Food and Agriculture
Organization of the
United Nations

Assessment of treated wastewater for agriculture in Lebanon

Final report

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1. Introduction

WATER AND AGRICULTURE

Lebanon has an area of 10 452 km^2 and ample water resources. Average annual rainfall in Lebanon is estimated between 600 and 900 mm along the coastal area, to 1 400 mm on the high mountains, and decreasing to 400 mm inland, with a minimum of 240 mm in the north of the Bekaa valley. Because of its topography Lebanon has limited arable land, but diverse agricultural and livestock production systems exist, which are well adapted to the variability of the agro-ecological zones.

According to the latest Agricultural Production Survey, between 2008 and 2009, the total cultivated area was 251 600 ha (Ministry of Agriculture 2010). In the last ten years, the cultivated area has increased by around 5 percent, with more than a 23 percent increase of irrigated agriculture.

The results of the agriculture census conducted in 2010 (Ministry of Agriculture 2010/2011) showed that almost 70 percent of total farm holders (169 512 farmers) have less than 1 ha, and cultivate less than 20 percent of the total Used Agriculture Area (UAA) which accounts to 231 000 ha. Around 3 100 farmers have holdings of more than 10 ha (1.8 percent) and cultivate around a third of the UAA. The average holding size is around
1.36 ha. The fragmentation of the small-size agricultural holdings does not allow economies of scale for production and marketing. The main agricultural products are citrus fruits, grapes, tomatoes, apples, vegetables, potatoes, olives, tobacco, poultry, cattle, sheep and goats. The Bekaa valley is the main agricultural region that produces wheat and most of the cultivated crops in Lebanon. The coastal zone supports intensive production of citrus, fruits, bananas and vegetables. Lebanon exports fruit and vegetables, is self-sufficient in poultry and produces part of the needed pulses, wheat and sugar.

The main sources of water for irrigation are the Litani River along the Bekaa valley and the Awali River in the south of the country. Lebanon is already using three quarters of its available water resources and the demand is still rising. The irrigated areas within the agriculture holdings represent almost half of the total UAA and according to the agriculture census 2010, it is estimated that almost half of the area within the agriculture holdings is irrigated with surface water, and the other half with groundwater (deep wells, recharge wells and springs).

As for the irrigation techniques, almost half of the irrigated areas within the agricultural holdings are irrigated by gravity whereas the remaining half is split equally between modern sprinkler and drip irrigation technology. The main irrigated crops are cereals, mainly wheat, citrus, potatoes and vegetables.

The irrigation potential, based on soil and water resources, is estimated at 177 500 ha. The irrigated area is estimated at 90 000 ha but is expected to increase to 150 000 ha by 2035 (National Investment Profile for Lebanon, 2010).

So far, the water sector does not have a national policy for Integrated Water Resources Management and delivers poor services at high costs (Water for Agriculture and Energy). Water sector inefficiencies are costing almost 3 percent of the annual GDP and the country will face chronic year round shortages by 2020 (National Strategy for the Wastewater Sector, 2012). Lebanon has public irrigation schemes composed of five large-scale schemes (> 1 000 ha), 62 medium-scale (100–1 000 ha) and small-scale (< 100 ha) schemes (Ministry of Energy and Water). Only two schemes use pressurized irrigation systems while the others use open canals for conveyance of water and surface irrigation technologies. The average size of irrigated plots for public irrigation schemes is 1.8 ha. Most of the schemes are 25–50-years old, poorly maintained and in an advanced state of deterioration. There are also problems of pumping water from rivers or wells due to the increasing cost of pumping, combined with poor efficiency of the distribution network.

The Ministry of Energy and Water (MEW) estimates that most of the public irrigation schemes do not have adequate operation and maintenance, which could impact the future sustainability of these schemes. The responsibility of maintenance of the irrigation schemes belongs to several organizations including local committees and farmers' groups however most of the medium irrigation schemes do not have a formal organization or unit in charge of operation and maintenance.

Impacts of the Syrian crisis on natural resources

Since March 2011, the Syrian crisis has resulted in massive inflows of displaced persons and refugees within Lebanon and across the region (Jordan, Turkey, Iraq and Egypt). Lebanon hosts the largest number of Syrian refugees (37 percent of the total Syrian refugees) making up already more than one third of the total population.

According to official estimates, more than 35 percent of the Syrian refugees are considered vulnerable including women (49 percent), children under the age of 12 (40 percent) and elderly (3 percent). The vast majority of the refugee population is poor with low educational level, few assets and limited employment opportunities.

The immediate response to the Syrian crisis from the Lebanese Government and the international community focused primarily on humanitarian assistance programs. Syrian refugee households have been receiving assistance in terms of food vouchers, food in kind, hygiene kits, health care or drugs, education support, furniture and clothing, and fuel subsidies.

Especially in those areas where large refugee settlements/camps are established, such as along the northern coast of Akkar, depletion of natural resources, alteration of habitats of fauna and flora as well as pollution, are evident. The flux of the refugees and their search for water points is resulting in a dramatic increase of solid waste along the rivers and coastline causing higher pollution levels of these ecosystems. An additional environmental impact resides in water pollution by leakage from sewage tanks or dumping into rivers, affecting directly natural ecosystems and food security. The deterioration of water quality is affecting not only potable water but also water used for irrigation. Solid wastes dumped in channels also results in obstruction of drainage systems which increases flood risks along rivers during winter - an example is Nahr el Joz in North Lebanon where refugees are settling in the Kfar Hilda area.

The influx of refugees in large numbers will definitely result in accelerated degradation of water resources for domestic use. Moreover, potato and vegetable growers in the Bekaa have increased their planted surface area in order to cover the increasing local demand for food commodities. Such increase in agriculture land cultivated for irrigated crops as well as the increase in domestic use has accentuated the depletion of groundwater. Farmers in Al Qaa area confirmed that the water table - which is usually situated at 150 meters at the beginning of winter - has dropped by 10 to 20 meters. Beside the environmental impact of depleted water resources, there has been an economic impact due to additional costs for energy to pump water from deeper aquifers and related transportation (increased by a minimum of 10 percent). Farmers in the Hermel area indicated that the cost of pumping water from Assi River or underground wells depended on the price for diesel which they used to buy from Syria (pre-crisis) for at least 20 percent less than its current price in Lebanon.

As for progress in achieving Millennium Development Goal 1, in Lebanon, the population living under the poverty line is 28.6 percent. Of these, 8 percent are extremely poor and live below the lower poverty line, estimated at 2.4 US$/capita/day, and cannot meet their food and non-food basic needs. Rural ecosystems are also deteriorating, mainly because of urban encroachment, water pollution and land abandonment. As a result, Lebanon is struggling with new and different health challenges such as micronutrient deficiencies, malnutrition and non-communicable illnesses.

USE OF TREATED WASTEWATER IN AGRICULTURE

In arid zone countries, water is a limiting factor to the development of agriculture. In Lebanon people can access an average of 1 100 m^3 per capita, compared to the global water resources average of 6 000 m^3 per capita (FAO Aquastat, 2008).

Water withdrawals in Lebanon account for 67 percent for agriculture, 32 percent for domestic use and 1 percent for industry (FAO Aquastat). Agriculture consumes 61 percent of water, 30 percent are consumed by domestic use and 9 percent by industrial use (MoEW, 2010).

In urban and peri-urban areas of districts affected by the high pressure of refugees coming from Syria water shortage is becoming a real problem: domestic water uses are in competition with agriculture for fresh water and the environment is polluted by large quantities of untreated wastewater released in abandoned lands. In these areas, most of the times farmers have no options than using untreated wastewater for agriculture and horticulture. In such conditions the safe use of treated wastewater allows recycling of nutrients for productive purposes and leads to a reduced discharge of blackwater into rivers and sea, freeing other fresh water resources for more vital uses. Domestic treated wastewater (TWW) is particularly indicated for fodder, food production and woody crops in agriculture and agroforestry systems that require secondary treated water with advantages to reduce treatment costs and increase organic matter in the soils.

Based on the above figures, it can be calculated that treating already 30 percent of the available domestic untreated water to be utilized in agriculture, including forestry and agroforestry systems of urban and peri-urban areas would allow an increase of 11 percent of the available water for agriculture and forestry for environmental purposes.

However, the issue of wastewater treatment and reuse in Lebanon must be seriously supported. The Ministry of Energy and Water (MoEW) in the 'National Strategy for Wastewater Sector' reports that in Lebanon there are 310 million m^3/year of available wastewater of which 250 millions are urban wastewater and 60 millions are industrial wastewater. Only two thirds of the population is connected to a sewage network but only 8 percent of wastewater reaches (four) operational wastewater treatment plants (Saida, Ghadir, Baalbeck and Yamouneh). There is no pre-treatment of industrial wastewater that is often discharged together with urban wastewater in sea, rivers or lands or unsafely used by farmers.

The Wastewater Master Plan issued by MoEW in 1994 and mentioned in the National Strategy for the Wastewater Sector 2012, reported that Wastewater Treatment Plants (WWTP) are yet insufficient. Of the 54 WWTPs recommended, seven have been completed along the coast (out of the 12 foreseen) but only two (Ghadir and Saida) are operational, five (Tripoli, Chekka, Batroun, Jbeil and Nabi Younes) lack of a sewage network, one is under construction (Sour), three are under preparation (Aabde, Kesrwane and Bourj Hammoud) and one (Sarafand) has not yet been funded. Inland, only two, Baalbeck and Yamouneh, of the 42 WWTPs are operating and they are working below their capacity: 10 percent and 50 percent respectively. Two plants, Nabatiye and West Bekaa are completed but not operational as they lack of a sewage network. Five, Kfasir, Yahmour, Zawtar, Bekaa, Tibnine and Zahle are under construction and 14 are under design. The remaining 19 are not yet funded. The report also mentioned 60 small size WWTPs that had been implemented in small municipalities but their operability status remains unclear, due to management by different local authorities.

Since the 2012 report, FAO is supporting Lebanon in strengthening the use of treated wastewater in agriculture. The current study made an effort to conduct a new assessment of the treatment wastewater plants by collecting and compiling new data based on data provided by the Council for Development and Reconstruction (CDR) and integrated with sources collected from other relevant institutions. According to the new data, there are 166 WWTPs in the country all at a different stage of development that will be described in the report below.

THE WASTEWATER STRATEGY

Wastewater collection, treatment and reuse in Lebanon are weak and not implemented. There is neither a policy/institutional framework on the treatment and re-use of wastewater nor guidelines on the most cost effective wastewater treatment techniques and on the use of TWW in agriculture.

The Government of Lebanon is committed to strengthen collection and treatment of wastewater and support the use of TWW in agriculture, industrial and amenity but also to recover TWW costs based on the polluter-pays-principle. Also, in trying to address the problems the Government has issued a national strategy for the wastewater sector that includes 5 strategic initiatives to 1) strengthen wastewater collection and reuse through the finalization of the waster network; 2) improve the regulatory and policy framework; 3) define responsibilities for services delivery on the use of TWW; 4) define financial measures to provide affordable services; 5) involve the private participation on the wastewater sector. Recently FAO has also responded to request of support from Lebanon with the implementation of two TCPs to prepare guidelines on both the use of TWW and sludge in agriculture.

The wastewater strategy aims to increase the present wastewater collection and treatment to 95 percent by 2020; to include pre-treatment of all industrial wastewater by 2020; to reuse all the inland wastewater treated at the secondary level; and to fully recover all the treated and maintenance costs according to the polluter pays principle by 2020.

Such outputs are scheduled to be delivered by 2020 but the government estimates seem to be too optimistic.

2. Purpose of this report

The Government of Lebanon, understanding the importance of the safe use of treated wastewater in agriculture as a valid means to reduce environmental pollution and increase water availability, has already planned an investment program to implement new WWTPs in most of the settlements. Nevertheless the unexpected amount of refugees that are still migrating from Syria are presenting an emergency related to food and environment, which requires the Government to improve and strengthen already implemented activities to reduce environmental pollution and respond to the increasing demand of water and food.

Despite the urgency of the problem, the Government has difficulties to improve wastewater treatment in the country. TWW are still managed by different institutions both at national and local level. There are gaps in data-collection, monitoring, management, and coordination of activities. In this regard it is important to create new reliable information on the status of TWW in the country. Further, the following responsibilities should be allocated to one institution: to manage TWW, to collect and coordinate data and information on water treatment and reuse at national level, and to monitor and strengthen the status of production and discharge of water.

The purpose of this study is to provide an updated and comprehensive database of information on the status and progresses made on the use of treated wastewater in Lebanon, to highlight data gaps and inconsistencies, and assess the potentialities of TWW using a case study approach in Caza (Province) through a GIS multilayer analysis.

The study is based on the work of the FAO project 'Coping with water scarcity - the role of agriculture – Phase III', active in Lebanon since 2011, which seeks to strengthen the safe use of treated wastewater in agriculture and deals with the agricultural component of water scarcity.

The study also presents a tool to support the Government of Lebanon to meet its stated objectives for agricultural water management and to develop new policies on the use of TWW. It will further contribute to the achievement of a number of existing national strategies relating to water, agriculture, environmental management and desertification.

3. Methodology

The analysis of the potentialities of TWW in Lebanon was carried out in two phases: the first phase focused on the review and the collection of new data on TWW at national level. The newly collected data were standardized, reviewed and cleaned. The discussion of quality of data available is reported in the chapter referring to data availability. Data was collected for the following variables described below (for the dataset table see Annex 2).

List of variables contained in the TWW dataset:

1) **Number**, identification number of the WWTP
2) **Caza**, district or province
3) **Project name**, Village of implementation of the WWTP
4) **Treatment**, level of water treatment produced by the WWTP
5) **Status**, implementation phase of the WWTP
6) **Capacity**, maximum volume of water potentially treated
7) **Pop-Served**, population potentially served by the WWTP
8) **Managed**, Institution responsible for the management of the WWTP
9) **Funding agency**, agency that financed the implementation of the WWTP

In the second phase, the newly compiled data on TWW were combined with basic geographic and environmental parameters in GIS to identify the location of already implemented WWTPs and eventually plan suitable and efficient locations for new WWTPs.

The following eight basic GIS parameters were combined with the TWW database:

1) **Population**

   Larger population affects the quality of environment by producing larger quantities of wastewater. Hence, population data are useful to understand if a WWTP network is sufficient or under estimated to serve the given area.

   In the present study population data are available but outdated as they refer to estimates done prior to 2005 and do not reflect the heavy population pressure due to the refugees that are escaping the dramatic conflict in Syria.

2) **Distance from human settlements**

   Wastewater treatment plants should be placed as far from urban residential settlements as they can since they can be risky for the environment and public health, produce unpleasant odors and be responsible for the increase of flies and mosquitoes. To minimize energy costs of pumping water, WWTPs should be planned in marginal lands of peri-urban areas, located in places relatively far from settlements and close to land that could benefit from the TWW produced. Thus, a buffer zone from urban areas should always be taken in consideration in planning and implementing WWTPs.

2) **Vegetation (and land use)**

Such data provide information on both the vegetation cover and land use and its changes. Land use maps are classified into different classes as forest, grassland, agriculture, industrial, residential areas. To reduce the environmental impact, WWTPs are always planned in marginal lands while residential areas, farms and gardens are marked as unsuitable classes to implement WWTPs. Unfortunately in the present study, land use maps were not available as will be discussed further in the results section.

3) **Hydrology**

Provides information on water bodies, such as river, lakes, swamp areas and groundwater. Any planning of wastewater treatment needs to take into consideration hydrology since effluents of WWTPs may affect surface water and groundwater bodies differently, and might have strong implications on water quality and water pollution.

4) **Geology**

Helps in locating suitable geological areas, and eventually plan the implementation of new WWTPs.

5) **Soil texture**

Soil texture affects seepage of sewage, absorption of pollutants, and surface water penetration into landfills. Sand, gravel fraction, salinity, alkalinity, and solubility affect the permeability of soils. Soil with intermediate to heavy surface texture, good pebbles ratio, moderate salinity, and low alkalinity are to be preferred in finding a suitable location for wastewater treatment plants.

6) **Slope**

Slope maps are relevant to identify new potential sites for the implementation of WWTPs. Site location has both environmental and economic implications. Construction of wastewater treatment plants in steep sites will increase excavation costs and embankment and will also increase risks of sewage leaking into surface and groundwater resources. On the other hand, the implementation of WWTP on a moderate steep land would reduce energy costs to pump TWW for irrigation. Many studies report that slopes with less than 12 percent decline prevent pollution runoff.

7) **Distance from major and minor roads**

Costs related to construction and maintenance of wastewater treatment plants increase with distance from roads.

8) **Human settlements**

Size of human settlements and production of sewage are important parameters to take into consideration in designing and sizing WWTPs and related sewage networks.

The GIS analysis based on the above parameters provided the availability of WWTPs and their location in the country (Figure 1). As a result, the following basic layers were developed and geo-referenced in the GIS:

- surface water bodies
- well distribution
- topography
- springs
- land cover
- land use
- roads
- soil types
- Geology

An in-depth analysis on the potential use of WWTPs was conducted on a study area identified in the province of Rachaiya (Caza Rachaiya) by combining the TWW dataset together with the GIS basic layers to illustrate the type of a detailed analysis that may be undertaken using GIS data. Information on the location of Rachaiya is provided in Figure 2.

4. Data collection and data availability

Data collection started in Lebanon in 2013 and involved a comprehensive search of available datasets from governmental agencies, national universities, national research institutes, and international organizations that were subsequently compiled by CDR. Data were then standardized, reviewed cleaned and compiled in the database by FAO consultants that worked in the framework of FAO project GCP/INT/124/ITA.

The new database comprises data for 166 wastewater treatment plants and is mainly based upon the compilation of 3 main sets of data: a dataset (Annex 2) that comprises 106 WWTPs mapped before 2005 (yellow in the table); a set of 53 newly mapped WWTPs located and mapped based on the data given by national partners (light green in the table) and 7 other sites that unfortunately cannot be located into the maps as no information on the coordinates was provided (pink in the table). As it can be seen, the database still contains a lot of gaps on data especially concerning treatment status, capacity and population and the lack of data has influenced the results of the GIS analysis

Maps and digital information regarding the eight basic parameters to be combined in the GIS together with treated wastewater data were made available by different Lebanese institutions. However for some of these datasets, no legend was available especially for land cover, land use, geology and soil. This has also affected the quality of the results. Moreover, despite the collection and compilation of new data, both TWW and GIS datasets still showed gaps and were based on outdated sources. Most of the sites did not report all the variables collected and the detailed analysis conducted showed that data homogeneity at province and country level was very low.

5. Results

ANALYSIS OF THE DATASET ON TWW

The newly compiled dataset on TWW showed a number of interesting results. Data reported that a total of 166 WWTPs are being implemented in the country.

The majority of WWTPs are reported to treat water at Secondary level. Of the 166 WWTPs, 139 are reported to treat water at Secondary level, 4 plants treat at Primary level, only 2 treat at Tertiary level and the remaining 21 did not report the level of treatment.

Data on information on the status of the implementation of the WWTPs is weaker than the previous information. Of the total 166 plants the majority corresponding to 70 WWTPs, or 42 percent of total plants, did not provide any information concerning the status of their implementation. 58 plants (or 35 percent of the total plants) have been declared completed but no information was available regarding their status of operationality. 37 (or 22 percent of the total plants) are under preparation and 1 still needs to be funded.

Also information on the volume of treated water and on the population with access to treated wastewater should be improved. Of the 166 WWTPs, only 59, or 36 percent of the total plants, report on the volume of treated wastewater and 80 plants report on the population served. However, more interesting than figures on the population served would be figures on the real operability of the WWTPs or the potentiality of serving the number of inhabitants compared to the population living in the settlement.

Despite being weak, data on the management of WWTPs in Lebanon show that WWTPs are still managed and maintained by several institutions. Despite the fact that management and maintenance is unknown for most of the WWTPs (70), the remaining 96 WWTPs are managed by municipalities (43), CDR (30) and MHER (18). The remaining 5 WWTPs are managed by other institutions such as the Federation of Higher Chouf (3), the Bekaa Watter East (1), and the Water Establishment (1).

Data on funding shows that WWTPs are financed by several donors of which the most prominent is the USAID followed by several European countries including France, Italy and Germany, plus other international banks, such as the Islamic Development Bank and the European Investment Bank.

Further, the study compared data on the number of people served by a WWTP with data on the total population of the area. The results showed that 86 sites, out of 166, did not provide any information on how many people the plant serves. Of the remaining 80 WWTPs, 71 overestimated the number of people serves, 5 underestimated their scope and the information from the remaining 4 plants was accurate.

GIS ANALYSIS

Results of the GIS analysis refer to the case study conducted on the Rachaiya province (Caza) that was chosen based on the availability of data on wastewater treatment and on other relevant criteria that are listed below.

1) **Data Availability**

   Both TWW data and GIS data are available for the seven WWTPs in the province with no gaps.

2) **Physical characteristics**

   Caza Rachaiya is considered a critical area because of different reasons. The Caza is located on the border with Syria that represents an additional constraint for the developing of wastewater treatment plants.

   The topography of the Caza has hills and slopes, with different water resources, both surface and groundwater, wide areas of grasslands and agriculture fields.

3) **Population**

   The Caza is considered critical as many Syrian refugees have settled in this area posing serious emergencies including environmental pollution.

Figure 1: Map of wastewater treatment plants in Lebanon

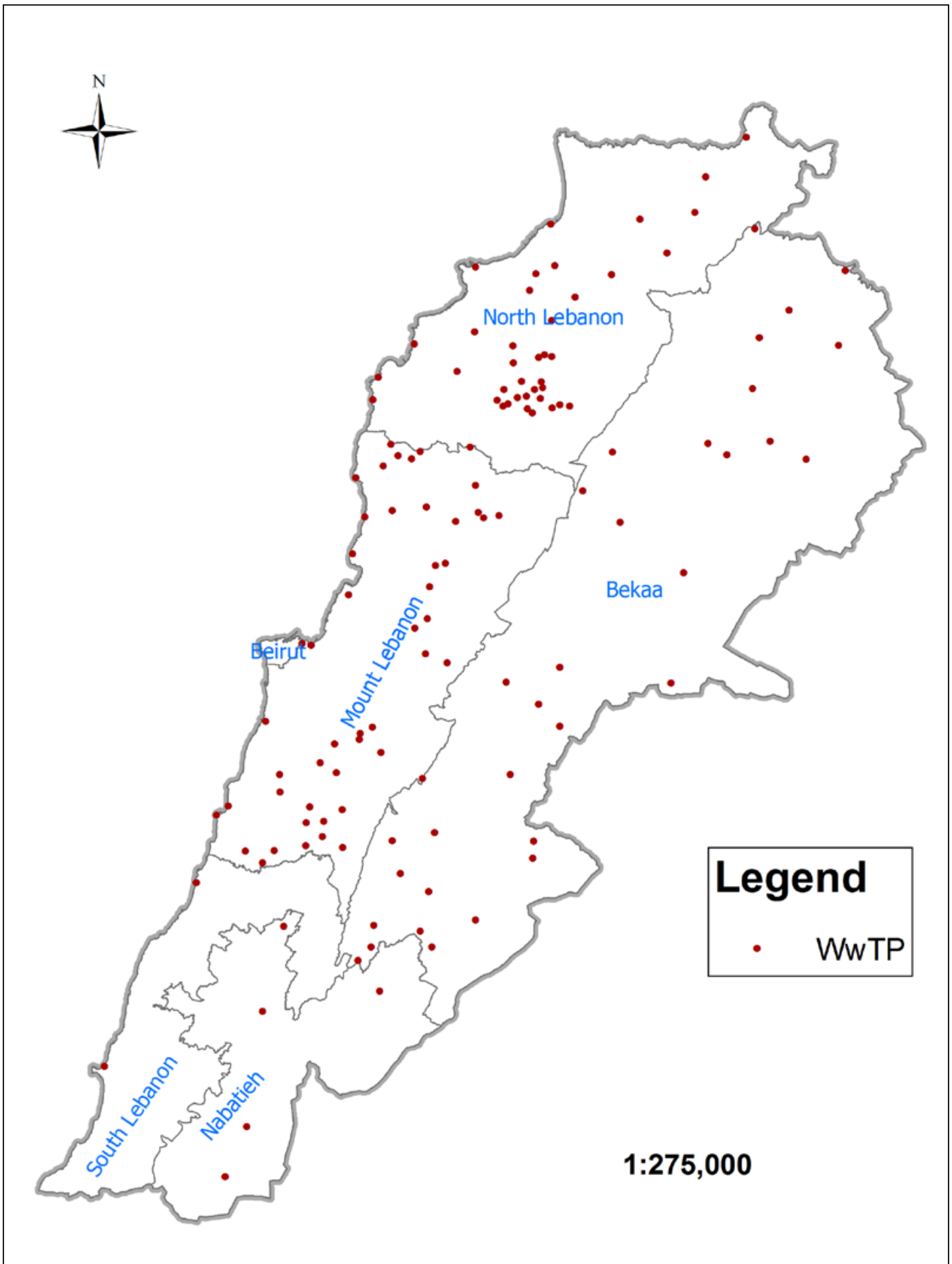
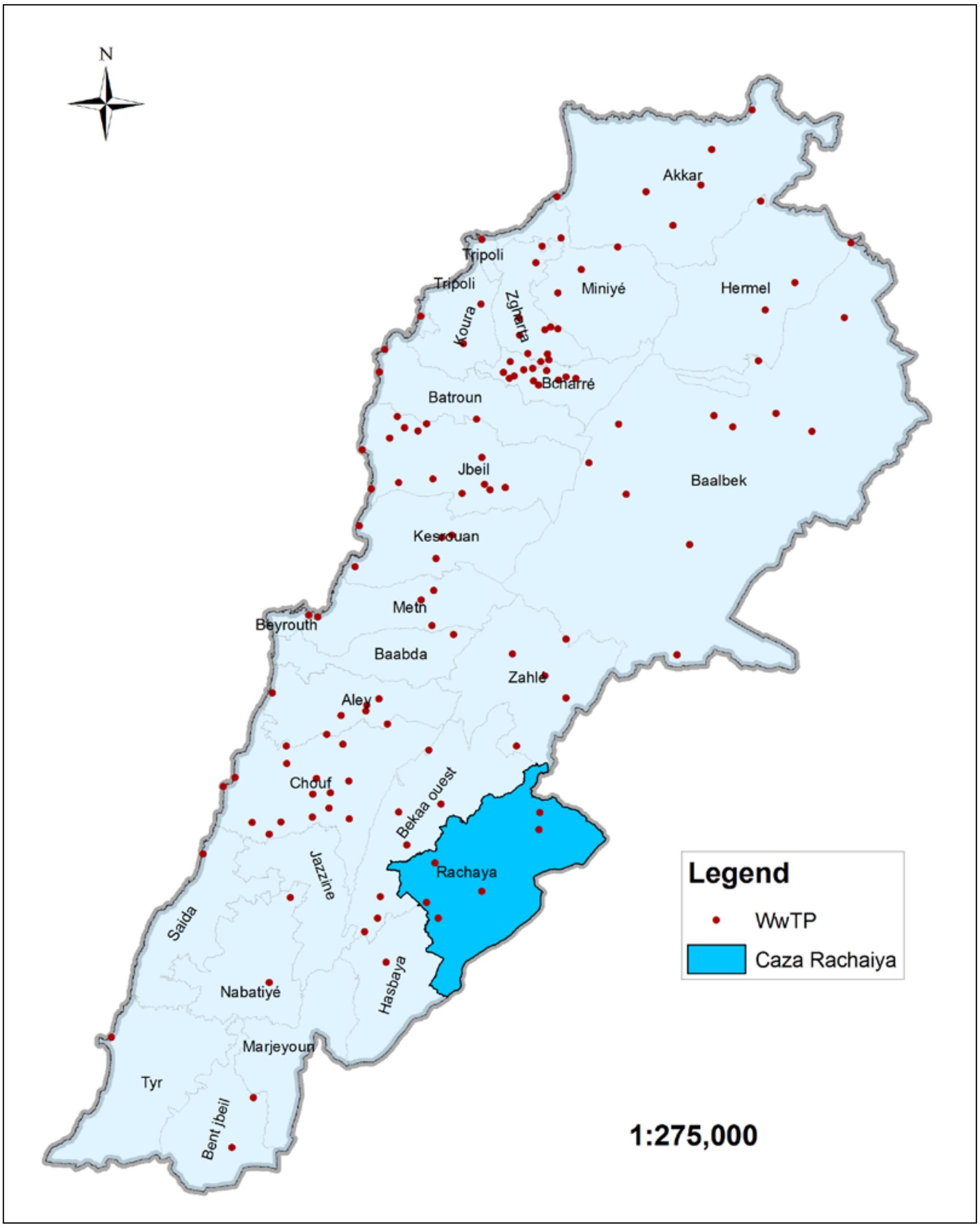


Figure 2: Location of Rachaiya Province in Lebanon



CAZA (PROVINCE) RACHAIYA STUDY AREA

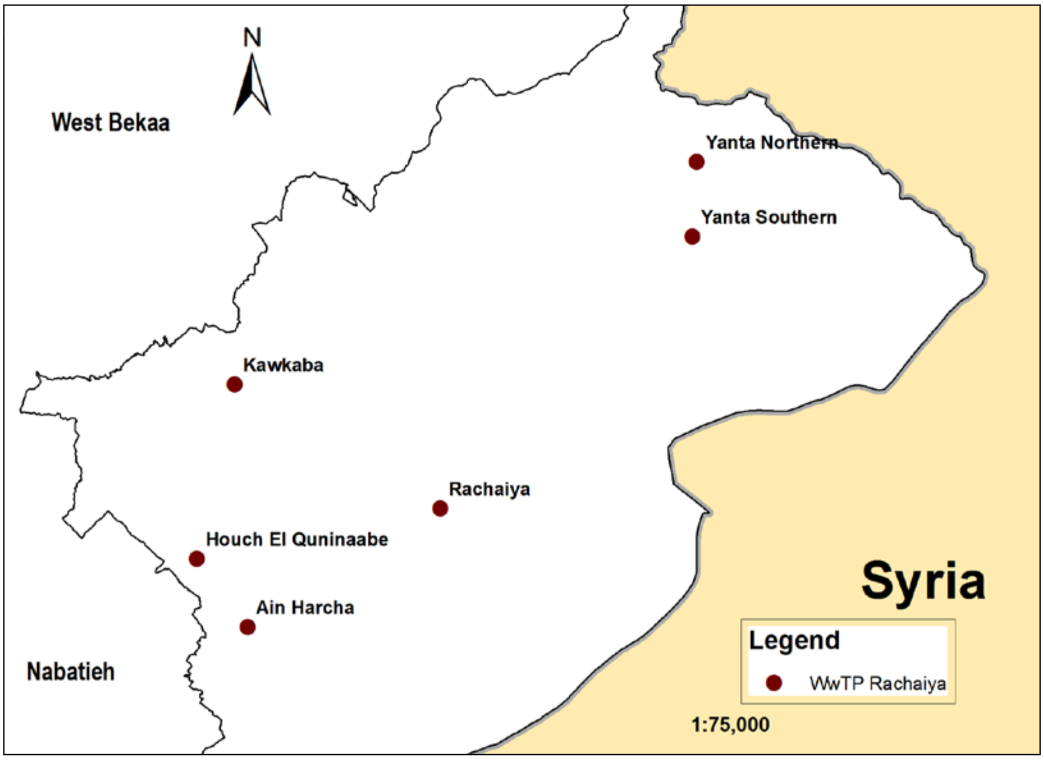
a) Wastewater Treatment Plants

A total of six wastewater treatment plants are located in Rachaiya

	WWTP Name	Treatment Type	Status	Capacity	Population Served	Managed	Funding Agency
1	Yanta Northern	Secondary	Completed	120	750	Municipality	USAID
2	Kawkaba	Secondary	Completed	135	2 000	Municipality	USAID
3	Ain Harcha	Secondary	Completed	120	1 200	Municipality	USAID
4	Rachaya	Secondary	Completed	100	6 000	Municipality	USAID
5	Haouch el quninaabe	Secondary	Completed	100	1 000	Municipality	USAID
6	Yanta Southern	Secondary	Completed	240	1 250	Municipality	USAID

The location of the plants is shown in the map below.

Figure 3: Location of wastewater treatment plants in Caza Rachaiya

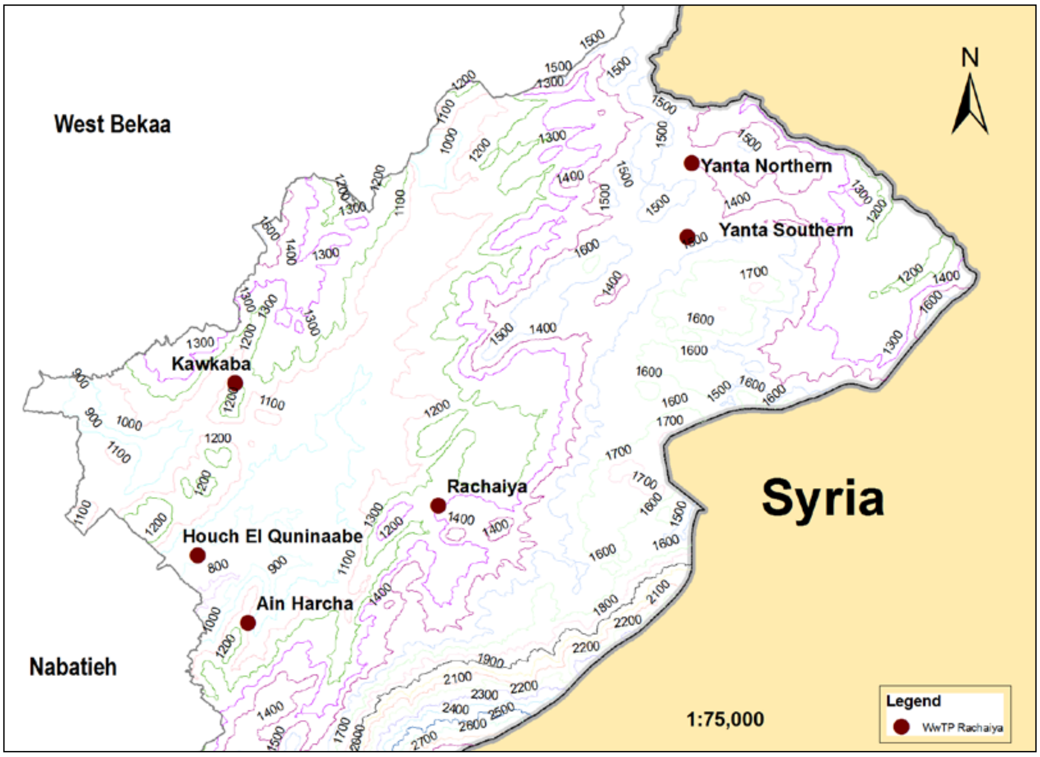


The map above shows the distribution of WWTPs in Rachaiya province and their distances.

Wastewater treatment plants of Ain Harcha and Haouch el quninaabe have a minimum distance of about 3.04 km. The Yanta North site is the closest to the international border, being located only at 2.04 km from the border. As mentioned the location of WWTPs should respect a minimum distance from any international border. A minimum distance from plants should also be considered during the planning of any new site.

b) Elevation contours (Topography)

Figure 4: Rachaiya province contour map (100 m interval)



The figure shows that in the study area altitudes range between a minimum of 600 m above the sea level (asl) and maximum of 1 600 m asl.

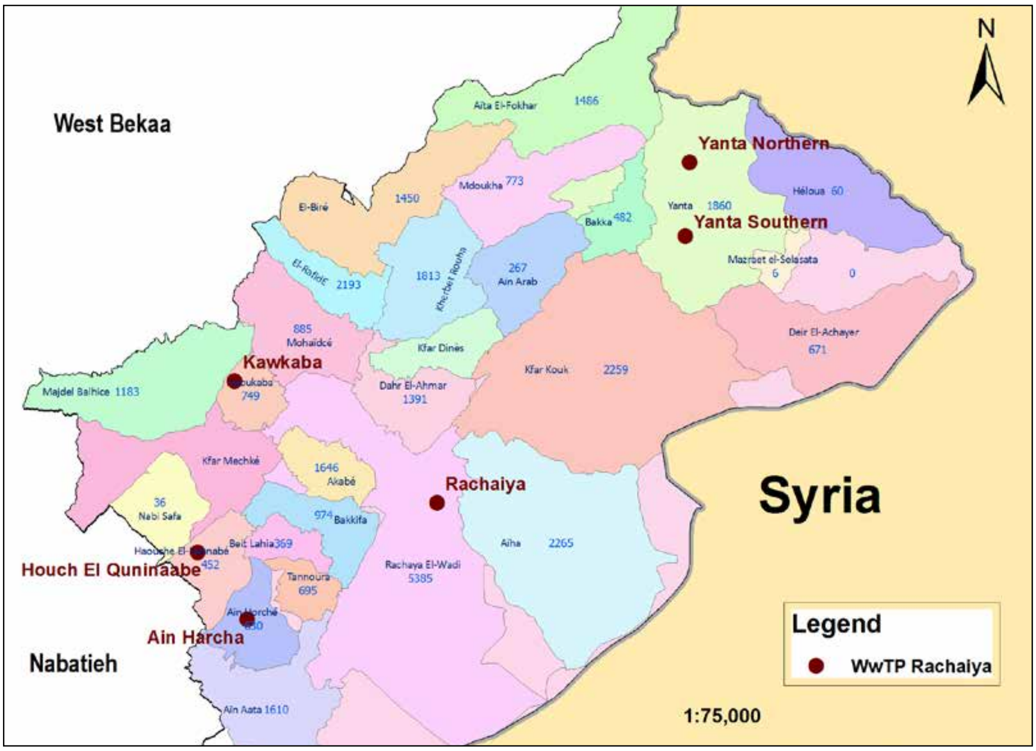
Yanta south is the highest site with an elevation of 1 600 m asl, while Houch El Quninaabe has the lowest elevation (800 m).

Elevation of any wastewater treatment plants, which are planned in the future, should always be lower than the lowest part of the settlement that they will serve.

The gradient of slopes is an important issue, both environmentally and economically. Construction of wastewater treatment plant in steep sites will increase the cost of excavation and embankment and also intensify the leachate sewage flow to surface and groundwater resources.

c) Population map

Figure 5: Rachaiya province population map (2005)



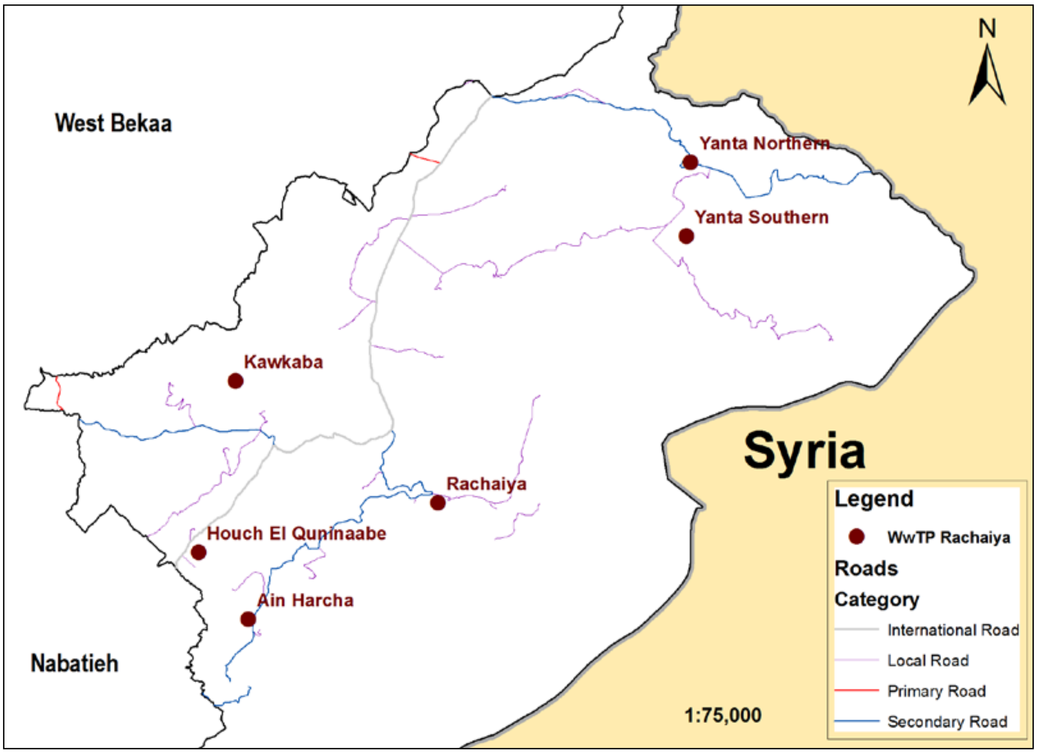
The population map shows population figures for the villages in the province in which the seven WWTPs are located. Caza Rachaiya has a total of 43 villages with a total of 33 146 inhabitants (2005 statistics). The comparison between the figures of the population served with the total population (total population served = 16 400 inhabitants) shows that 49.47 percent of the total population are served by wastewater treatment plants (Table 1).

However, if we compare data on the population served for each site and the population figures of the adjacent villages, it can be assumed that some sites are serving more than one surrounding village.

Finally it has to be noted that the population figures are relatively old (before 2005) and specific growth rates should be taken into account including the latest increase of population due to the influx of Syrian refugees over the past three years.

d) Distance from major roads

Figure 6: Caza Rachaiya major roads map



Distance from the roads increases the cost of wastewater treatment plant construction and maintenance.

e) Hydrology

Figure 7: Map of wells and springs in Caza Rachaiya

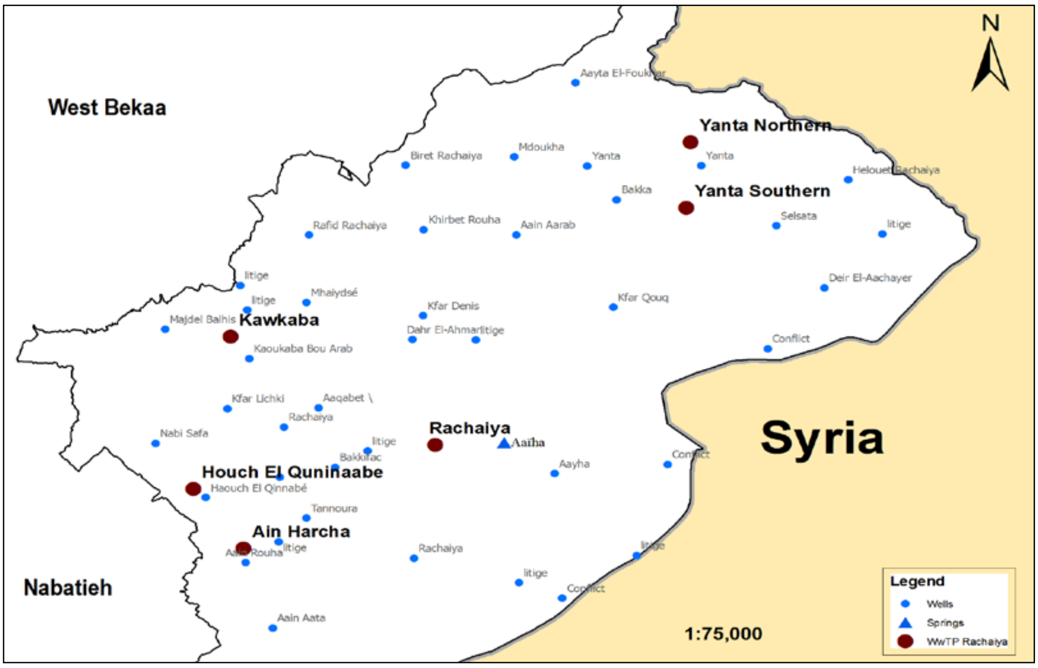
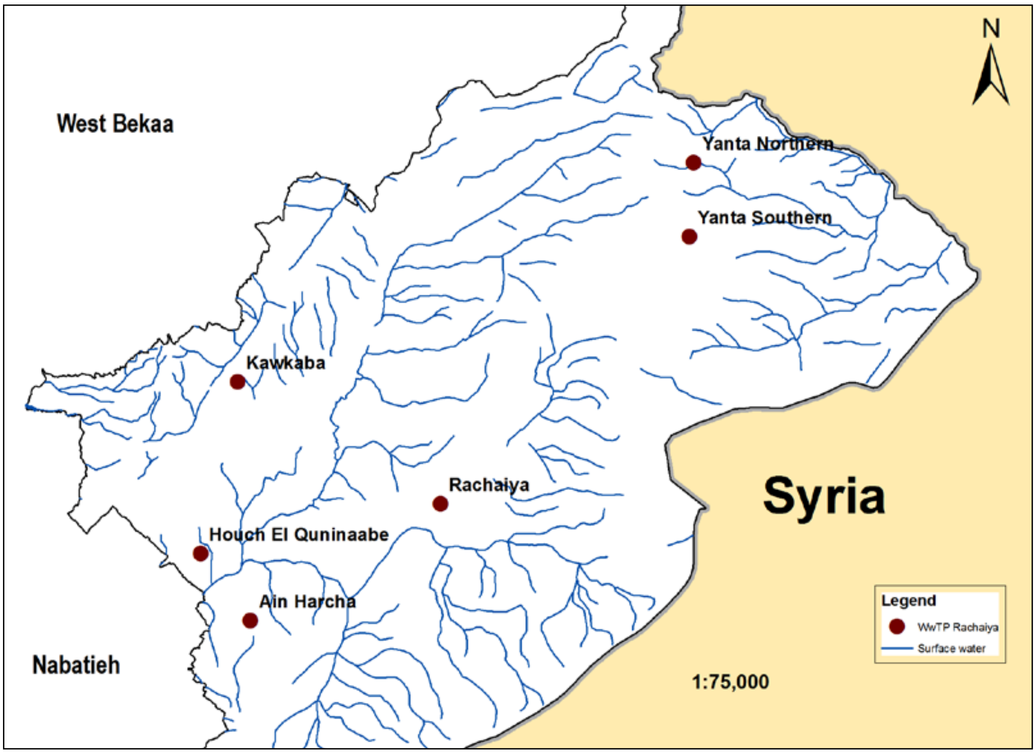


Figure 8: Caza Rachaiya surface water map



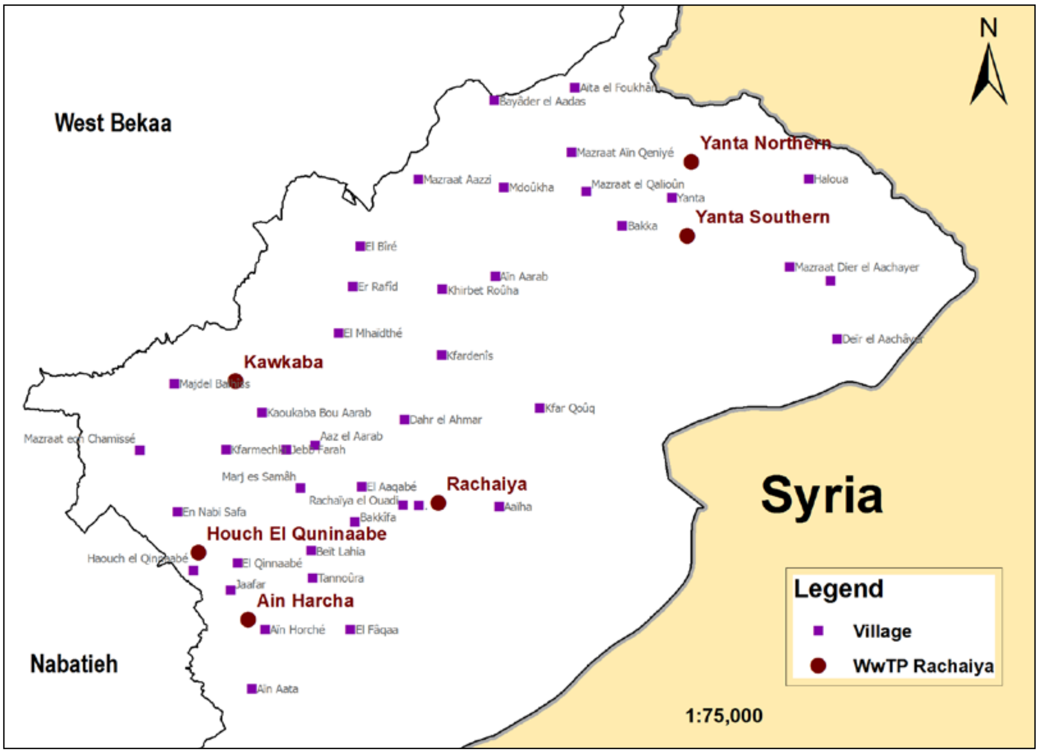
Two maps were taken into consideration to evaluate relationships between hydrology and WWTPs: the groundwater map (Figure 7) and the surface water map (Figure 8).

The groundwater map shows that WWTPs were built within the vicinity of wells and springs. This increases the risk of pollution of groundwater resources from sewage disposal in the area.

The surface water map shows that the WWTPs in the area were implemented without considering the distance from surface water bodies. They are indeed located relatively far away from the main river (Nahr El Litani) but still too close to its tributaries. Distance from water bodies should be taken into consideration when planning new WWTPs in order to reduce the risk of polluting fresh water resources.

f) Distance from human settlements

Figure 9: Caza Rachaiya town and villages map



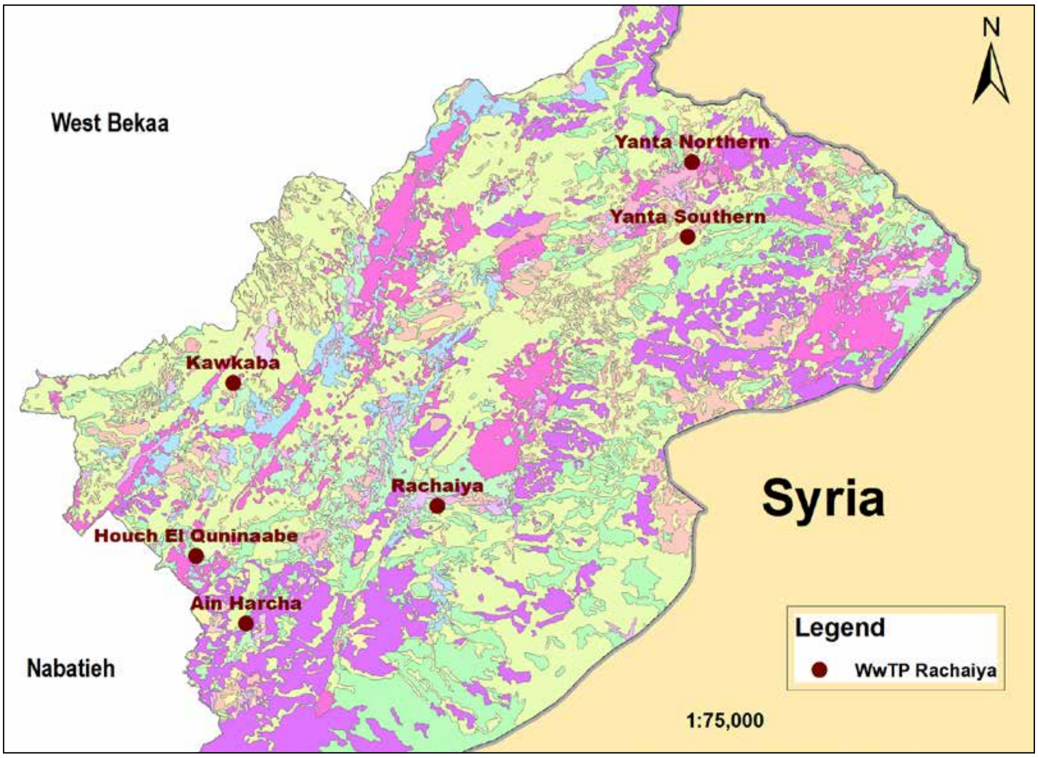
Human settlements are responsible for wastewater production. This is the most important factor to take into consideration during the implementation of WWTPs and of the related sewage networks.

In our study area most WWTPs are too close to towns and villages and the risk for public health is high. The map shows that there is no sufficient buffer zone between settlements and WWTPs.

Due to increased risk of environmental pollution and the production of unpleasant odors, wastewater treatment plants should be placed far from residential zones, in peri-urban areas. A comprehensive analysis of their distance from towns should be conducted to support the planning of new WWTPs and residential areas should be classified according to their distance from the WWTPs buffer zone.

g) Land cover

Figure 10: Caza Rachaiya province vegetation and land use map



The map (Figure 10) shows the vegetation cover in the Rachaiya study area. According to the information collected by several national institutions it was possible to assess some of the most important vegetation classes.

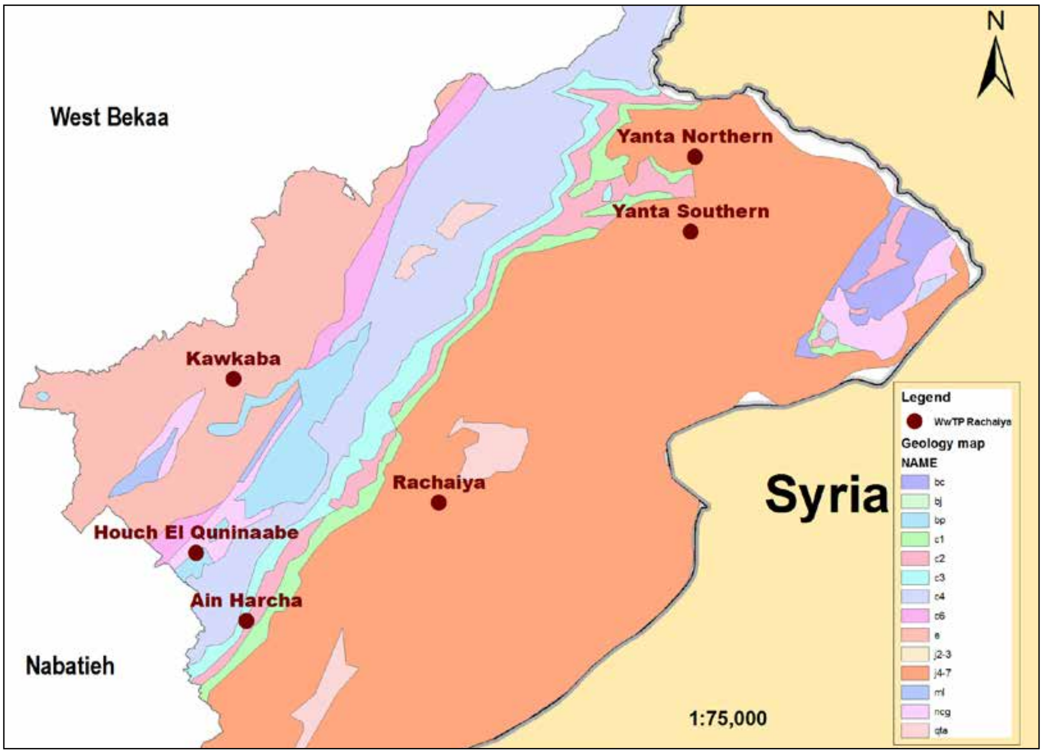
The dominant vegetation class in the study is 'clear grassland" (violet), followed by 'dense grassland" (green) while the class 'crops" (pink) covers less than 20 percent of the area.

According to the information collected by several national institutions the dominate land use was for urban settlements, including residential and mixed (residential/retail) areas and archeological sites.

As residential areas, farms and gardens are not suitable for the construction of waste-water treatment plants, it would be important to define areas suitable for the implementation of WWTPs.

h) Geology

Figure 11: Geological map of Caza Rachaiya province

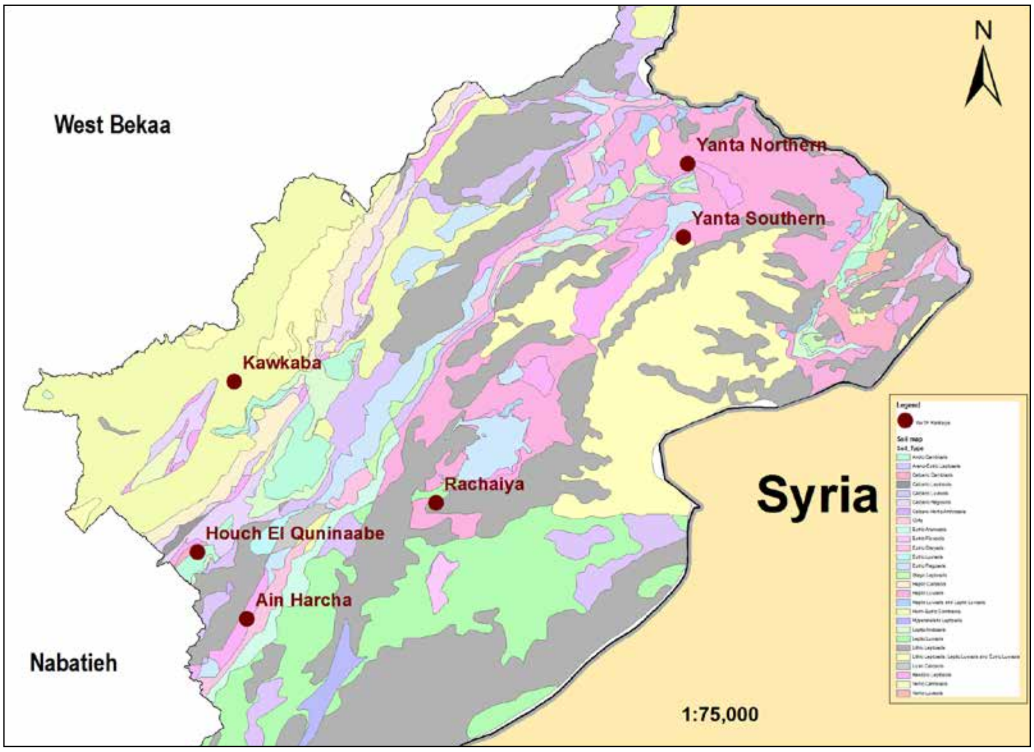


The geology map (Figure 11) showed that the Caza contains a wide variety of geological classes. The Jurassic limestone is the dominant geological formation in the area.

The geological profile of the area it is crucial in planning new WWTPs.

i) Soil

Figure 12: Rachaiya province soil map



The soil map (Figure 12) derived by national institutions showed that the Caza contains a wide variety of soil classes. The dominant soils types are Haplic Calcisols, Calcaric Cambisols and Lethic Leptosols respectively. Soil texture is strongly related to sewage seepage, pollutant absorption and surface water penetration into landfills. The composition of soil particles affects the permeability of soils.

Soil texture needs to be taken into consideration in planning wastewater treatment plants.

DATA QUALITY ASSESSMENT

Despite the great effort made in collecting and compiling data on TWW in a new updated dataset, the quality analysis revealed that most of the data provided by the national institutions were relatively old and not updated. Most of the WWTPs had no coordinates therefore they had to be positioned on maps with the support of Google Earth. As a consequence, the positioning was not always accurate. Often the coordinates of sites had to be modified in their distance and some were even located in neighboring provinces (Caza). Maps such as the soil map, hydrology map and geology map were received from the national institutions without classification or categorization of the given codes.

6. Conclusions

Wastewater, if properly managed, can be transformed from a potential threat to a good source of additional water that can free the use of additional fresh water for agriculture and domestic uses.

There are still too many institutions involved and probably competing on the management of TWW in Lebanon. The Government of Lebanon needs to allocate responsibility to manage treated wastewater at national level to one institution. The management should be based on accurate and homogenous information on the status of TWW at the national level.

The present study was the first attempt to create a reliable database on treated wastewater at national level, and to provide the Government of Lebanon with a useful tool to manage the already existing network of wastewater treatment plants.

Collected data were analyzed, standardized and cleaned from inconsistencies. This also provided the opportunity to identify and highlight information gaps. Data related to Caza Rechaiya were then analyzed using the Geographical Information System.

The case study of Rachaiya was used an example to assess the wastewater treatment sub-sector. Similar approaches can be used in other provinces to assess and provide a more detailed picture of wastewater treatment in Lebanon.

The results of the GIS analysis provided a methodology to manage data at regional or national level. However useful GIS outputs can only be obtained with good quality data. Without reliable data it is impossible to achieve good outputs.

Annex 1: References

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Annex 2: Dataset on TWW

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
1	Bekaa	Iaat	Secondary	Completed	120 000	Bekaa Water Establishment	IBRD	88 000
2	West Bekaa	Jeb Jannine	Tertiary	Completed	10 000	CDR	IDB	67 000
3	Zahle	Ferzol	Secondary	Completed	1 000	Municipality	USAID	7 400
4	West Bekaa	Mashghara	Secondary	Completed	5 000	Union of Municipalities	USAID	357 000
5	Batroun	Chekka	Secondary	Completed	-	CDR	-	24 000
6	Bekaa	Eastern Bekka	Secondary	Completed	160	Municipality	USAID	1 000
7	Bekaa	Western Bekka	Secondary	Completed	160	-	USAID	6 000
8	Rashaiya	Yanta Southern	Secondary	Completed	240	Municipality	USAID	1 250
9	Rashaiya	Yanta Northern	Secondary	Completed	120	Municipality	USAID	750
10	Chouf	Nabi Younes	-	Completed	-	-	France	88 000
11	Maten	Bourj Hammoud	Primary	under preparation	-	-	-	2 000 000
12	Baalbak	Deir Al Ahmar	Secondary	Completed	3 000	Municipality	USAID	3 500
13	Chouf	Barouk	-	Under preparation	8 000	-	-	-
14	Chouf	Safa	-	Under preparation	20 000	-	-	-
15	Keserwan	Jeita-Keserwan	-	Under preparation	-	-	-	505 000
16	Nabatieh	Nabatieh	Secondary	Under preparation	-	-	-	100 000

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
17	Baabda	Hammana	Secondary	Completed	1 050	-	-	7 000
18	Rachaiya	Kawkaba	Secondary	Completed	135	Municipality	USAID	2 000
19	Nabatieh	El Mari	Secondary	Completed	220	Municipality	USAID	1 300
20	Dinniyeh	Markibta	Secondary	Completed	195	Municipality	USAID	1 300
21	Jezzine	Wadi jezzine	Secondary	Completed	150	Municipality	USAID	1 500
22	Saida	Barteh	Secondary	Completed	195	Municipality	USAID	1 300
23	Jezzine	Ghobbatie	Secondary	Completed	250	Municipality	USAID	2 800
24	Jezzine	El Rihan	Secondary	Completed	820	Municipality	USAID	4 500
25	Jezzzine	Snayya	Secondary	Completed	60	Municipality	USAID	600
26	Jezzine	Haytoura	Secondary	Completed	100	Municipality	USAID	1 000
27	Jezzine	Aychieh	Secondary	Completed	150	Municipality	USAID	1 500
28	Chouf	Ammatour	Secondary	Completed	900	Municipality	USAID	-
29	Chouf	Maasser El Chouf	Secondary	Completed	450	Federation of Higher	USAID	3 000
30	Chouf	Khraibeh	Secondary	Completed	450	Municipality	USAID	3 000
31	Chouf	Bchetfine	Secondary	Completed	120	Municipality	USAID	1 200
32	Baabda	Qornayel	Secondary	Completed	900	Municipality	USAID	6 000
33	Hasbaya	Al Fardis	Secondary	Completed	120	Municipality	USAID	1 200
34	Hasbaya	Ain Qenia	Secondary	Completed	1 125	Municipality	USAID	7 500
35	Hasbaya	Hebbariye	Secondary	Completed	920	Municipality	USAID	9 200

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
36	Hasbaya	Kfar Hamam	Secondary	Completed	115	Municipality	USAID	1 700
37	Hasbaya	Mimes 1&2	Secondary	Completed	120	Municipality	USAID	3 000
38	Rachaiya	Ain Harcha	Secondary	Completed	120	Municipality	USAID	1 200
39	Chouf	Jabaa El chouf	Secondary	Completed	300	Federation of Higher Chouf	USAID	2 000
40	Nabatieh	Kfar Fila	Secondary	Completed	525	Municipality	USAID	3 500
41	Hasbaya	Chouaia	Secondary	Completed	50	Municipality	USAID	700
42	Hasbaya	Ain Jarfa 1&2	Secondary	Completed	375	Municipality	USAID	2 500
43	Hasbaya	Abou Qamaha	Secondary	Completed	90	Municipality	USAID	600
44	Hasbaya	Kfeir	Secondary	Completed	450	Municipality	USAID	3 000
45	Marjayoun	Qlaiyaa 1	Secondary	Completed	600	Municipality	USAID	4 000
46	Marjayoun	Qlayiaa 2	Secondary	Completed	200	Municipality	USAID	1 300
47	Marjayoun	Deir Mimass	Secondary	Completed	200	Municipality	USAID	1 300
48	Hasbaya	Marj el Zouhour	Secondary	Completed	120	Municipality	USAID	1 200
49	Akkar	Bqerzala	Secondary	Completed	-	Municipality	USAID	1 800
50	Akkar	Hmaira	Secondary	Completed	40	Municipality	USAID	600
51	Akkar	Charbilla	Secondary	Completed	-	Municipality	USAID	1 152
52	Rachaiya	Rachayia	Secondary	Completed	100	Municipality	USAID	6 000
53	Rachaiya	Haouch el Quninaabe	Secondary	Completed	100	Municipality	USAID	1 000

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
54	Sour	Sour	Secondary	-	-	CDR	EIB	200 000
55	West Bekaa	Kellaya	Secondary	-	-	MHER	-	-
56	West Bekaa	Yohmor	Secondary	-	-	MHER	-	-
57	West Bekaa	Qaraaoun	Secondary	under preparation	24 000	MHER	Italy	-
58	West Bekaa	Saghbine	Secondary	Completed	560	MHER	-	3 700
59	West Bekaa	Deir Tahnic	Secondary	-	-	MHER	-	-
60	Saida	Saida	Primary	Completed	-	CDR	Japan	390 000
61	Chouf	Serjbal	Secondary	-	-	CDR	-	-
62	Chouf	Wadi Es Sit	Secondary	-	-	CDR	-	-
63	Aley	Jisr El Kadi	Secondary	-	-	CDR	-	40 000
64	Chouf	Nabaa Es Safa & Ain Zhalta	Secondary	-	-	CDR	-	20 000
65	Aley	Ghadir Stp	Primary	Completed	-	CDR	Germany	250 000
66	Maten	Dora Stp	Primary	-	-	CDR	-	-
67	Maten	Bteghrine	Secondary	-	-	CDR	-	-
68	Zahle	Zahlé	Tertiary	Under preparation	35 000	MOE/CDR	Italy	-
69	Zahle	Timnne Tahta	Secondary	Under preparation	-	MHER	-	100 000
70	Jbeil	Jbail	Secondary	Under preparation	35 500	CDR	France	800 000
71	Jbeil	Kafr	Secondary	-	-	CDR	-	-
72	Jbeil	Ain Kfaa	Secondary	-	-	CDR	-	-

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
73	Jbeil	Haqel	Secondary	-	-	CDR	-	-
74	Jbeil	El Kharbe	Secondary	-	-	CDR	-	-
75	Jbeil	Tartij	Secondary	-	-	CDR	-	-
76	Jbeil	Laqlouk	Secondary	-	-	CDR	-	-
77	Jbeil	Qartaba	Secondary	Under preparation	-	CDR	Italy	11 600
78	Jbeil	Lassa	Secondary	-	-	CDR	-	-
79	Jbeil	Yanouh	Secondary	-	-	CDR	-	-
80	Jbeil	Qarqaiya	Secondary	-	-	CDR	-	-
81	Batroun	Selata	Secondary	-	-	CDR	-	30 000
82	Baalbeck	Hasroun	Secondary	Under preparation	-	MHER	-	4 800
83	Bcharré	Bcharré	Secondary	Completed	-	MHER	-	17 600
84	Tripoli	Tripoli	Secondary	Completed	-	CDR	EIB	1 000 000
85	Akkar	El Abdé	Secondary	Under preparation	185 000	MHER	-	-
86	Jbeil	Bchille	Secondary	-	-	CDR	-	-
87	Jbeil	Chloumay	Secondary	-	-	CDR	-	-
88	Baalbeck	Chlifa	Secondary	-	-	MHER	-	-
89	Keserwan	Maamaltein	Secondary	Under preparation	-	CDR	-	-
90	Baalbeck	Mrah Abiad	Secondary	-	-	MHER	-	-
91	Hermel	Mrah El Dahar	Secondary	Under preparation	-	MHER	-	-
92	Hermel	Madaech	Secondary	Under preparation	-	MHER	-	-

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
93	Hermel	Houch Beit Ismail	Secondary	Under preparation	-	MHER	-	-
94	Akkar	Michmich	Secondary	Under preparation	-	MHER	Italy	68 000
95	Akkar	Jebrayel	Secondary	under preparation	-	MHER	France	61 500
96	Akkar	Akkar Atika 1&2&3	Secondary	Completed	260	MHER	USAID	2 550
97	Akkar	Qoubayat El Gharbie	Secondary	Completed	1 350	MHER	USAID	9 000
99	Akkar	Nahr Chadra	Secondary	-	-	MHER	-	
99	Koura	Koura	-	-	-	CDR	France	-
100	Baalbeck	Laboué	Secondary	Under preparation	-	CDR	IBRD	47 000
101	Zahle	Ablah	Secondary	Completed	2 000	Municipality	USAID	14 630
102	Zgharta	Myriata	Secondary	-	-	-	-	-
103	Minieh-Danieh	Terbol	Secondary	-	-	-	-	-
104	Hermel	El Boustan	Secondary	-	-	-	MHER	-
105	Keserwan	Zouk	Secondary	-	-	-	-	-
106	Keserwan	Mazraat Kfarzebian	Secondary	Under preparation	-	-	-	35 000
107	Keserwan	Mairouba	Secondary	-	-	-	-	-
108	Jbeil	Ghalboun	Secondary	-	-	-	-	-
109	Keserwan	Halat - Nahr Ibrahim	Secondary	-	-	-	-	-
110	Maten	Mchikha	Secondary	-	-	-	-	-

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
111	Bcharré	Hadchit	Secondary	-	-	-	-	-
112	Bcharré	Blaouza	Secondary	-	-	-	-	-
113	Batroun	Haouqa	Secondary	-	-	-	-	-
114	Bcharré	Bana	Secondary	-	-	-	-	-
115	Batroun	Aabdibe	Secondary	-	-	-	-	-
116	Zgharta	Mazraat Al Nahr	Secondary	-	-	-	-	-
117	Bcharré	Barhalioun	Secondary	-	-	-	-	-
118	Bcharré	Mazraat Bani Saab	Secondary	-	-	-	-	-
119	Bcharré	Qnat	Secondary	-	-	-	-	-
120	Bcharré	Beit Menzer	Secondary	-	-	-	-	-
121	Bcharré	Qnaiouer	Secondary	-	-	-	-	-
122	Bcharré	Hdet Ej Jobeh	Secondary	-	-	-	-	-
123	Bcharré	Brissat	Secondary	-	-	-	-	-
124	Zgharta	Sebaal	Secondary	-	-	-	-	-
125	Zgharta	Aintourine	Secondary	-	-	-	-	-
126	Zgharta	Aslout	Secondary	-	-	-	-	-
127	Zgharta	Mazraat Tefah	Secondary	-	-	-	-	-
128	Zgharta	El Bheira	Secondary	-	-	-	-	-
129	Zgharta	Kfar Sghab	Secondary	-	-	-	-	-

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
130	Baabda	Tarchich	Secondary	-	-	-	-	-
131	Aley	Majdel Baana	Secondary	-	-	-	-	-
132	Aley	Ain El Halazoun	Secondary	-	-	-	-	-
133	Aley	Habramoun	Secondary	-	-	-	-	-
134	Aley	Roueisset En Naaman	Secondary	-	-	-	-	-
135	Chouf	Klailiye	Secondary	-	-	-	-	-
136	Chouf	Moukhtara	Secondary	-	-	-	-	-
137	Chouf	Ainbal	Secondary	-	-	-	-	-
138	Chouf	Bater	Secondary	-	900	-	-	6 000
139	Chouf	Gharife	Secondary	-	-	-	-	-
140	Chouf	Bsaba	Secondary	-	-	-	-	-
141	Chouf	Bkifa	Secondary	-	-	-	-	-
142	Chouf	Majdlouna	Secondary	-	-	-	-	-
143	Chouf	Mazraat El Mahtaqra	Secondary	-	-	-	-	-
144	Chouf	Baiqoun	Secondary	-	-	-	-	-
145	Baalbeck	Harfouch	Secondary	-	-	-	-	-
146	Zahle	Aanjar/merj	Secondary	Under preparation	-	-	Italy	300 000
147	Baalbeck	Yammouné	Secondary	under preparation	340	-	CDR	2 500
148	Minieh-Danieh	Bakhaoun	-	Under preparation	-	-	Italy	48 000

No.	Caza	Project Name	Treatment	Status	Capacity	Managed	Funding Agency	Population served
149	Batroun	Batroun	-	Under preparation	-	-	France	30 000
150	Hermel	Hermel	-	Under preparation	-	-	Italy	96 000
151	Hasbaya	Hasbaiya	-	Under preparation	-	-	Italy	-
152	Bent Jbail	Bent Jbail	-	Under preparation	-	-	Italy	-
153	Chouf	Mazraat Ech Chouf	-	Under preparation	-	-	Italy	-
154	Maten	Khenshara	-	Under preparation	-	-	-	-
155	Koura	Amioun	-	Under preparation	-	-	-	-
156	Keserwan	Hrajel	-	Under preparation	-	-	Italy	40 000
157	Bent Jbail	Chakra	-	Under preparation	-	-	Italy	-
158	Keserwan	Tabarja	-	Under preparation	-	-	JBIC	425 000
159	Chouf	Chouf Coastal Area	-	Under preparation	-	-	France	-
160	Nabatieh	Jbaa	Secondary	Completed	150	Municipality	USAID	-
161	Hasbaya	Chebaa	Secondary	Completed	900	Municipality	USAID	6 000
162	Hasbaya	Khiam	Secondary	Completed	600	Municipality	USAID	6 000
163	Saida	Sarafand	-	To be financed	-	-	-	-
164	Nabatieh	Kfarsir, Yohmour, Zawtar	-	Under preparation	-	-	-	-
165	Bent Jbail	Tebnin & Chakra	-	Under preparation	-	-	-	-
166	Hasbaya	Aarkoub	-	Under preparation	-	-	-	-

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