
Discount Rate	10%	
Increase in yield	0.9	t/du Production will increase from 2.1 t/du to 3 t/du
Price of crop	1500	$/ton as per the survey
Cost of fertilizers	137	$/du as provided in the survey
Saving in fertilizers	26%	Remarkable input of nutrients from Ablah TSE
Area potentially irrigated	250	du

4.2.3 Environmental and social impacts

The study shows that the proposed intervention in Ablah would has the following advantages:

1. It is socially acceptable by the farmers of Ablah. The survey's results as well as the focus groups showed that farmers are all eager to have an alternative water source to their wells as yields are decreasing and the cost of energy is increasing (refer to results of questionnaires)
2. It would have a positive impact on livelihoods by means of increased productivity. Nutrients embedded in the treated water would allow a 42% increase in production while reducing fertilization input by 26% (refer to Table 5)

It also presents serious challenges:

1. The O&M cost is high (around 54,000 USD/yearly) since operation is highly energy consumptive with the water being pumped three times (from chlorination channel, from tank at the WWTP and from lake). This makes cost-recovery challenging (see section 5.5).
2. Transitioning to collective use will be challenging as farmers are used to be autonomous when irrigating from their wells. The distribution of water should be organized to ensure a fair allocation of water in accordance with the cultivated area. This will require forming a farmers committee and setting rules for the system's operation and maintenance and cost-recovery (see Section 5.4).
3. While the impact of the reuse system would be positive for Ablah farmers, it can be negative on downstream users and the environment. Reusing water in Ablah will reduce the ratio of clean water in the polluted Litani (and further in Qaraoun Lake) and the volume of available water for farmers pumping from the river downstream without alternatives for freshwater use (see Nassif 2016).

The main environmental and social Impacts of the rehabilitation of Ablah water reuse project are provided in Table 6 below.

Table 6: Assessment of the Environmental and Social Impacts of the rehabilitation of Ablah water reuse project

Impact	Assessment of Impact
Environmental	
Water conservation due to reduction of groundwater extraction	P
Energy consumption due to the operation of pumps	2N
Environmental impact on the Litani	2N
Social	
Aesthetic and touristic impact	0
Potential reuse of agricultural lands and income generation for users	P
Sustainability of agriculture and rural life	P
Challenge of transition from individual to collective irrigation	N

5 GOVERNANCE AND COST-RECOVERY PLANNING AND RISKS

Before investing in any new reuse system, it is crucial to have an elaborate governance and cost-recovery plan designed and negotiated with the different stakeholders. For this it is important to consider both the official regulatory framework and the socially embedded arrangements (Cleaver 2002; Nassif and Tawfik., 2022). In Lebanon, while the discussion of water and wastewater governance is often centered on central-state administrations, community-based institutions and private arrangements have long had a primordial role in managing irrigation schemes (Nassif 2019), drinking water systems (Allès 2019) and sanitation services (Machayekhi et al. 2014; Eid-Sabbagh et al. 2022). Ablah is a good example of a town where both wastewater management and irrigation are self-governed, with limited involvement of state administrations.

The following sections provide an overview of the legal framework organizing water and wastewater management in Lebanon and elaborates on the role of municipalities and irrigation committees in both wastewater and irrigation governance. A more detailed overview can be found in ReWater MENA's national report as well as a detailed analysis of the governance barriers of wastewater management and reuse within the political economy context of the country (Eid-Sabbagh et al. 2022).

5.1 STATE ADMINISTRATIONS

The formal governance of the water and wastewater sector in Lebanon is organized by Law 221/2000 and the Water Code (2018)[9]. Based on these legal texts, **the Ministry of Energy and Water (MEW)** is on the top of the hierarchy. It is responsible for policies and planning with regards to sanitation and water management in the country, including drinking water and irrigation. It is also responsible for the qualitative and quantitative protection of freshwater and groundwater resources. In coordination with the MEW, the **Council of Development and Reconstruction (CDR)** is also responsible for planning and executing water and wastewater infrastructure financed by international funds. The CDR has been directly in charge of executing most large hydraulic and sanitation works since the 1990s (Eid-Sabbagh et al. 2022).

Under the MEW, four **Regional Water Establishments (RWEs)** created by Law 221/2000 are tasked with planning, executing, and operating drinking water, sanitation and irrigation systems, in each of the following regions: Bekaa, Beirut and Mount-Lebanon, South-Lebanon, and North-Lebanon. RWEs are supposed to recover the costs of operation through levying fees from residential units. Under the oversight of the MEW, **the Litani River Authority (LRA)** is in charge of developing and managing irrigation systems on a part of the Litani Basin. It also has responsibilities in monitoring freshwater flows on national scale, and groundwater levels on the Litani River Basin. The (LRA) has also competencies in qualitative water monitoring on parts of the Litani River Basin (Nassif 2019).

[9] The water code was established by Law 77 on 13/4/ 2018 and modified by Law 192 on 16/10/2020.

The **Ministry of Environment (MoE)** is responsible for setting environmental laws and regulations including water pollution. It is also officially in charge of enforcing environmental regulations through an affiliated 'Environmental Police' within the Ministry. This executive body was recently institutionalized as part of the MoE's organigram but was not enacted on the ground.

The **Ministry of Agriculture (MoA)** is responsible for planning small-scale irrigation systems and providing extension services to farmers for on-farm agricultural and irrigation practices. The **Lebanese Agricultural Research Institute (LARI)** acting under the MoA is responsible for developing research to support agricultural and irrigation development. LARI has water and soil testing labs in different regions in Lebanon including in central Bekaa in Tel Amara, close to Ablah WWTP.

The **Lebanese Standards Institution (known as LIBNOR)** acting under the Ministry of Industry is responsible for developing national standards to regulate products' quality, methods of testing and other processes related to private businesses and public administrations. LIBNOR has been recently leading the development of official standards for water reuse in collaboration with the other Ministries, the RWES, LARI and other stakeholders. ReWater MENA has been supporting this process.

5.2 COMMUNITY-BASED INSTITUTIONS

Municipalities are public institutions elected at town level and manage a number of public services. Their mandate is organized by Law 118 of 1977 that grants them (among others) the authority to implement water and wastewater projects. In 2000, the implementation of Law 221 reduced the agency of municipalities over water and wastewater governance by tasking RWEs to manage drinking water, wastewater, and irrigation services. But in practice, many municipalities still govern their water and wastewater systems. This happens due to the weak administrative capacity of the state to take over and operate infrastructure (see below), and/or the reluctance of municipalities to give away their water rights over local sources and infrastructure for distrust in state-managed water services and power contestation by local elites (Allès, 2019; Nassif, 2019).

Nevertheless, although priority over planning and funding lies at the central level, municipalities still detain legal responsibility in water and wastewater governance. Law 347/2001, amending the reform Law 221/2000, states that the latter does not in any way diminish the responsibilities and competencies of the municipalities as enshrined in the municipal law and the law on municipal taxes. They retain their responsibility (as enshrined in Law 118) to manage wastewater networks within municipal boundaries. Within their mandate also lies the protection of public health. This has been interpreted as a legal permission to manage wastewater treatment (Machayekhi et al. 2014).

Municipalities receive a relatively small amount of funds from the central government[10] and levy a local residential tax related to the rental value of properties as well as the maintenance of sidewalks and sewer networks. For a municipality with a medium population size (like Ablah), such funds allow to operate and

[10] Municipalities (and Union of Municipalities) receive support from the 'Independent Municipal Fund' which is a form of central government funding mechanism using taxes and fees on telecommunications and electricity. It is managed by the Ministry of Finance. Funds received by Municipalities depend on the size of the local population.

maintain infrastructure but are not sufficient to pay for capital costs for which they usually rely on external donors' money (Telvizian and Aoun, 2021).

Unions (or Federations) of Municipalities are public institutions that group several municipalities to allow them to undertake projects that exceed the financial possibilities of municipality. They can be in the form of major urban works, firefighting, slaughterhouse management, waste management, sanitation, sewerage systems development, road safety etc. Ablah is member of the Federation of Zahleh Union of Municipalities (localiban.org).

Irrigation committees in Lebanon are local institutions through which a group of farmers manage a collective irrigation system. They are found around spring-based systems, where landowners have 'water rights' linked to land ownership[11]. Irrigation committees do not have a sophisticated organizational framework. Their functioning depends on customary rules with some influence by Ottoman law and they operate under the supervision of the respective municipality. In the Bekaa region, farmers elect yearly 'water distributors', in Arabic 'Shawwa', that are approved by the Municipality and the Mohafez. Their role is to manage water within a branch of the collective system. Shawwa organize water turns, operate the gates, and manage canal's maintenance works. They collect irrigation fees from farmers (based on the irrigated area) and are compensated a percentage of this fee.

A **Water Users Association (WUA)** is as an institutionalized for community irrigation governance promoted worldwide in the last 30 years to transfer the operation of state-built irrigation systems at farmers' level (Vermilion, 1997; Ghazouani et al. 2012). In Lebanon, a legal framework for WUAs was envisioned in 2012[12] and the main concepts adopted in the Water Code (2018). However, no WUAs are legally established in Lebanon. Furthermore, different attempts to form farmers' associations in a state-based irrigation system (Canal 900, South-Bekaa) proved unsuccessful due to technical deficiencies within the system, reluctance of the irrigation administration (the LRA) to delegate tasks, and failure to integrate existing social arrangements (Nassif 2019).

5.3 CRISIS IMPACT AND STRUCTURAL DEFICIENCIES

5.3.1 Crisis impact on the water sector administration and Ablah Municipality

The financial crisis in Lebanon (starting 2019) had serious repercussions on the functioning on the water sector administration and its capacity to provide public water and wastewater services (MEW 2022). In

[11] These water rights (to surface water) were recorded on property titles under land reforms conducted by the French Mandate around the 1920's and represent water use in that period. They were shaped by socio-economic factors and political power of that historical period (Ghiotti and Riachi, 2013; Nassif, 2019).

[12] Within the 'Hydro agricultural project for Marjeyoun area', a UNDP project in partnership with the LRA and AFIAL association. The aim of the project was to develop detailed feasibility studies for one of the sub-areas of the Canal 800 irrigation system planned as part of the Litani Project in South Lebanon and establish Water Users Association to manage the future systems.

summer 2021, UNICEF warned that Lebanon's water supply system is 'on the verge of collapse' (UNICEF 2021), and the situation has worsened today with no reforms envisioned and the weakening government's capacity to pay for salaries and fuel. Lebanon's civil servants are leaving in droves and those who stayed are commuting to their offices one or two days a week (Salame, 2022). This includes the case of the Bekaa Water Establishment (BWE) where dozens of employees left mostly to work with NGOs where the pay is in 'fresh' dollars. The latest Director General resigned in 2021 and since then 13 out of the 17 engineers he had hired to strengthen the capacity of his administration before the crisis left as well[13].

The BWE essentially relies on NGOs funds, individual and political parties' donations to pay for infrastructure operation and sometimes salary compensations[14]. Several WWTPs managed by the establishment stopped operating (e.g. Iaat) or operate thanks to donors' funds. An illustrative case is Zahleh WWTP which operation is covered by a UNDP project since the beginning of September 2022[15]. According to the MEW, donors such as UNICEF, USAID and AFD will be supporting the operation of 30 medium to large WWTPs throughout Lebanon.

Small WWTPs such as Ablah are not considered part of this list of priority. Ablah WWTP operates only during hours of public electricity supplied by EDZ (12/24 hours)[16] and there are no funds available to operate the local generator. As an alternative, solar panels are being installed with the support of an NGO and should be connected to EDZ grid, which is expected to reduce the electricity bill. The management of Ablah WWTP is further complicated by the resignation of the municipal board in summer 2022. Municipal services continue under the supervision of the Region (Mohafaza) but are slowed down. This has a consequence on the financial compensation of staff among whom the operator of Ablah WWTP whose pay was interrupted for several months. One needs to mention that this comes as an additional burden to the reduction of his salary's value (which is still in the L.L). and his lack of access to the 'social allocation' disbursed by the government to public employees.

In May 2022, the Ministry of Energy and Water issued a 'Road Map to Recovery of the Water Sector' with the support of the Agence Française de Développement (AFD) but the plan has not yet been officially approved (MEW 2022). With no financial recovery plan for Lebanon and no government formed since the latest parliamentary elections (May 2022), it is not clear whether this plan would be implemented and if one could expect a close recovery of the state apparatus.

5.3.2 Structural deficiencies of the water sector

[13] Most of them were hired under a non-permanent status and do not benefit from the 'social allocated' allocated provided to permanent employees. Information provided from an official in the BWE interviewed in November 2022.

[14] According to the same informant, local stations in Zahleh provided fuel for free for technicians operating water networks. The initiative was taken by a dynamic department director asking fuel stations' owners from the community to support 'those who are providing water'. In the Northern part of the BWE's territory, where most residents are from Hezbollah constituents, the party is paying for the operation of wells. Interviewed in November 2022.

[15] Information provided by a high-level official interviewed at the Ministry of Energy and Water in November 2022.

[16] Field visit to Ablah in November 2022.

It should be highlighted that the governance problems of the water sector do not result from the crisis. Long before the financial collapse, the different public administrations struggled to implement their legal mandates. The four Regional Water Establishments (RWEs) supposed to take over drinking water, sanitation and irrigation services were only operating a part of drinking water networks (MEW 2020). Irrigation was largely community-managed except for some schemes managed by the LRA on the LRB (Nassif 2019). Furthermore, among the 104 WWTPs implemented, only 10 were managed by the RWEs and 5 are well operational. The rest is still managed by the CDR, and many are governed by municipalities (Eid-Sabbagh et al. 2022).

The incapacity of RWEs to operate infrastructure essentially lies in their incapacity to recover costs of O&M from residential units as per the model imagined by the reform (MEW 2020). They are poorly staffed, have weak political power to levy fees, and subject to interference from the various political fractions (Eid-Sabbagh, 2015; Allès, 2019; Nassif, 2019; Eid-Sabbagh et al. 2022). Amongst the four RWEs, the Bekaa Water Establishment (related to our case study) has the weakest cost-recovery rate (around 30% in 2020 according to the Update of the National Sector Strategy (MEW 2020)). The crisis has further impacted its capacity to levy fees, with an estimated reduction of 25% in 2020 (Eid-Sabbagh et al. 2022). Today, the BWE functions without a Director General, and employees struggle on daily basis to operate infrastructure.

In addition to issues of infrastructure operation, the governance of wastewater management in the country suffers from fragmented planning, and weak monitoring of treatment processes and treated effluent's quality. As detailed and illustrated in ReWater's national study, planning has long been fragmented and mostly managed by the CDR with weak coordination with the MEW and little involvement of RWEs and municipalities. On the other hand, many small scale WWTPs were implemented in partnership with municipalities and no involvement of the central government (Eid-Sabbagh, 2022).

Monitoring water quality is also a shared responsibility between different administrations, namely the MEW, the MoE, and the RWEs (see Annex 4). However, neither of the two ministries have the executive power and administrative capacity to do so. At present, water sampling and testing differs from case to case depending on depending on the available resources which largely depend on donor funds and technical assistance. In recent years, the four RWEs were equipped with water quality labs to monitor the performance of WWTPs.

5.4 GOVERNANCE PLAN

The proposed governance plan for the management of Ablah WWTP and Reuse System was developed based on the official legal framework of the water and wastewater sector (mainly Law 221 and the Water Code), current governance practices, and the consultations with the different national and local stakeholders (see 3.2). It was found that the that the governance of the system by the community was a viable option. State administrations are already struggling in ensuring the operation of state-owned infrastructure and looking to develop institutional arrangements that allow them to legally delegate service provision to municipalities.

- **The Municipality of Ablah** is the owner of the WWTP and the associated reuse irrigation system. The municipality currently manages the WWTP and agrees to supervise the operation of the reuse system. Ideally, the municipality would form a 'water users association' as per the Water Code (2018) directions and develop its organigram in discussion with farmers. It can also start with forming an irrigation committee (allowed by the municipal law). The municipality would directly operate the main infrastructure though the WWTP operator[17] and delegate the operation of the secondary branches of the network to the WUA/irrigation committee. The municipality would be responsible for the maintenance of all equipment, either directly or by engaging the WUA of farmers committee. It needs to be closely involved in developing the farmers committee, grant transparency in decision-making act as a referee in case of conflict. However, it should be reminded that the current municipal board resigned in mid-2022 which had impact on the operation of the WWTP. For several months, the WWTP operation solely depended on the responsible engineer investing on his own time without getting paid[18].

- The **Bekaa Water Establishment** as per its mandate over wastewater treatment and irrigation will ideally take the lead on coordinating between state administrations and Ablah Municipality to ensure adequate system's implementation and operation. It would partner with the Municipality of Ablah and contribute to the development of the WUA/farmers committee. In collaboration with the Ministry of Energy and Water and the Ministry of Environment, it will play the role of direct monitoring on water quality.

- **The Irrigation committee (or WUA)** would collectively set its own organigram and rules, with the help and arbitrage of the municipality. It will be responsible for distributing water within the secondary branches of the system through a 'Shawwa' that will organize water turns, collect tariff and ensure proper maintenance. The Shawwa will be appointed or elected by farmers under the supervision of the municipality. The timing of irrigation supply from the main pumping stations will be coordinated with the operator of the WWTP.

- **The Ministry of Energy and Water and the Ministry of Environment** should develop a clear water quality monitoring plan to monitor the performance of the WWTP and ensure compliance of the operator the standards. Given LARI's experience in conducting research related to water reuse and the on-going development of reuse standards, it is suggested that water testing is conducted at LARI's premises. The water quality monitoring plan will abide by the guidelines for wastewater reuse quality proposed in 2010 by the FAO (see Annex 10) and later by the official regulations under development by LIBNOR.

- **LARI and the Ministry of Agriculture** would develop and implement an extension program to guide farmers in their cropping and risk management practices.

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[17] The main pumping stations located within the WWTP, the conveyance pipe between the WWTP and the collection reservoir, the collection reservoir and the irrigation and filtration stations located near collection reservoir.

[18] Interview with Mohamed Boudaya in September 2022.

5.5 COST RECOVERY OPTIONS AND CHALLENGES

The funding and cost recovery options have not been discussed in depth in the consultation process and need to be studied with care by the project owners, potential investors, and beneficiaries. Nevertheless, this section summarizes the main costs and discusses some funding and cost-recovery options based on information collected from the survey and insights from stakeholder interviews. Results challenge the objective of covering the reuse system’s operation costs from users and generating income for operators as hoped by the municipality of Ablah and sometimes promoted by donors. They also show the necessity of setting other financing options and developing a flexible tariff tailored to the different costs farmers pay for their existing access to wells to create incentives for using the system.

5.5.1 Infrastructure financing

The hydraulic development option selected by stakeholders has an estimated capital cost of around 500,000 USD. Given the current crisis, neither Ablah Municipality or State administrations will be able to pay for such cost and will need an external investor such as an international development organization. It is not recommended however to finance any infrastructure building before setting a realistic cost-recovery mechanism as the cost of operation will only be partially recovered from farmers’ financial contribution (see below). Moreover, it is to be kept in mind that Ablah WWTP currently operates only half of the time (12/14). With the increasing devaluation of the Lebanese Pound against the Dollar, the suspension of fuel’s subsidisation by the government (in 2021), and the unclarity around the financial recovery program of the country, the municipality was reported unable to pay for the cost of generator. In November 2022, an NGO partnering with the municipality was equipping the plant with solar panels expected to supply the needed complementary energy requirement. However, a close follow up ensuring continuous energy supply is a must before any extension is made to the system.

5.5.2 Operation and maintenance financing

The cost of operation and maintenance has an estimated operation and maintenance cost of 53,278 USD/year. The total potentially irrigable area in Ablah is 250 du (25 ha). Farmers would then have to pay around 213 USD/dunum which is considerably higher than the range of individual pumping costs which, according to the survey varies from 31 USD to 83 USD/dunum depending on well depth[19]. The estimated

[19] Most wells are located on plot, which is different than the case of Zahleh where some wells were found to be located several Km away from the plots.

reduction of 26% in fertilization costs from nutrients embedded in water would ideally reduce around 35 USD from the individual production costs but it is not guaranteed that farmers would accept to pay this amount for their access to water if freshwater is accessible at the same or lower cost. One farmer reported to be willing to pay 365 USD/du/year but this unlikely to be realistic given the average cost of individual access to water.

This means that more than half of the cost of operation will need to be subsidized. This conclusion joins what has been found in other cases in MENA and worldwide, where most water reuse projects are unlikely to achieve full cost recovery and might only recover part of the operation costs (Hanjra et al. 2015; Gebrezgabher et al. 2022). Options of reducing the cost of pumping (by installing solar systems for example) are recommended to be explored (Gebrezgabher et al. 2022) but this would require additional capital investment.

More generally, the question of cost-recovery opens the topic of who can and who should pay for the cost of water supply in general and irrigation water and reuse more specifically. Many options exist (subsidies from central government based on levied income tax, taxes on big farms/commercial enterprises in the Bekaa, and others) but would be challenging to implement given the ultra-liberal policies of the Lebanese government and the neo-liberal logic of full-cost recovery from users (Eid-Sabbagh, 2015). This study is an opportunity to open the debate around these questions.

6 CONCLUSION

Taking Ablah as one of the two case studies was an opportunity to take a closer look at the community-based model of wastewater treatment and reuse governance. It was found that the Municipality of Ablah was able to sustain and monitor the operation of the (externally funded) WWTP for around ten years through local municipal funds and with limited support from State administrations such as the BWE. The reuse system implemented in 2015 by an external project with the collaboration of the Ministry of Agriculture and LARI was also operated by Ablah for two years. However, the premature interruption of the system did not allow to assess whether the community would have been able to financially sustain the operation of the system, establish satisfying allocation rules in a system where irrigation was traditionally performed on individual basis, and mitigate health and agronomic risks. The present study shows that farmers alone will not be able to cover the cost of operation and maintenance and that other financing options will need to be found. Under the current financial crisis, the Municipality of Ablah is unable to cover the energy needs of the WWTP and is unlikely to be able to support the operation of the system. Financial support from the (Lebanese) Independent Monetary Fund is barely sufficient to pay employees' salaries and far to be used as a support. In any case, when funds will be available, coordination or partnership arrangements with State administrations (such as the BWE, the Ministry of Agriculture and LARI) should be developed. Support of operator in water quality monitoring and farmers in extension services can be done with relatively low-cost.

More largely, this study case indicates the relevance of State administrations building on local institutional arrangements to anchor and legitimize their territorial action. As a matter of fact, there are ongoing discussions at the central level around the relevance of establishing partnerships between State administrations and municipalities as a solution to the governance constraints faced by State administrations. The present study case hopes to contribute to these reflections.

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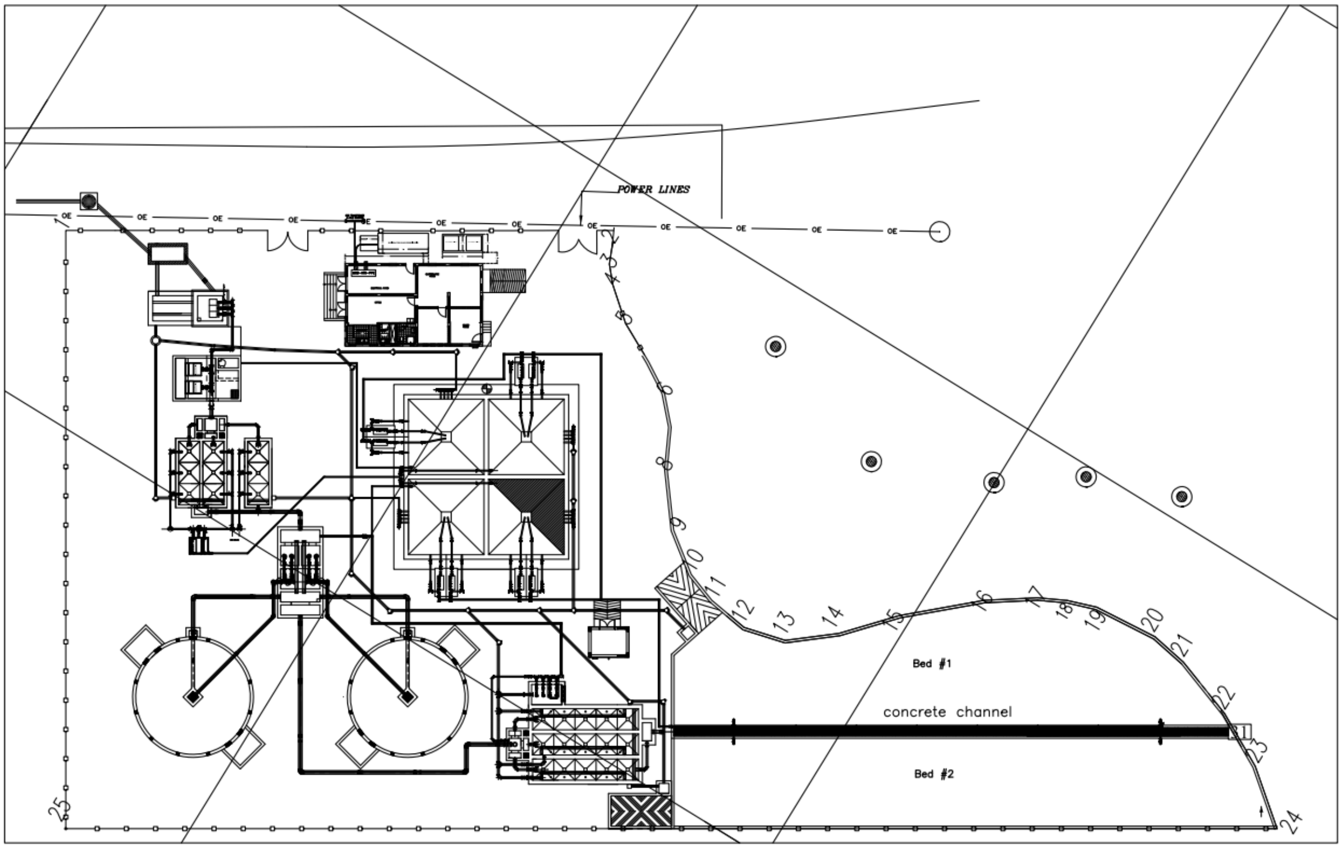
ANNEX 1: MEMBERS OF THE NSC MEETING IN MAY 2019

Institution	Name	Position
MEW	Mr. Moufid Dheini	Head of Wastewater Department
	Mr. Yasser Suleiman	Engineer in Directorate of Exploitation
	Mr. Benoît Fahed	Advisor to the Minister
MoE	Mrs. Sabine Ghosn	Head of Urban Environment and Pollution Control Department
	Mrs. Jamila El Hadi	Environmental Engineer in the same department
LRA [Note]	Mr. Nassim Abou Hamad	Head of Governance Department
CDR	Mr. Roy Yazbeck	Assisting BWE in coordinating with donors
BWE	Mr. Souheil Rouphael	Engineer working on WWTPs
BMLWE	Mr. Fady Eid	Engineer
SLWE	Mr. Maarouf Mezher	Engineer working on WWTPs
LARI	Dr. Marie-Thérèse Abi-Saab	Head of Water and Climate Unit
	Mr. Salim Fahed	Research assistant in the same department

Note: the LRA withdrew its participation from the NSC in July 2019

ANNEX 2: GENERAL LAYOUT OF ABLAH WWTP



Source: Provided by the operator of Ablah WWTP

ANNEX 3: ABLAH EXISTING AND UPDATED IRRIGATION NETWORK LAYOUT (IN A SEPARATE VOLUME)

ANNEX 4: FARMERS SURVEY TEMPLATE

Source of water: Well

GENERAL					
1	Village				
2	Name of the farmer				
3	Cadastral area and No.				
4	Agricultural area	Ha			
5	Type of irrigated crops and cultivated areas by season	Season 1		Season 2	
		Crops	Cultivated area / Ha	Crops	Cultivated area / Ha
		1:		1:	
		2:		2:	
		3:		3:	
6	Land tenure (ownership, land rental)	Own [ ] Rental [ ] Other (specify) [ ]			
7	Gender	Male [ ] Female [ ]			
PRODUCTION AND ON-FARM IRRIGATION SYSTEM					
8	Do you have any livestock? Number	Yes [ ] [ ] No [ ]			

9	Current on farm irrigation system	Surface [ ] Sprinkler [ ] Drip [ ] Other (specify) [ ]	
10	**On-farm irrigation system cost**	**LL or US$**	
11	On-farm pumping station cost (Per your project)	LL or US$	
12	On-farm annual pumping cost (Choose one of the 2 options)	LL or US$	Per Ha: Per your project:

PRODUCTION AND ON-FARM IRRIGATION SYSTEM

13	On-farm filtration station cost (Per your project)	LL or US$	
14	Annual cost of maintenance of the on-farm irrigation system (Choose one of the 2 options)	LL or US$	Per ha: Per your project:
15	Annual fertilization cost (Choose one of the 2 options)	LL or US$	<u>Crop 1:</u> Per ha: Per your project: <u>Crop 2:</u> Per ha: Per your project: <u>Crop 3:</u> Per ha:
16	Annual production quantity (Fill for each crop)	Tons	Crop 1: Crop 2: Crop 3:
17	Selling price at farm gate per ton (Fill for each crop)	LL or US$	Crop 1: Crop 2: Crop 3:

18	Annual gross return (Choose one of the 2 options)	LL or US$	Per ha: Per your project:
MAIN SOURCE OF WATER			
19	Water source	Well	
20	-		
21	Do you face any problem of water scarcity for agricultural use?	Yes [ ] No [ ]	
22	Are you satisfied with your access to water?	Yes [ ] No [ ]	
	If no, please elaborate why		
23	Well ownership	Direct / owned [ ] Indirect / collective [ ]	
24	date of well drilling		
MAIN SOURCE OF WATER			
25	Well depth (m)		
26	well yield / flow	m3/h: Inch:	
27	Well water charges (Fill for each crop, per ha or per your project)	LL or US$	Crop 1: Per ha: Per your project: Crop 2: Per ha: Per your project: Crop 3: Per ha:
28	-		

29	Pump ownership and use	Direct / owned [ ] Indirect / collective [ ]
30	Pump power/flow	HP [ ] m3/h [ ] Inch [ ]
31	Cost / cost share of the pump of the well	LL or US$
32	Annual pumping cost / cost share (Choose one of the 2 options)	LL or US$ Per Ha: Per your project:
33	-	
34	Conveyance infrastructure associated to well	
35	Do you experience a decrease in well yield in the summer and/or in years of low rainfall?	Yes [ ] No [ ]
36	When does water stop being available in the well?	
37	-	

MAIN SOURCE OF WATER

38	Does this prevent you from planting a second season crop?	Yes [ ] No [ ]
39	Does this condition your choice of crop?	Yes [ ] No [ ]

SECONDARY SOURCE OF WATER

40	Do you have a second source of water? (well). If yes answer the question related to the well	Yes [ ] No [ ]
41	Well ownership	Direct / owned [ ] Indirect / collective [

42	date of well drilling		
43	Well depth (m)		
44	well yield / flow	m3/h: Inch:	
45	Well water charges (Fill for each crop, per ha or per your project)	LL or US$	<u>Crop 1:</u> Per ha: Per your project: <u>Crop 2:</u> Per ha: Per your project: <u>Crop 3:</u> Per ha:
46	Pump ownership and use	Direct / owned [ ] Indirect / collective [ ]	
47	Pump power/flow	HP [ ] m3/h [ ] Inch [ ]	
48	Cost / cost share of the pump of the well	LL or US$	
49	Annual pumping cost / cost share (Choose one of the 2 options)	LL or US$	Per Ha: Per your project:

SECONDARY SOURCE OF WATER

50	Conveyance infrastructure associated to well		

51	In case of a shortage of water, what do you?	[ ] Reduce pumping, [ ] Lower the pump, [ ] Buy water from another well, [ ] Rent another plot in case not owner
52	Did you ever deepen the secondary well?	Yes [ ] No [ ]
53	Did you have to drill another well?	Yes [ ] No [ ]

WILLINGNESS TO USE TREATED WASTEWATER

54	Will you be willing to use treated wastewater instead of your well or as a complement to your well?	Yes [ ] No [ ]
55	Who do you think owns the treated wastewater?	
56	Will you accept that the treated effluent be conveyed in your irrigation system?	Yes [ ] No [ ]
57	Willingness to pay (WTP) for wastewater reuse	Yes [ ] No [ ]
58	If willing to pay then for what?	• Capital cost of new on-farm drip irrigation system required for the treated waste water reuse [ ] • For the volume of treated waste water reuse provided [ ]
59	How much are you willing to pay for wastewater reuse?	LL or US$ / m³
60	Are you aware of water quality and potential implication on human, animal and environmental health? If yes, please elaborate.	Yes [ ] No [ ]

WILLINGNESS TO USE TREATED WASTEWATER

61	Do you know what are the limitations of the reuse of wastewater? If yes, list the limitation on the reuse of water.	Yes [ ] No [ ]

GENDER

62	Household head structure: male-headed, female-headed, couple-headed household.	
63	Number, sex and age of all household members.	
65	What were the most important problems/ health, natural, economic or social, your household aced as far as negative impacts to your household, household members' livelihoods and/or the household's agriculture/livestock during the last 12 months were concerned?	
65	What effect, do you expect, will the new treated wastewater quantities have on the labour input of [women/men/boys/ girls/male farm worker/female farm worker]?	

ANNEX 5: FARMERS SURVEY SUMMARY RESULTS

General Information	• **The main crop cultivated in Ablah are table grapes.** • **All the interviewees own the land that they are cultivating.** • **Four interviewees were male and one interviewee was a female.**
Production and on-farm irrigation system	• None of the interviewees has livestock. • 100% of the interviewees irrigate their vine grapes by dripper. • The cost of the on-farm irrigation system (drip or sprinkler) is around 300 US$/du. 60% of the interviewees got their on-farm irrigation system as a donation from the former project (ACCBAT). • The on-farm pumping station cost ranges between 81 and 363 US$/du depending on its specifications • The on-farm annual pumping cost ranges between 67 and 147 US$/du depending on the economy of scale and the well system. • The annual cost of maintenance of on-farm irrigation system is considered negligible for 60% of the interviewees and between 10 and 12 US$/du for the others. • The annual fertilization is around 137 US$/du for grapes for 60% of the interviewees. • Average annual production of table grape is 2.1 t/du, ranging from 1.8 to 2.8 t/du. • Selling price at farm gate for table grapes is 2,000 US$/ton for 60% of the interviewees and is ranging between 730 and 2000 US$/ton for the five interviewees. • Annual gross return ranges from 380 US$ /du to 1,550 US$ / du.
Main source of water	• Currently, the main source of water in Ablah is groundwater as farmers own private wells. These wells were drilled between 1996 and 2017 with a depth ranging from 50 to 130m. The interviewees responded unanimously that this water source is scarce and that they were not satisfied with their access to water. 3 of the five interviewees pointed out that the water is not sufficient and one interviewee pointed out that the water is very calcareous. • Their annual pumping cost is around 83 US$/du. • The interviewees unanimously confirmed that they experience a decrease in the yield of the wells in the summer and in years of low rainfall. 60% of the interviewees stated that water stop being available in the wells at the beginning of August and 40% at the beginning of October.
Secondary source of water	• 40% of the interviewees have a secondary source of water (private well). These wells were drilled between 1957 and 2011 and have a depth of 15m and 90 m respectively. • The annual cost of pumping varies from 31 to 37 $ per du.

	• In case of water shortage, the interviewees buy water from another well or reduce the pumping hours.
Willingness to use treated wastewater	• 100% of the interviewees are willing to use the treated wastewater instead of their wells or as a complement to water from their wells and are willing to pay for the volume of water provided. • 100% of the interviewees stated that they think the Municipality of Ablah owns the treated wastewater. • 100% of the interviewees accept that the treated effluent is injected in their irrigation system. • 100% of the interviewees are willing to pay for volume of treated waste water provided and 40% are willing to pay the rate that will be agreed upon within the Municipality of Ablah. One interviewee is not sure, one interviewee did not answer and one interviewee is willing to pay 0.83 $/CM of treated waste water equivalent to 364 $/du /year. • 40% of the interviewees replied that they were not aware of treated water quality and potential implication on human, animal and environmental health and that they did not know the limitations of the reuse of the wastewater. 80% of the interviewees confirmed that they know the limitations of the reuse of wastewater which is according to 60% of the interviewees mainly on fruit trees .
Gender	• The majority of all interviewees are married. 20% of the interviewees said that the household is couple-headed, 40% male-headed and 40% female-headed. • 60% of the interviewees stated that the most important health problems they encountered in the last 12 months was COVID-19 Pandemic. • 100% of the interviewees are expecting an increase in their production due to the use of treated wastewater for irrigation and consequently an improvement of their financial situation and that of their families.

ANNEX 6: IRRIGATION ZONING SCHEDULE FOR ABLAH REUSE SYSTEM

No.	Status	Name of the Farmer	Plot No.	Plot Area (SM)	Net Irrigated Area (SM)	Daily Water Need (CM/day)	Irrigation Supply (CM/h)
1	Former Beneficiary	Youssef Jabbour	529-530	4,700.00	4,500.00	20.25	7.99
2		Naji Yunis	532	3,000.00	3,000.00	13.50	5.33
3		Fadi Abou Zogheib	374	7,600.00	7,600.00	34.20	13.50
HYDRO ZONE 1 (35CM/H - 1500LM)					**15,100.00**	**67.95**	**26.82**
POSSIBILITY OF EXTENSION OF HYDRO ZONE 1					**4,607.21**	**20.73**	**8.18**
4	Former Beneficiary	Bosaybes Faraj	568 + half of plot 569	8,000.00	8,000.00	36.00	14.21
5		Nabih Bosaybes	570 + half of plot 569	7,200.00	7,200.00	32.40	12.79
6	Proposed Beneficiary	Khodor Al Hasan	694 to 697	8,016.00	8,000.00	36.00	14.21
HYDRO ZONE 2 (45CM/H - 950 LM)					**23,200.00**	**104.40**	**41.20**
POSSIBILITY OF EXTENSION OF HYDRO ZONE 2					**2,137.84**	**9.62**	**3.80**
7	Former Beneficiary	Nawal Bou Zaydan	660	3,517.00	3,517.00	15.83	6.25
8		Abo Zaydan Elyas	663 to 670	7,000.00	7,000.00	31.50	12.43
9		Khalil Bousaybis	713	5,060.00	5,060.00	22.77	8.99
10	Proposed Beneficiary	Aly Al Hasan	721	6,965.00	6,900.00	31.05	12.25
HYDRO ZONE 3 (45CM/H - 950 LM)					**22,477.00**	**101.15**	**39.92**
POSSIBILITY OF EXTENSION OF HYDRO ZONE 3					**2,860.84**	**12.87**	**5.08**

No.	Status	Name of the Farmer	Plot No.	Plot Area (SM)	Net Irrigated Area (SM)	Daily Water Need (CM/day)	Irrigation Supply (CM/h)
11	Former Beneficiary	Rida Bou hamdan	474	14,343.00	5,000.00	22.50	8.88
12		Hocep Arzomaniayan	468	3,947.00	3,947.00	17.76	7.01
13		Assaf Khazzaka	592	10,000.00	10,000.00	45.00	17.76
14		Arzomaniayan Waskin	463	4,500.00	3,700.00	16.65	6.57
15		Jean Michael Bsaibes	1611	4,486.00	4,486.00	20.19	7.97
HYDRO ZONE 4 (50CM/H - 350 LM)					**27,133.00**	**122.10**	**48.19**
POSSIBILITY OF EXTENSION OF HYDRO ZONE 4					**1,020.15**	**4.59**	**1.81**
16	Former Beneficiary	May Mazraani	602, 603 & 604	9,539.00	9,500.00	42.75	16.87
17		Youssef Nicolas Semaan	607	4,500.00	4,500.00	20.25	7.99
18		Georges Louis Samaha	609	5,000.00	5,000.00	22.50	8.88
19		Abdo Semaan	624	5,000.00	1,877.00	8.45	3.33
20		Miled Geryes Bou Zaydan	614	4,500.00	4,500.00	20.25	7.99
HYDRO ZONE 5 (58CM/H - 550 LM)					**25,377.00**	**114.20**	**45.07**
POSSIBILITY OF EXTENSION OF HYDRO ZONE 5					**7,280.66**	**32.76**	**12.93**
21	Former Beneficiary	Nicolas Mhanna	454	3,200.00	3,200.00	14.40	5.68
22		Mhanna Rizk	1649	2,650.00	2,650.00	11.93	4.71
23		Michel Chakar	581	3,656.00	2,600.00	11.70	4.62

No.	Status	Name of the Farmer	Plot No.	Plot Area (SM)	Net Irrigated Area (SM)	Daily Water Need (CM/day)	Irrigation Supply (CM/h)
24		Toni Dib Skaff	739	10,000.00	5,000.00	22.50	8.88
HYDRO ZONE 6 (30CM/H - 900 LM)					**13,450.00**	**60.53**	**23.89**
POSSIBILITY OF EXTENSION OF HYDRO ZONE 6					**3,441.89**	**15.49**	**6.11**
TOTAL					**126,737.00**	**570.32**	

ANNEX 7: ABLAH EXISTING AND UPDATED IRRIGATION NETWORK LAYOUT (IN A SEPARATE VOLUME)

ANNEX 8: NPV AND BCR FOR ABLAH WATER REUSE PROJECT

Year	WWTP Operator		Farmers in Ablah		Discount Rate (10%)	Total Dicounted Costs ($)	Total Discounted Benefits ($)	NPV ($)
	Total Costs (a)($)	Total Revenues (b) ($)	Total Costs ($)	Total Benefits (c) ($)				
1	500,000		-	346,463	0.90909	454,545	314,967	(139,579)
2	53,278		-	346,463	0.82645	44,031	286,333	242,302
3	53,278		-	346,463	0.75131	40,029	260,303	220,274
4	53,278		-	346,463	0.68301	36,390	236,639	200,249
5	53,278		-	346,463	0.62092	33,081	215,126	182,045
6	53,278		-	346,463	0.56447	30,074	195,569	165,495
7	53,278		-	346,463	0.51316	27,340	177,790	150,450
8	53,278		-	346,463	0.46651	24,855	161,628	136,773
9	53,278		-	346,463	0.42410	22,595	146,934	124,339
10	53,278		-	346,463	0.38554	20,541	133,577	113,036
11	53,278		-	346,463	0.35049	18,674	121,433	102,760
12	53,278		-	346,463	0.31863	16,976	110,394	93,418
13	53,278		-	346,463	0.28966	15,433	100,358	84,925
14	53,278		-	346,463	0.26333	14,030	91,235	77,205
15	53,278		-	346,463	0.23939	12,754	82,941	70,186
		-				**811,348**	**2,635,227**	**1,823,879**

Total volume of water produced by WWTP over the whole irrigation season = 1,500 CM/day x 4 months' x 30 days

(a) The investment costs are estimated at 500,000 US$ during the first year. The yearly O&M cost is estimated at 53,278 US$

(b) The revenue of the operator will be generated from the water fees collected

(c) Total revenues include the revenues generated from the increase in yield in season 1 estimated at 337,500 US$/year and savings in fertilizers estimated at 8,963US$/year based on 26% saving over the total budget of 137 $/du used on 250 du

ANNEX 9: ADMINISTRATIVE OVERLAPS IN THE WATER AND WASTEWATER SECTOR

Role	CDR	MoEW	MoF	MoE	MoA (irrigation)	MoPH (drinking water)	Municipalities	WE	WB	Donors	NGOs	Research	Media	Water Users
Funding	X		X					Cost recovery?	X	X				
Policy & Strategy	X Master Plan	X National		X	X	X		X Regional	X	X		X		
Planning	X	X			X			X	X	X		X		
Contracting/ Constructing	X	X			X		X	X	X	X	X			
Development & Implementation	X	X					X	X		X	X			
Operation & Maintenance	X						X	X		X				
Tariff/ Tax Collection			X				X	X Propose tariffs						X
Legislation, rules and regulation		X		X	X	X					X Lobby	X		
Services & interactions with water users		X		X	X		X			X	X		X	X
Monitoring & Evaluation		X		X	X	X		X		X	X	X		

Source: Machayekhi et al. 2014.

ANNEX 10: FAO PROPOSED GUIDELINES FOR WASTEWATER REUSE IN AGRICULTURE

Class	I	II	III
Restrictions	Produce eaten cooked; irrigation of greens with public access	Fruit trees, irrigation of greens and with limited public access; impoundments with no public water contact	Cereals, oil plants, fiber and seed crops, canned crops, industrial crops, fruit trees (no sprinkler irrigation), nurseries, greens and wooden areas without public access
Proposed treatment	Secondary + filtration + disinfection	Secondary + storage or maturation ponds or infiltration percolation	Secondary + storage/oxidation ponds
BOD5 (mg/L)	25	100	100
COD (mg/L)	125	250	250
TSS (mg/L)	60 (200 WSP)	200	200
pH	6- 9	6 - 9	6 - 9
Residual Cl2 (mg/L)	0.5 - 2	0.5	0.5
NO3-N (mg/L)	30	30	30
FC(/100ml)	<200	<1000	None required
Helminth eggs (/1L)	<1	<1	<1

Source: FAO, 2010.

Note: Irrigation of vegetables eaten raw is not allowed