Version 1.0 | November 2018

LCEC Guidelines

on Preparing Technical Proposal for Softscaping and Efficient Irrigation

Applies to LEA financing mechanism loans

Prepared by the Lebanese Center for Energy Conservation

LCEC Guidelines for Softscaping and Efficient Irrigation Systems for Residential and Commercial Applications

This guideline is prepared in cooperation with the USAID-funded Lebanese Water Project (LWP).

Version 1.0| November 2018

Introduction:

The Lebanese Environmental Action (LEA) is a national financing mechanism dedicated to the financing of environmental loans for water, air and environment. LEA is a joint initiative between the Central Bank of Lebanon (BDL) and the Ministry of Energy and Water (MEW).

As part of the contract signed between BDL and the Lebanese Center for Energy Conservation (LCEC) under the name "Technical Support Consultancy Services Agreement in Energy Efficiency and Renewable Energy", the Technical Support Unit to the Central Bank of Lebanon (BDL) at LCEC is dedicated to offer BDL technical assistance to evaluate the eligibility of submitted loans under LEA.

Important Notes:

1. *This project proposal guideline is designed to help potential beneficiaries, consultants, and contractors in preparing comprehensive technical reports and proposals about softscaping and efficient irrigation systems in residential and commercial applications.*

2. *This project proposal template is a mandatory requirement towards facilitating the green loan application process through the national financing mechanism LEA.*

3. *This project proposal template is prepared by the Lebanese Center for Energy Conservation-Technical Support Unit to the Central Bank of Lebanon and is available for public use.*

4. *This guideline will be updated constantly, kindly always refer to the latest version.*

5. *For questions, clarifications, or suggestions, please contact the LCEC: 01-569101 or by email: energy@lcec.org.lb*

Evaluation of projects requesting financing of softscaping and efficient irrigation systems for residential and commercial applications under LEA will be based on these issued Guidelines. Contractors are entailed to abide by the requirements set in these guidelines and must submit the technical reports following the steps and regulations clearly identified.

I. Introduction

Landscaping is the process of altering the existing design and the visible features of an area of land according to the needs and desires of the user and conditions of the site. The two main components in a landscape design are softscape and hardscape. Hardscaping is the construction of hard surfaces such as retaining walls, walkways, wooden structures, concrete and stone works, and other works. Softscaping refers to the plantation of trees, shrubs, bushes, groundcovers, grass, etc. Sustainable landscaping balances between both elements in order to main the natural features of the site, offset negative environmental impact, and increase longevity of the landscaped area.

Efficient irrigation is the process of irrigating with minimal water consumption while meeting the water requirements of the plants with nominal water losses caused by evaporation and runoff. Modern efficient irrigation technologies can increase water use efficiency to up to 95% in comparison to traditional methods. Adopting efficient irrigation systems is essential to maintain and extend the community's potable water supply, especially during the dry season.

The right design of softscaping and irrigation determine the outdoor water use of the facility. Selecting the right species along with an efficient irrigation system could result in a significant reduction of the outdoor water use. Accordingly, sustainable landscaping will beautify the property, as well as protect natural resources and the environment, save water and reduce maintenance needs.

This guideline is for the **softscaping** component of landscaping and **efficient irrigation system**.

II. Softscaping

1. Applicability for LEA

It is important to pinpoint that not all items under softscaping are financed under the LEA financing mechanism. This section provides a clear list of the financeable items to prepare the technical study for the softscaping measure accordingly.

Softscaping items eligible under the LEA financing mechanism are:

- Soil amendments: Peat and topsoil;
- Fertilizers;
- Trees, shrubs, flowers and grass lawn.

Important note: Crops for commercial purposes are not financed (i.e. fruit trees, edible crops, etc.). Upon the quantity of the edible crops seeking financing, the LCEC reserves the right to investigate the case and not finance the edible crops.

2. Requirements under LEA

This section covers the requirements under LEA and the information to include in the technical study. As a minimum, the study should include the following:

a. Description of the current state of the land to be landscaped. Specify:
   - Landscape area (in m^2);
   - Soil type (sandy[1], silt[2], loam[3] or clay[4]);
   - Water source (municipal, rainwater, treated effluent wastewater, private source), quantity and quality;
   - Climatic characteristics of the area;
   - Existing plantation, if any.

b. Background Information about the plants that already exist in the area. This information is used to assess whether the selected trees, flowers and grass can easily adapt with the surrounding environment;

c. The list of plants, including species, specification (height, girth, pot size, etc.) and quantities, the corresponding covered area for each plant (in m^2) and crop coefficient factor. The crop coefficient (Ks) is the proportion of water used by the plant compared to water evaporation. The crop coefficient is found in the USAID-LWP- Outdoor Water

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[1] Sandy soil has very poor ability to retain water and makes it hard for plant roots to absorb water. However, it plays a very good role in the drainage system. It is a less fertile soil but it can be improved by adding organic matter.

[2] Silt is a fertile type of soil and has good water retention properties. However, it has a very unstable structure and is very prone to erosion.

[3] Loam is a combination of sand, silt, and clay. It is the best medium for growing plants. It provides the proper amount of water and the nutrients needed to the plant. Loam is formed in nature when dead plants and animals decay and mix in sand, clay and silt.

[4] Clay has very high water retention properties because the pore spaces between the particles are very small. For this reason, clay soil inhibits the plant roots from absorbing oxygen. As a result, they rot.

Reduction Calculator in section 5 below entitled “Environmental Sustainability Analysis”. Complete and insert Table 1 in the project proposal;

Table 1 List of Plantation

Type of plant	**Specifications**	**Quantity**	**Covered Surface Area per plant type (in m^2)**	**Crop Coefficient (Ks)**
Insert text here	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
Insert text here	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
Insert text here	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*

Helpful note: Plants should be selected and planted according to adaptability to the climatic, geologic and topographical conditions of the project site. Low-water use, deep-rooted plants and native species are highly recommended, as well as plants that are well suited for the soil type that exists on site. Plants should be grouped into hydrozones with plant species having similar water demands and by their soil, sun, shade, and maintenance requirements.

d. Type of fertilizers, if any, and frequency of application;
e. Type of soil amendments, if any, with justification of the need. Specify the quantity used in m^3/m^2;
f. Landscaping design and annotated layout;
g. Official BOQ from the supplier/contractor that should include:
    - Supplier/Contractor details;
    - Plant Cost in USD/unit or LBP/unit;
    - Fertilizers’ cost;
    - Soil Amendment Cost;
    - Implementation cost.

Important Note: Stones that might be used in the landscaping should also be from a reclaimed source and should follow the LCEC Guideline for Stone Cladding and Retaining Walls- Stone Retaining Walls section. Download the latest document from the LCEC website. http://lcec.org.lb/en/NEEREA/DownloadCenter/TemplatesGuidelinesMemos#page=3

III. Efficient Irrigation System

1. Applicability for LEA

Good irrigation is about managing the soil moisture level so that the plant is maintained in the desired conditions, while reducing water losses and wastage.

Efficient irrigation revolves around 4 key pillars that need to be implemented to ensure that the irrigation of the landscaped areas is efficient. They are the following:

- Amount of water applied is appropriate to plant and soil;
- Irrigation schedule is appropriate for plant and weather;
- Water is applied uniformly and effectively;
- Water is being applied directly to the root zone without wastage through runoff, deep drainage, ineffective coverage and other sources.

Efficient irrigation systems that abide by the above-mentioned points are eligible under LEA financing mechanism.

Efficient Irrigation system items eligible under the LEA financing mechanism are:

1. Emitters;
2. Pipes;
3. Valves and relevant accessories;
4. Pressure regulator;
5. Controller;
6. Flow meters;
7. Pumps;
8. Fertilizer mixer;
9. Filters;
10. Moisture and other sensors;
11. Installation cost.

2. Requirements under LEA

This section covers the requirements under LEA and the information to include in the technical study. All requirements are further detailed in section 4, Efficient Irrigation System Design. As a minimum, the study should include the following:

a. Hydrozones and Specifications;
b. Efficient Irrigation System Design;
c. Environmental Sustainability Analysis;
d. Irrigation Scheduling per Hydrozone;
e. Efficient irrigation network design and layout;
f. Datasheet of components seeking financing under LEA;
g. Official BOQ from the supplier/contractor that should include:
   - Supplier/Contractor details;
   - Components' Cost in USD/unit or LBP/unit;
   - Installation cost (in USD or LBP).

3. Water Reduction Target

Project proposals requesting financing for the efficient irrigation measure under LEA should have at least <u>30%</u> reduction of the project's water requirement from the calculated baseline for the site's peak watering demand. **<u>Projects with less than 30% water reduction will be disqualified</u>.**

4. Efficient Irrigation System Design

This section provides guidance on how to prepare and present the efficient irrigation system technical study.

4.1 Hydrozones and Specifications

A hydrozone is an area containing plants with similar water requirements that will be irrigated on the same schedule, using the same irrigation method. The grouping of plants into areas of similar water requirements allows the irrigation system to be designed and managed so that the optimal depth of water can be applied. In areas of mixed planting, including trees in grass areas, it is necessary to divide the irrigation system controlled so that the areas close to the trees are separately controlled. If this is not achieved, then the irrigation system will be operated to provide enough water to the trees and the grass area will be overwatered.

Complete and insert Table 2 in the project proposal. Add rows as needed.

Table 2 List of Hydrozones

Hydrozone	Name of Species	Irrigation Type (drip, sprinkler, bubbler, etc.)	Surface Area of Each Hydrozone (in m^2)
1	*Insert text here*	*Insert text here*	*Insert text here*
	Insert text here		
	Insert text here		
2	*Insert text here*		*Insert text here*

	Insert text here	*Insert text here*	
	Insert text here		
3	*Insert text here*	*Insert text here*	*Insert text here*
	Insert text here		
	Insert text here		

4.2 Irrigation System Components and Specifications

In general, the irrigation system consists of, but is not limited to, the following components:

1. Application System:
    a. Emitters.
2. Distribution System:
    a. Lateral pipes.
3. Conveyance System:
    a. Main lines;
    b. Sub main lines;
    c. Valves;
    d. Pressure regulator.
4. Commanding System:
    a. Pumps;
    b. Filters;
    c. Fertilizer mixers;
    d. Controller;
    e. Flow meters;
    f. Moisture and other sensors.

4.2.1 Emitters

The most suitable efficient emitter should be selected for irrigation. Irrigation emitters deliver water to plants covering either the whole planted surface (plants and soil) such as sprinklers, micro-sprinkles or directly to each plant such as drippers. The efficiency in water delivery of emitters ranges from 75% for sprinklers to 95% for drippers in comparison to traditional measures such as hose irrigation that has an efficiency of 50% as compared to surface irrigation. Drippers, sprinklers, etc. should be sized to provide even and adequate water distribution to plants. The pressure and water flow requirements of irrigation components are specified by the manufacturer and should be respected in the design. Improper design leads to wasted water. The number of emitters per plant is determined using the water requirements of the plant and the flow characteristic specific to the emitters.

Complete and insert Table 3 in the project proposal. Add rows as needed.

Table 3 Emitters' Specifications

Hydrozone	**Irrigation Type (drip, sprinkler, bubbler, etc.)**	**Emitter Brand and Reference Number**	**Emitter Flow Rate (in liter/hour)**	**Quantity**	**Hydrozone Flow Rate (in liter/hour)**
1	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
2	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
3	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*

a. Sprinkler Irrigation (Sprinklers and Micro-sprinklers)

Sprinkler irrigation is a method of applying irrigation water, which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops, which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable an efficient and uniform application of water. Proper overlap of water streams jetting from the sprinklers should ensure even coverage of the entire irrigated surface.

b. Drip and Micro-Irrigation (Bubblers and Drippers)

One of the most effective forms of irrigation is micro or drip irrigation. Drip irrigation employs emitters that slowly apply water to crop root zones. Drip irrigation usually consists of a pressurized tubing system that runs along crop/plant rows. These tubes are fitted with drippers (inline or online) at specific distances. The two distinct features of micro-irrigation are high irrigation frequency and localized water application to only the root zone.

The application efficiency of irrigation systems is the amount of water delivered to the plant versus the total amount of water sent out into the system. The efficiency of each irrigation method is shown in Table 4.

Table 4 Irrigation Methods' Efficiency

Irrigation method	**Application efficiency**	**Water saving as compared to surface irrigation (approximate)**
Hose Irrigation	50%	Not Efficient
Sprinkler	75%	1.8 Times
Drip	90%	1.1 Times

4.2.2 Pipes

Pipe sizing depends on the required pressure on the dripper or sprinkler etc. and the pressure loss in the pipes, laterals, mains and components (filters, mixers, gages, valves). Water velocity in the pipes should be kept between 1.5 to a maximum of 2 m/s. Excessive water velocities leads to the rapid wear and tear of the network. Software or tables in the pipe datasheet can be used to determine pipe diameters. The tables will indicate pipe diameter vs. flow at a given flow velocity (1.5 to 2 m/s). Before sizing the lateral pipes, the type of pipes should be specified (PVC, HDPE, PEX, etc.). The sizing of the lateral pipes is done in reverse. The first pipe to be sized is the pipe reach supplying toe last of the further emitter from the valve. When the size has been established for that reach, the next reach in, supplying the last two emitters should be sized. The process continues, moving upstream from the last emitter and toward the valve.

Complete and insert Table 5 in the project proposal. Add rows as needed.

Table 5 Piping Details

<table>
<tr><th>Hydrozone</th><th>Lateral Pipe Diameter (in mm)</th><th>Quantity</th><th>Unit Length of Pipe (in lm)</th><th>Submain Line (in mm)</th><th>Quantity</th><th>Unit Length of Pipe (in lm)</th><th>Main Line (in mm)</th><th>Quantity</th><th>Unit Length of Pipe (in lm)</th></tr>
<tr><td rowspan="3">1</td><td>Insert text here</td><td>Insert text here</td><td>Insert text here</td><td rowspan="3">Insert text here</td><td rowspan="3">Insert text here</td><td rowspan="3">Insert text here</td><td rowspan="9">Insert text here</td><td rowspan="9">Insert text here</td><td rowspan="9">Insert text here</td></tr>
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</table>

4.2.3 Valves

Upon completing the drawing of the plan, where every area to be irrigated has been drawn with properly spaced emitters, the number and sizes of valves can be determined. As a basic rule, valves should be split into equal flows.

Complete and insert Table 6 in the project proposal. Add rows as needed.

Table 6 Valve Details

Valve Type (Gate, Ball, Solenoid, backflow preventer, etc.)	Size	Quantity
Insert text here	*Insert text here*	*Insert text here*
Insert text here	*Insert text here*	*Insert text here*
Insert text here	*Insert text here*	*Insert text here*

4.2.4 Pump

Pump sizing depends on the required flow, water velocity and pressure losses in the system. Pump operating curves or software can be used for sizing to ensure adequate water delivery and reduce unnecessary energy consumption. Flows and pressures are determined by emitter manufacturers and the irrigation-scheduling plan. The pressure to be delivered by the pump is determined by the pressure needed to properly operate the drippers and sprinklers. Emitter manufacturers set pressure requirements. Added to the pressure needed by the emitters are friction losses in pipes and fittings and pump efficiency. The flow of the pump is determined by the flow of each emitter multiplied by the number of emitters operating at the same time in one section.

Complete and insert Table 7 in the project proposal. Add rows as needed.

Table 7 Pump Details

Type of Pump (Centrifugal, booster, etc.)	Brand	Model	Operating Conditions		Power (in kW)
			Head (in m)	Flow (in m^3/h)	
Insert text here	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*

4.2.5 Flow Meters

Flow Meters should be installed at the pump level to monitor water consumption volumes and any potential leaks.

Please provide flow meter datasheet, highlighting selected model and operating conditions.

4.2.6 Filters

Filter sizing depends on the quality of water especially relating to solids content. Filters could be installed on the main supply line and on the laterals in the case of drippers or any other type of micro-irrigation. Main filters should be equipped with gauges before and after the filter to detect clogging and clean the filters. Clogged filters increase pressure on the pump and lead to unnecessary energy consumption.

Please provide filter datasheet, highlighting selected model and operating conditions.

4.2.7 Fertilizer Mixers and Injectors

Fertilizer mixers and injectors deliver fertilizers directly in the irrigation system. They can be manually adjusted or automatic. Automatic mixers and injectors can reduce over fertilization if properly operated. Fertilizers and over-fertilization are a cause of water pollution surface and ground.

Please provide filter mixers and injectors datasheet, highlighting selected model and operating conditions.

4.2.8 Automatic Controller

Controllers automatically operate the irrigation system based on timed application of water. They can be simple timers set by the gardener based on the irrigation scheduling study or they can be coupled with a simple weather station and/or tensiometers to accurately time and dose irrigation based on weather conditions, thus, tremendously reducing unnecessary water use and supplying only the necessary plant water requirements.

Please provide automatic controller datasheet, highlighting selected model and operating conditions.

4.2.9 Moisture Monitors (Tensiometers)

Tensiometers measure actual soil moisture content and can be connected to above controllers to prevent irrigation when enough water is still in the soil from a previous irrigation or from a rain event. Moisture sensors can be wired or wireless and should be installed as per the recommendations of the manufacturer taking into consideration soil and plant variability.

Please provide tensiometer datasheet, highlighting selected model and operating conditions.

4.2.10 System Installation

Installation costs are covered under the LEA financing mechanism. Good installation practices must avoid leaks as it is a major source of water loss. Irrigation systems should be watertight and must be pressure tested at installation. Leaks from pipes and emitters should continuously monitored to reduce water loss and prevent plant death from water logging or dryness if the emitter stops receiving water.

5. Environmental Sustainability Analysis

Environmental sustainability analysis is the calculation of the water savings that will arise upon the implementation of softscaping and the installation of the efficient irrigation system. For this purpose, the USAID-funded Lebanese Water Project (LWP) developed the outdoor water reduction calculator. Fill in the calculator as per the instructions inside, print on an A3 paper (size 297 x 420 mm) and attach it to the technical study of the project proposal.

Please find attached the Water Reduction Calculator.

The steps of the environmental sustainability analysis are divided into 4 steps:

5.1 Determining Plant Water Requirement

Determining the plant water needs (evapotranspiration) is a crucial first step in properly sizing the irrigation system and ensuring high efficiency in delivering the needed amounts of water to plants without excess water consumption. Determining water needs prevents over irrigation. Using the calculated crop water requirements during irrigation can save up to 30% of the used water in Lebanon.

Evapotranspiration (evaporation from soil and transpiration of the plant), in simple terms, is the amount of water used by plants to grow and produce. It is calculated using formulas such as Penman-Monteith. Evapotranspiration is affected by: temperature, humidity, solar radiation, air speed, and air related parameters. Evapotranspiration varies with the season to reach a peak around July, August.

Plant evapotranspiration or water need called ETp is a product of ETo, the baseline evapotranspiration and Ks a plant-specific factor that varies from one plant to another.

ETp=ETo*Ks

Where:

ETp= Plant Evapotranspiration in mm/day applied per m^2

ETo=Baseline Evapotranspiration in mm/day applied per m^2

Ks= Crop Coefficient of the specific crop

An efficient irrigation system should be sized to meet the peak water requirements of the landscaped area. For this purpose, use the peak ETo of the corresponding area of the project proposal. The calculated average potential Evapotranspiration (ETo) at different climatic zones in Lebanon using Penman - Monteith Equation is attached in Annex 1.

The provided USAID-LWP Outdoor Water Reduction Calculator is based on the above system and formulas.

5.2 Determining Hydrozone Water Requirements

Since a hydrozone is an area containing plants with similar water requirements, the peak water requirements of a specific hydrozone (ET_L) can be calculated using the highest crop coefficient in that specific hydrozone.

The plant evapotranspiration (ETp) requirements need to be multiplied by the planted surface area to get the required volume of water per day for each month/growth segment in the season. The calculated volume per day is then used to determine the volume of water needed over a specific irrigation time interval.

Increases in flow and pressure to compensate for the conveyance and pumping systems should not exceed 15% of needed pressure and flows.

At the initiation phase of a garden, water requirements are a bit higher than the calculated needs. This is due to the additional needs for starting and rooting new plants.

Lawns have cooling requirements in hot summer temperatures; this is added on top of the normal requirements.

The hydrozone evapotranspiration or water need called ET_L is a product of the baseline evapotranspiration, the highest Ks factor and the surface area of the hydrozone.

$ET_L = ETo * Ks_1 * A$

Where:

ET_L = Hydrozone Evapotranspiration in mm/day

ETo=Baseline Evapotranspiration in mm/day applied per m^2

Ks_1= Highest Crop Coefficient in the specific hydrozone

A= Area of Hydrozone in m^2

Repeat this step for all the hydrozones available in the landscaped area. The evapotranspiration rate of each hydrozone should be calculated separately.

5.3 Water Savings in Hydrozones

The Water Savings of each hydrozone (in mm/day) arising from the installed efficient irrigation system is calculated as followed:

$$WS = \frac{ETL}{Hose\ Irrigation\ Efficiency} - \frac{ETL}{Efficient\ Irrigation\ Efficiency}$$

This exercise should be done for all the hydrozones.

For the irrigation methods' efficiency, please refer to Table 4.

It should be noted that this exercise allows to calculate water savings during the peak watering season.

5.4 Total Water Saving

The total water saving achieved from the efficient irrigation systems installed is the sum of the water savings achieved in the different hydrozones during the peak watering season (from May to September).

WSp= WS1+WS2+WS3+…

Where:

WSp= Total water saving during the peak watering season in mm/day

WS1= Water saving during the peak watering season in hydrozone 1 in mm/day

WS2= Water saving during the peak watering season in hydrozone 2 in mm/day

WS3= Water saving during the peak watering season in hydrozone 3 in mm/day

Throughout the year, plant water requirements are met by 2 means: rainfall and irrigation.

To calculate the yearly total water savings from the efficient irrigation system, monthly rainfall data (in mm/month) must be taken into consideration when calculating the plant evapotranspiration rate. For simplification purposes and to calculate the yearly total water saving, this guideline assumes an average of 200 irrigation days, during which rainfall is unable to satisfy plant water needs.

As such, the yearly total water saving is calculated as followed:

WSt= WSp*200 Irrigation days

Where:

WSt: Yearly total water savings from the efficient irrigation system in mm/year

WSp: Total water saving during the peak watering season in mm/day

N.B: 1 mm/year = 1 Liter/year

6. Irrigation Scheduling per Hydrozone

Areas of land to be irrigated are divided into plots/sections and irrigated one after the other and not all at the same time. A piece of land can be divided into several sections. Sections are not irrigated altogether but in rotation one after the other. Flows to each section should be almost equal. The time interval between one irrigation to another in the same section is determined by the amount of water stored in the root zone (the length of the root) and the amount of daily evapotranspiration. The root zone is considered as a reservoir that is filled with water and gradually emptied by evapotranspiration to be refilled again by the next scheduled irrigation. The root zone should only be emptied up to 40% of its content and not more, otherwise the plants will wilt. If, for instance, the root zone is 50 cm, water content in 40% of the root zone can be safely depleted before the next scheduled irrigation. As such, 20 cm of water can be depleted before the upcoming irrigation cycle. If, for instance, the specific daily evapotranspiration is 0.8 cm/day than the interval between irrigation cycles is 25 days.

Accordingly, this plot of land can be divided into a max of 24 sections that can be irrigated daily and in turn. The flow required by the pump is the flow need for one section at a time not all the garden.

Scheduling irrigation reduces the sizes of mainlines and pumps, thus reducing costs and energy requirements.

Complete and insert Table 8 in the project proposal.

Table 8 Irrigation Schedule

Hydrozone	**Root Zone (in cm)**	**ET_L (in mm/day)**	**Irrigation schedule (in days)**
1	*Insert text here*	*Insert text here*	*Insert text here*
2	*Insert text here*	*Insert text here*	*Insert text here*
3	*Insert text here*	*Insert text here*	*Insert text here*

7. Summary Table

Upon the completion of the study, complete and insert Table 9 in the project proposal.

Table 9 Summary Table

Hydrozone	**Area (in m^2)**	**Method of Irrigation**	**Peak Evapotranspiration Rate of the Hydrozone (ET_L) (in mm/day)**	**Irrigation Schedule (in Days)**	**Water Savings (in L/year)**
1	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
2	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
3	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
				Total Water Savings in L/year	

N.B: 1 mm/year = 1 Liter/year

IV. Annex

1. Annex 1

Calculated Average Potential Evapotranspiration (ETo) at Different Climatic Zones in Lebanon, (mm/day applied per m²) Using Penman - Monteith Equation.

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAX
Elevation (m)	ETO (mm/day)												
North 1 From ARIDA to BATROUN													
0-250	2.3	2.6	3.2	3.7	4.5	5.4	6.0	5.9	5.3	4.2	3.1	2.5	6.0
250-450	2.0	2.3	3.2	3.6	4.5	5.7	6.0	5.8	4.5	3.3	2.5	1.8	6.0
450-650	1.8	2.2	2.8	3.9	4.5	5.9	6.3	6.3	5.0	3.6	2.7	2.0	6.3
650-850	1.3	1.4	2.0	2.8	3.4	3.8	5.3	5.5	4.1	3.4	2.2	1.8	5.5
850-1100	1.3	1.4	2.0	2.8	3.4	3.8	5.3	5.5	4.1	3.4	2.2	1.6	5.5
>1100	0.9	1.2	1.8	2.7	3.7	4.7	5.3	5.1	3.7	2.7	1.8	1.2	5.3
North 2 From BATROUN to BEIRUT													
0-250	2.5	2.8	3.4	3.9	4.9	6.0	6.5	5.9	5.1	4.0	2.7	2.6	6.5
250-450	2.0	2.5	3.1	3.6	4.6	5.6	5.6	5.1	4.6	3.5	2.6	2.2	5.6
450-650	1.9	2.3	3.0	3.8	5.0	5.7	5.8	5.3	4.5	3.5	2.2	2.0	5.8
650-850	1.6	2.1	2.7	3.3	4.4	5.5	5.8	4.8	4.3	3.0	2.3	2.2	5.8
850-1100	1.7	2.0	2.7	3.6	4.6	6.0	6.3	4.2	4.6	3.9	2.3	1.6	6.3
>1100	1.1	1.1	2.0	2.9	3.6	5.8	6.4	6.5	4.9	3.9	2.3	1.9	6.5
South 1 From BEIRUT to SAIDA													
0-250	2.2	2.6	3.3	3.8	4.7	5.9	6.2	5.9	5.0	3.7	2.8	2.3	6.2
250-450	2.0	2.4	3.1	3.7	4.8	5.6	5.5	5.3	4.6	3.5	2.6	2.3	5.6
450-650	2.2	2.6	3.3	3.8	4.7	5.9	6.2	5.9	5.0	3.7	2.8	2.3	6.2
650-850	1.9	2.3	2.9	4.0	5.3	6.5	6.2	5.6	4.6	3.7	2.6	2.1	6.5
850-1100	1.5	1.9	2.7	3.8	5.0	6.2	6.7	6.1	4.8	3.2	2.3	1.7	6.7
>1100	1.0	1.1	1.8	2.9	3.8	5.6	6.4	6.2	4.5	3.2	1.9	1.3	6.4
South 2 From SAIDA to NAKOURA													
0-250	2.2	2.4	2.9	3.6	4.5	5.5	5.7	5.4	4.5	3.5	2.9	2.5	5.7
250-450	2.0	2.2	3.0	3.7	5.1	5.3	5.4	5.2	4.1	3.3	2.4	2.3	5.4
450-650	2.0	2.3	3.1	4.1	5.4	6.3	5.8	5.7	4.6	3.8	2.7	2.3	6.3
650-850	1.8	2.1	2.9	3.9	5.3	6.3	6.2	5.9	5.0	4.4	2.9	2.1	6.3
850-1100	1.4	1.7	2.7	3.9	5.3	6.9	7.3	5.7	5.2	3.5	2.1	1.1	7.3
North Beqaa From BAALBACK to HERMEL area													
> 950	1.2	1.5	2.5	3.6	5.4	7.2	7.7	7.3	5.3	3.8	2.6	1.7	7.7
Middle Beqaa From SHTOURA to BAALBACK													
850 - 950	2.3	2.1	2.6	3.6	4.4	5.2	6.4	6.4	5.7	6.3	3.4	2.4	6.4
South Beqaa From SHTOURA to QAROUN													
650-850	1.5	1.8	3.0	3.8	5.0	6.9	7.0	6.4	4.8	3.4	2.5	1.7	7.0
850-1100	1.4	1.6	2.3	3.2	4.7	6.6	7.1	6.7	4.7	3.4	2.4	1.5	7.1
>1100	1.1	1.5	2.5	3.8	5.3	7.2	7.2	6.7	5.2	3.2	1.9	1.3	7.2

Ref.: Nimah M., Workshop on Irrigation Principles and Irrigation System Design, AUB, 2007