Water Conservation in Arid Countries, Small Friendly Environmental Lakes and Dams, Research Study of a Small-Scale Experimental Dam Project on a Small River

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Abstract
Lebanon is one of these arid countries that need water. However, some scientists claim that there is sufficient water in Lebanon, but the reality is the contrary. This is due the fact that there is a lack of water in Lebanon. More than that current studies show that 70% of surface water goes to the sea. To solve this problem, we should have an effective technical and economical solution. For that, we have an opinion, which is under study, in order to congregate water behind small-scale dams into lakes. These lakes called mountain lakes.
We take the Alzahrani River as an experimental field research. In this river is more than 18.9 million cubic meters of water, which annually goes to the sea during wintertime and springtime.
In order to achieve this experimental small-scale dam project, we had the correct land surveying, geological, hydrological, geotechnical, and structural and environmental research information. After, we formulate these results for further research that can be typical for along side of the basin of (Al-Zahrani) River and all the small rivers of Lebanon and arid countries.

Keywords
Water Conservation; Small Gravity Dams; Mountain Lakes; Hydrogeology; Water Flow; Structure; Hydrology; Environmental Implications

Introduction
Water is becoming a scarce commodity in Lebanon and the arid countries in general. Additionally in many places even though it found in optimum amounts, there are numerous problems associated with management, distribution and quality. Conservation is a pressing issue. Small lakes behind small friendly environmental [1], dams are one solution that could alleviate this shortage and distribution in a country like Syria, Jordan, Saudi Arabia, and Lebanon, which has many rivers, that flows in most cases to the sea without proper exploitation [2]. Studies show that 70% of the surface water flows into the Mediterranean without proper and sustainable exploitation of the water resources please see the Algorithm of the water quantities in Lebanon on the figure1) [3].
Although the construction of large-scale dams de-commissioned, there is a plan to built more than ten large dams in Lebanon [4]. However, Lebanon’s mountainous topography renders itself well to the design and construction of small mountain lakes, behind a small concrete gravity or arch dams, for conservation purposes. In this paper work, we choose thee Al-Zahrani River as a pilot project, in the south of the country as a typical case in hand whereby 18.9 Mm³ of water practically flow into the sea without a clever exploitation.

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The River flows primarily during winter and spring and during the rest of the year, it practically dries up. The Al Wadi Al-Akhdar, which was a well-known touristic area and as such exploited by many restaurants is practically non-existent and the restaurants are out of business because of improper use of the River waters.

In order to conserve and have water available throughout the year it is propose to look into the feasibility of small dams along the course of the River. This might result in a better exploitation of the resource and better allocation for the various uses: agriculture domestic etc. The Al-Tasse source rends itself to such a feasibility study.

Figure 1: Algorithm of water quantities in Lebanon [1]

Table 1: The Quantities of water need in Lebanon, from this year up to year 2040 without the Syrian refugees in Lebanon

<table>
<thead>
<tr>
<th></th>
<th>Year 2018</th>
<th>Year 2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water</td>
<td>400 Mm³</td>
<td>900 Mm³</td>
</tr>
<tr>
<td>Irrigation</td>
<td>700 Mm³</td>
<td>2100 Mm³</td>
</tr>
<tr>
<td>Industry</td>
<td>100 Mm³</td>
<td>250 Mm³</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1200 Mm³</td>
<td>3300 Mm³</td>
</tr>
</tbody>
</table>

Table 1: The Quantities of water need in Lebanon, from this year up to year 2040 without the Syrian refugees in Lebanon

Objective

The objective of this study is the conservation of water, and the suitable use of the surface water such: Rainwater, rivers, sea springs, land small springs, surface water, and snow [6, 7]. This objective achieved by the construction of small concrete gravity or arch dams, and for Sea springs, achieved by the construction of marine terminals in the shoreline of Lebanon or any arid countries having these springs. This is a functional plan for the water conservation in Lebanon, and arid countries. The research about marine terminals discussed in other paper work, but our study currently concentrated on the small gravity or arch dams for mountain Lakes. In addition, the need of water in Lebanon from 2015 up to Year 2040 indicated in the table (1) below.

This figure shows according to the last research that, the need of the water conservation in Lebanon is necessary and the problem of shortages of water is evitable. In order to achieve this above motioned need of water we proposed a plan to built small gravity dams at all the small Rivers and Sprigs in Lebanon [3].

Methodology

The proposed small dam will be a small concrete gravity or arch dam. The following major investigations will conduct:

4.1. Multidisciplinary Approach

We have reached an era when the Engineer must cooperate with members of other disciplines if this pilot project completed for optimum benefits and minimum adverse effects, an example of the number of disciplines involved, relative to the Alzahrani dam project indicated in the table (2) below [1, 2, 8].

4.2. The Environmental Implications [1]

1) Land inundation: The creation of a reservoir will inundate frequently good land, and may cause people to dislodgment of people, in our project, this condition is resolved, and no loss of productivity and personal hardship.

2) Wildlife: There is no species can be destroyed during the construction period

3) Archaeology: There is no inundation of items of value.

4) Beauty: Areas of beauty will not change.

5) Retention of silt from the lower valley, which would normally enrich the land solved by excavation of shafts before the Lake

6) River Regime - a period of dry Riverbed below the dam will occur
7) Flood Warnings - alteration of natural flow can be serious to inhabitants and wildlife
8) Effects of Storage on Quality of Water
9) Fish - Nitrogen Problem
10) Water-Bourne diseases
11) Requirement of fish ladders for fish to continue spawning
12) Induced Earthquakes consequent to filling large reservoirs
13) Climatological Change.
14) Access roads during construction destroying the natural environment
15) River pollution from:
   - Waste water from excavations
   - Construction and removal of cofferdams
   - Wash water from concrete and aggregate plants
   - Oil leakage and waste disposal
   - Sewage and storm water
   - Soil erosion during reservoir cleaning
16) Other effects:
   1. Fire Risks
   2. Aesthetic appearance of final dam
   3. Air pollution
   4. Noise pollution
   5. Dust pollution

4.3. The Project Site
The site chosen for the study is the Al wadi Al-Akhdar, approximately 5 km inland from the city of Nabatieh; and 75 km from Beirut (Figures 2 and 3). The actual surveys, studies and the EIA [1] did determine the actual site of the small proposed pilot concrete gravity or arch dam. Also we select three sites for three dams, earth and concrete gravity and arch dam, and in our study we concentrate on one site on the area of En Nqaip.

The streambed elevation of the dam site is about (elevation of the waddy Alzahrani + the elevation of the dam.) which is about 540+12 meters near the area of En Nqaip. Precipitation in the Alzahrani watershed averages 700-800 millimeters per year, with virtually zero rainfall occurring from June through September. Stream flow from the watershed, in the Embouchure station only. The database taken from the Alytani office from 1965 to 1973 shows the average (0.887) m³/s. For Al-Zahrani River, the total quantities are equivalent to about (27.6) Mm³ per year, and this was before the complete exploitation of the Altasee source.

<table>
<thead>
<tr>
<th>Civil Engineering</th>
<th>Sanitary Engineering</th>
<th>Hydraulic Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Engineering</td>
<td>Electrical Engineering</td>
<td>Illumination Engineering</td>
</tr>
<tr>
<td>Air Pollution Engineering</td>
<td>Acoustic Engineering</td>
<td>Demography</td>
</tr>
<tr>
<td>Landscape Architecture</td>
<td>Construction Methods Analysis</td>
<td>Ecology</td>
</tr>
<tr>
<td>Geography</td>
<td>Environmental Engineering</td>
<td>Geomorphology</td>
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<tr>
<td>Geology</td>
<td>Hydrology</td>
<td>Agricultural Economics</td>
</tr>
<tr>
<td>Meteorology</td>
<td>Soil</td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>Forestry</td>
<td>Range Management</td>
</tr>
<tr>
<td>Fish</td>
<td>Wildlife</td>
<td>Legal</td>
</tr>
</tbody>
</table>
In addition to that, we should notice the drought during the last 13 Years, which is shows the diminishing of the monitored quantities of water.

4.4. The Geological and Geotechnical Study

Based on available information, a geologic land survey conducted. Additionally any land use plans that are available consulted. GIS and any other source of information used in view of eventually having an Environmental Impact Assessment report (EIA). Geological faults as indicated in the figure 4), which should be treated, and prepared by using the conventional method testing, or by using the non conventional methods such as electrical physics and seismic wave reflection using tomography, or by any other methods will be treated in other separated paper work [2, 9].

The reservoirs for the proposed Alzahrani dam extend about 500 meters upstream of Axis A-A on the Alzahrani River. The reservoir is not wide through its length. The stratigraphy in the reservoir is mainly a stone with marl and argillaceous interbeded. In the vicinity of the dam site, there is a sequence of interbeded limestone and marls that extends from Axis A-A upstream for about the entire riverbed at the proposed dam location, the Alzahrani River is presently cutting floodplain and terrace deposits. The present floodplain and active river deposits are only in wintertime and having maximum thickness of 50 centimeters in the River bad.

These deposits are composed of silt, sand, gravel and cobbles. These lacustrine deposits are nearly all lowly clayey soils with occasional sandy lenses of variable thickness.

4.5. The Hydrological and Hydro-Geological Study

Basic hydro geological and climatologic data has been collected and used in order to determine the availability of water and in view of planning reservoir release patterns over 12 months if possible. Studies based on a constant release during the six driest months of the year: June to November [10].

For laboratory testing, there will be close collaboration with the faculty of Engineering of the
Lebanese University and the Litany Water Authority. In addition, private engineering firms are approach for assistance in acquiring some instrumentation.

4.6. The Survey Study
A complete survey study was conducted for the lake and the dam site, and sections were taken for the lake each five meters and for the dam each one meter, please see on figure 5 and 6 respectively the complete contour line and the colored view of the Lake surface.

4.7. Financial Study and Project Costs
The construction cost estimate for this project in 2018 $ US, and the financial analyses are provided in the table 3.

Figure 5: Complete Contour Line of the Lake

Figure 6: Colored Plan View of the Lake Surfaces
4.8. Concrete Gravity and Arch Dam Design and Analysis

4.8.1 The Design [12] of Typical Dam for This Pilot Project Were Including the Flowing

1) Loads
   Primary Loads, Secondary Loads, Exceptional Loads, Load combination

2) Concrete Gravity Dam Analysis
   a) Rotation and Overturning
   b) Translation and Sliding: 1) Sliding factor, 2) shear friction factor, 3) Limit equilibrium factor.
   c) Overstress and material failure

3) Stress analysis for gravity dam
   using elastic theory, and using finite element method elastic analysis and elasto-plastic analysis.

4) Arch dam analysis
   Arch geometry and profile, constant angel profile, Cupola profile Arch stress analysis using elastic theory.

4.8.2 Using (Excel Program)
   For a suitable solution and easy calculation of each dam design (arch or concrete gravity) the excel program was used [11, 12].

4.8.3: Examples of Small Dams Considered Sites and Lakes [10] In Different Places

Conclusion and Recommendations
1) The Quantities of water needed in Lebanon up to Year 2040 are 3300 Mm³, and the available quantities of surface water not exploited are 3233 Mm³, which mean the need of these quantities of water is essential.

2) The construction of large-scale dams reevaluated internationally, and even some dams are de-commissioned, there is a plan to built more than twenty large dams in Lebanon. However, Lebanon’s mountainous topography renders itself well to the design and construction of small mountain lakes, behind a small concrete gravity or arch dams, which are friendly to the environment, and to the economy, and having excellent safety conditions.

Table 3: Construction Cost Estimate for the Project

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam Crest Elevation</td>
<td>552 m</td>
</tr>
<tr>
<td>Release Rate</td>
<td>0.3 m³/s</td>
</tr>
<tr>
<td>Water Supply</td>
<td>500,000 to 750,000 m³</td>
</tr>
<tr>
<td>Cost of Money</td>
<td>7%</td>
</tr>
<tr>
<td>Escalation Rate</td>
<td>4%</td>
</tr>
<tr>
<td>Period of Amortization</td>
<td>20 years (2018 to 2045) or decision date.</td>
</tr>
<tr>
<td>Period of Construction</td>
<td>3 years and one years for each dam (beginning in 2018), or decision date.</td>
</tr>
<tr>
<td>Construction Cost (2015), or you take the construction cost for the decision date.</td>
<td>$US 950,000.00 which are 750,000.00 for the first dams + 200,000.00 for the construction of the road and the cost for the site conversation with environmental works.</td>
</tr>
<tr>
<td>Interest During Construction</td>
<td>$US 50,000.00</td>
</tr>
<tr>
<td>Average Unit Cost of Water (2015)</td>
<td>$US 200/1,000 m³</td>
</tr>
<tr>
<td>O,M&amp;R (First Year)</td>
<td>$US 10,000.00</td>
</tr>
<tr>
<td>Annual Cost (First Year)</td>
<td>$US 750,000.00</td>
</tr>
<tr>
<td>Annual Cost (Second Year)</td>
<td>$US 500,000.00</td>
</tr>
<tr>
<td>Annual Cost (Third Year)</td>
<td>$US 500,000.00</td>
</tr>
<tr>
<td>Total Cost for three years</td>
<td>$US 1,750,000.00</td>
</tr>
</tbody>
</table>
Figure 7: Examples of Proposed Sites and Dams in Different Places on the Rivers

Arabsalim, EnNqaip proposed sites dams and lake, before and after

Ansar Lake on the AL Howe small spring, before and after

JubaaJllica Proposed site on the
3) By this pilot project (small concrete gravity dam) used for water conservation purposes, we did create a small mountain lake behind it, that can be used in addition to the drinking water, turistic, fishing and irrigation purposes.

4) This research project repeated on the same river in order to conserve all the surface water goes to the sea in the winter and spring time, at good design conditions and good costly manner.

5) This research project is applicable for every small River and springs in Lebanon or in Arab Word, Also in the all World.

6) This research project needs to be finance and achieve by the help from the local Governments, and Municipalities which they did have high interest of such project, or by the help from the International organizations.

7) For this project, we have many options for selecting sites with appropriate conditions such as large area for the reservoir that located far away from the geological faults.

8) We can avoid the realty conditions, by choosing the sites owned by local Municipalities.

9) Easley we can choose the sites applicable for (EIA) Environmental Implementation Acts.

10) In case of existing very low permeable soil, and not using geotextile as water proofing, the lake will help in slowly feeding the water table.

Reference
1. (1997) United Nations environment program, water branch, integrated approach to development, management and use of water resources. SPLIT.


