Journal of Social Sciences (COES&RJ-JSS)
ISSN (E): 2305-9249 ISSN (P): 2305-9494
Publisher: Centre of Excellence for Scientific & Research Journalism, COES&RJ LLC
Online Publication Date: 1st January 2015
Online Issue: Volume 4, Number 1, January 2015
https://doi.org/10.25255/jss.2015.4.1.726.744

Managerial Efficiency Modeling of Water use in the Republic of Lebanon

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Abstract
Lebanon is one of the few countries in the Middle East with adequate water. Rainfall is relatively plentiful and the country is blessed by several large rivers. But when the residents of Beirut and its surrounding suburbs turn on their water taps, most of the time, nothing trickles out. In summertime, the water supply can be as little as three hours per day for many households, Government negligence, waste water mismanagement, and sanitations are the most problems of the shortage of water in Lebanon.
This paper presents a detailed study of the water situation in Lebanon, as the water shortage is a serious problem that affects the life of Lebanese citizens, presented in this paper a detailed budgeting system for the water in Lebanon by measuring incomes from rains, rivers, snow, outcomes from sanitation, waste water, and mismanagement .
This paper depends on secondary data as published reports, statistics, and studies by Lebanese governmental agencies, as well as on the Lebanese water strategic planning program of 2010 of the Ministry of Water and Power that helps define different aspects of this research.
This paper focuses on the generation of solutions in the near future and the long term as well, and discusses briefly the Lebanese situation using analyzed data. Moreover, the paper's outcome is cast into a water budget which gives a future prospect for the water situation in Lebanon, and it indicates ways and means to overcome the water shortage in the country.
Keywords: Water, Water budget, Lebanon, Water Scarcity, efficient water utilization.
JEL Classification Codes:
C5; Q2; Q14; Q15; R14

Citation:
Hamdar, Bassam; Hejase, Hussin; Boulos , Joseph (2015); Managerial Efficiency Modelling of Water use in the Republic of Lebanon; Journal of Social Sciences (COES&RJ-JSS), Vol.4, No.1, pp: 726-745; https://doi.org/10.25255/jss.2015.4.1.726.744.

1. Introduction

Water has been a main issue in the international agenda for decades especially for the last 30 years. Many conferences were held for the discussion of the water issue beginning with the International Conference on Water (Mar de la Plata, 1977) followed by the International Conference on Water and the Environment (Dublin, 1992) and the First World Water Forum (Marrakech, 1997). The United Nations asked for assessments of the state of the world's fresh resources of water in the form of the World Water Development Report (WWDR), in which the Food and Agriculture Organization (FAO) interferes closely in view of the critical role of water in the human life especially in food production and agriculture. And in order to discuss the increasing water scarcity, FAO undertook to compile existing information on water resources in the framework of the Aquastat program.

1.1Existing Sources of Global Information on Water Resources

Scarce information exists on water resources at a country level. The only study conducted in the 1970s entitled "World Water Resources and Their Future" (L'vovitch, 1974) remains in use as a reference work in this field.. Other publications by Shiklomanov (1997,1998 and 2000), which are the most up-to-date sources of information on water resources regarding regional and continental level, provided data for water resources in 51 countries. More useful compilations are by Gleick (2000) and the World Resources Institute (1994 and 2000). The latter provides the most recent systematic information about water resources at a country level. It is mainly a compilation of existing information.

1.2Renewable and Non-renewable Water Resources

The following is a distinction between renewable and non-renewable water resources:

- Renewable water resources are computed on the basis of the water cycle and represent the long term flow of rivers and underground water.
- Non-renewable water resources are groundwater bodies (deep aquifers) that have a negligible rate of recharge on the human time-scale and thus, can be considered non-renewable.

1.2.1Natural and Actual Renewable Water Resources

A country's internal and external water resources; whether a surface water or groundwater generated through the hydrological cycle makes its total water amount. It is identified as natural renewable water resources and the amount is computed on a yearly basis. On the other hand, actual renewable resources vary with time and usage pattern and as a result are allied to a specific year.

1.2.2Exploitable Water Resources

Not all natural fresh water whether surface or groundwater can be accessed. Exploitable water resources consider many factors such as the economic and the environmental possibility of using dams or extracting groundwater as well as using water that naturally flows to the sea.

1.2.3Internal Renewable Water Resources

Internal Renewable Water Resources (IRWR) is a part of the water resources (surface water and groundwater) generated from endogenous precipitation. Although the hydrological cycle links all waters, surface water and groundwater are usually studied separately and represent different development opportunities. Surface water is the water of rivers and lakes; whereas, groundwater is the water captured in underground reservoirs.

1.2.4External Water Resources

External water resources are defined as part of a country's renewable water resources that enter from upstream countries through rivers or aquifers. The total external resources are the inflow from neighboring countries (transboundary flow) and a part of the resources of shared lakes or Border Rivers.

1.3The Method Used to Compute Water Resources by Country

The FAO/ Bureau de Recherche Géologique et Minière (BRGM) first described in 1996 a method to assess renewable water resources by country. A set of rules and guidelines is used to calculate it and the method consists of several steps used for each country which are:

1. The selection of the most accurate data sources
2. The assessment of the internal renewable water resources
3. The assessment of the natural and actual external water resources (outflow and inflow)
4. The assessment of total renewable water resources
5. The calculation of the dependency on external water known as the dependency ratio
6. The cross-checking inflows and outflows between countries to ensure consistency

1.3.1Water Quality and Non-conventional Water Sources

Water Quality

Physical, biological and chemical variables make water quality differences in addition to quality standards for water's purpose of use. A grid with specific criteria and variables is used to evaluate the water quality. Moreover, available brackish water used for specific purposes such as desalination and certain agricultural production can be included in the assessment of freshwater resources when it is scarce and under pressure.

2. Need for the Study

Generally, Lebanon is considered as the most water rich of Arab states. Dating back to biblical times, "the country has been known as an oasis of lush greenery and abundant water resources. (FAO, 1997) This however does not necessitate the fact that Lebanon does not suffer from water shortages. "Lebanon has the most water of any Middle Eastern country, but is subject to persistent chronic water shortages due to mismanagement and poor infrastructure."

This paper researches the water resources in Lebanon, the availability of these resources, and how these resources are used and distributed through the country.

3. Problem Definition

Lebanon's water supply and sanitation continues to face numerous challenges despite the reconstruction of its infrastructure after the deadly Civil War that lasted from 1975 to 1990 .Fifteen years later in 1990 and again during the Israeli-Lebanese war in 2006, the Lebanese water infrastructure was reconstructed to reduce water leakages and waste, and to create more efficient water distributional channels. However, water mismanagement and inefficient water uses are still posing the greatest problem for this resource.

4. Previous research

Water is the most valuable resource for the survival of human beings on earth, and the scarcity of water is an issue that might cause future tension and confrontation among the countries of the Middle East (Hamdar, 2003). Therefore, many countries are becoming

more aware of water scarcity including the republic of Lebanon. The water budget process can encompass various levels of assessment which start simple and grow more complex when there are concerns about how much water is available at any level. The higher the level, the more complex the science involved and the narrower the geographic focus. Water budgets commonly go well beyond how much water is available and where it is. They also include a detailed understanding of the low dynamics. These low dynamics include the origin and movement of ground water and surface water as well as the interaction between the two systems. This overall interdependent understanding is necessary for sound water management. Water budget studies consider the volumes of water within the various reservoirs of the hydrologic cycle and the low paths from recharge to discharge. Water budgets need to consider this information on a variety of spatial and temporal scales.
(Famigietti and Rodell, 2013) Indicated that the earth's climate is changing, and so is its hydrologic cycle. Recent decades have witnessed rising rates of global precipitation, evaporation, and freshwater discharge. Extreme flooding is occurring with greater intensity and frequency in some regions; in others, extreme drought is becoming more common. Most climate models indicate that by the end of this century, the dry regions of the world will become drier, whereas the wet areas will become wetter. Meanwhile, groundwater reserves, the traditional backup for water supplies during extended periods of drought, are in decline globally. GRACE (the Gravity Recovery and Climate Experiment, a joint U.S.-German satellite mission) monitors these variations on monthly to decadal time scales, providing detailed data on the water cycle that are an essential prerequisite for contemporary water management.

Rahgozar et al. (2012) highlighted the use of simultaneous measurements of soil moisture profiles and water table heads, along a flow path to determine evapotranspiration (ET) along with other components of the water budget. The study was conducted at a small-scale (~0.8 Km^2) hydrologic monitoring field site in Hillsborough County, Florida, from January 2002 to June 2004. Frequency Domain Reflectometry soil moisture probes, installed in close proximity to water table monitoring wells were used to derive changes in the soil water storage. A one-dimensional transect model was developed; changes in the soil water storage and water table observations served as input to determine all vertical and lateral boundary fluxes along the shallow water table flow plane. Two distinct land cover environments, grassland and an alluvial wetland forest, were investigated in this particular study. The analysis provided temporally variable ET estimates for the two land covers with annual totals averaging 850 mm for grassland, to 1100 mm for the alluvial wetland forest. Quantitative estimates of other components of a water budget, for example, infiltration, interception capture, total rainfall excess, and runoff were also made on a quarterly and annual basis. Novelty of this approach includes ability to resolve ET components and other water budget fluxes that provide useful parameterization and calibration potential for predictive simulation models.

Iturbe et al. (1999) addressed the probabilistic modeling of water balance by highlighting the soil moisture dynamics under seasonally fixed conditions at a point. Moreover, Iturbe et al. (1999) described the water balance through the representation of rainfall as a marked Poisson process which in turn produces an infiltration into the soil dependent on the existing level of soil moisture. The losses from the soil are due to evapotranspiration and leakage which are also considered dependent on the existing soil moisture. The steady–state probability distributions for soil moisture are then analytically obtained. The analysis

of the distribution allows for the assessment of the role of climate, soil and vegetation on soil moisture dynamics. Further hydrologic insight is obtained by studying the various components of an average water balance. The realistic representation of the processes acting at a site and the analytical tractability of the model make it well suited for further analyses which consider the spatial aspect of soil moisture dynamics.
To better present the importance of water and water budgets and the management of this vital resource, a formal definition of the water budget adopted by this study is as follows:

5. Definition
A water budget is a basic tool that can be used to evaluate the occurrence and movement of water through the natural environment. Water budgets provide a foundation for evaluating its use in relationship to other important influencing conditions such as other ecological systems and features, as well as social and economic components (how much water is being used by industry, residents, etc).

6. Research methods
Water budgets are developed by measuring or estimating the inputs and outputs of a hydrologic system. Inputs are the processes that add water to the system; these include precipitation and inflow from surface water and groundwater. Outputs are the processes that remove water from the system; these include evapotranspiration, the various uses of water by humans, and outflow from surface water and groundwater

6.1 Water Balance Equation
The water balance equation relates the inputs and outputs of a hydrologic system mathematically according to the law of conservation of mass. The water balance equation is given by:

(Input) – (Output) = (Change in Storage) (1)

Or, in finite difference form:

(Input) – (Output) = $\Delta S/\Delta t$

Where: ΔS = change in storage

Δt = time interval over which water budget is evaluated

This means that, in any given period of time, the difference between the amounts of water entering and leaving the watershed equals the change in the amount of water stored in the watershed. The terms in the equation can be expressed in units of volume (e.g., cubic meters (m3)) or units of equivalent depth over the area of the watershed (e.g., millimeters (mm)).Since there are several types of inputs and outputs, the above equation can be expanded to represent each input and output as a separate term. The expanded water budget equation can be given by:

(P + Gnet) – (ET + Qnet + Dnet + Wnet) = ΔS[1]

Where: P = precipitation

Gnet = net groundwater in

ET = evapotranspiration

Qnet = net streamflow out

Dnet = net diversions out

Wnet = net human withdrawals

ΔS = change in storage

Except in very simple cases, the terms of this equation cannot be estimated without uncertainty to consider the terms as estimated long-term values and to include a residual term (“Residual”) in the equation. The residual term includes the errors and uncertainties associated with estimating the water budget components and, in some cases, can include other terms of the water budget equation that cannot be measured or estimated by other means (e.g., the estimation of Gnet in the absence of reliable groundwater flow models).The following equation was used as the basis for developing the water budgets presented in this section:

$(P + Gnet) – (ET + Qnet + Dnet + Wnet) \pm \Delta S = Residual$

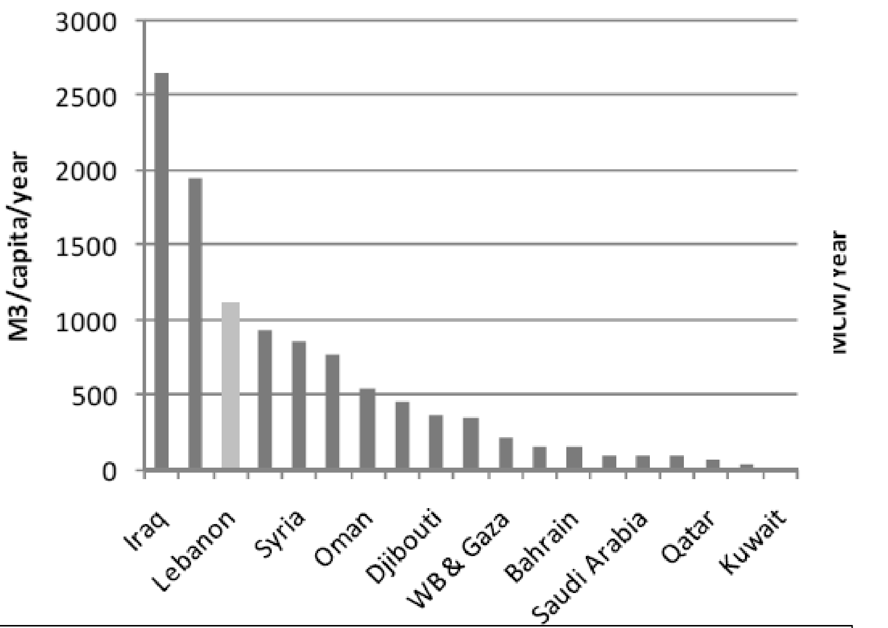
The water budget equation is applied to a fixed volume in space (control volume) that corresponds to the plan area of a watershed. The top and bottom surfaces of the control volume are the plan area of the watershed, and the sides are defined by projecting the Water budgeting for abstraction, allocation

7. *Water Budgeting in Lebanon*

7.1 Water Budgeting

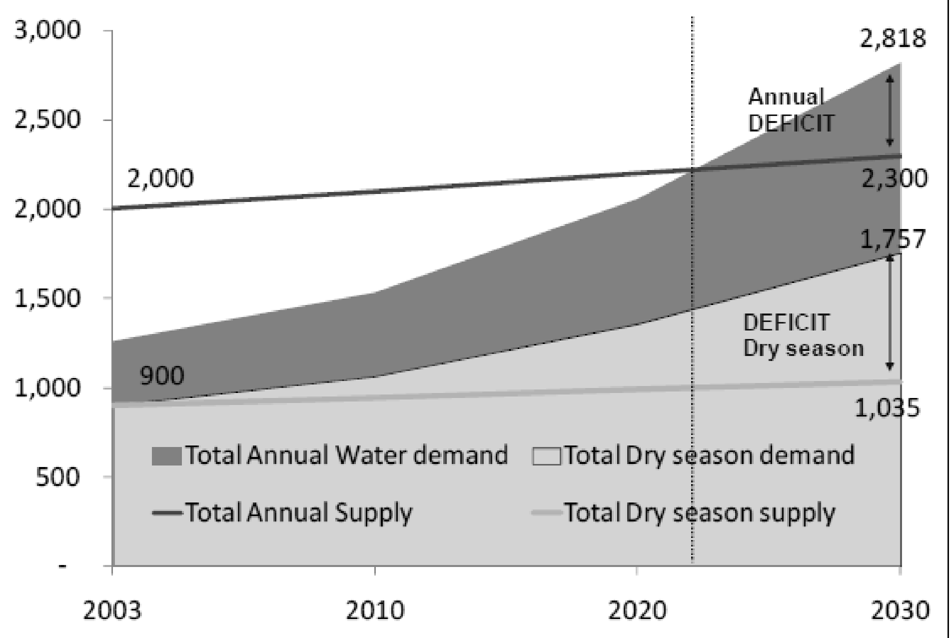
Lebanon has diversified water resources compared to close by countries. It is among the countries with the highest total renewable water resources in the region, second only to Iraq and Iran. (Figure 1) Nevertheless, Lebanon faces water shortages during the dry season which extends over four months between July and October due to the following factors: very low water storage capacity, high amount of water lost to the sea, growing demand for water, and deficiency of existing water networks. About 0.7 Billion Cubic Meters (BCM) of runoff rain water is currently lost to the sea every year. It is estimated that the seasonal imbalance of water resources will lead to chronic water shortages by 2020**,** unless actions are taken to improve efficiency and increase storage capacity (Figure 2)

Figure 1 Total Renewable Water Resources Per Capita



Source: FAO AQUASTAT 2003-2007.

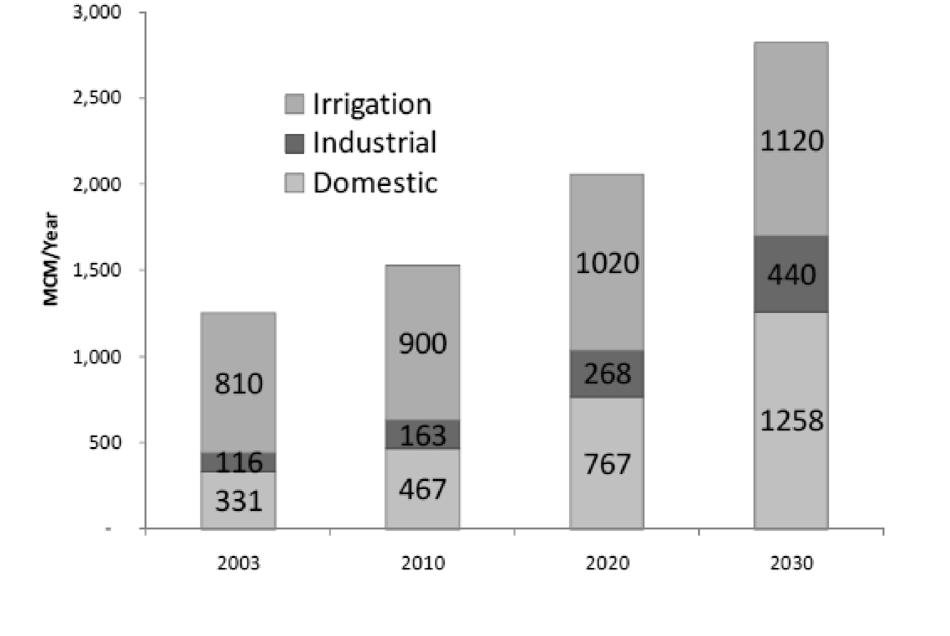
Figure 2 Annual Water Demand-Supply Balance



Source: World Bank 2003.

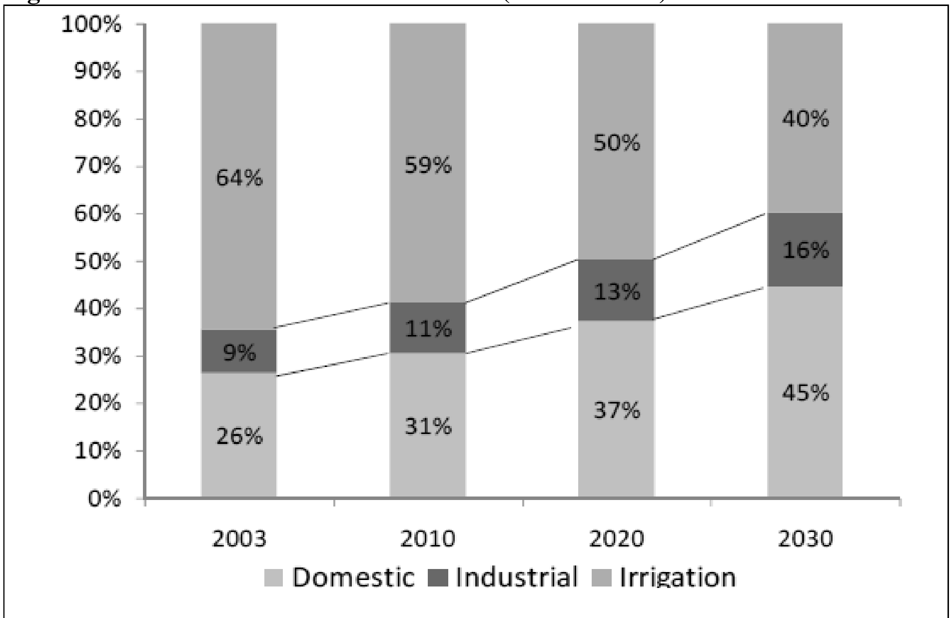
The composition of water demand is expected to change over the next 20 years as it will be largely driven by the increase in domestic and industrial demand. Currently, agricultural irrigation is the largest user of water resources, which accounts for 64 percent of water demand in Lebanon. However, this trend is expected to be reversed over the next 20 years, as domestic and industrial water demand are anticipated to grow at about 5 percent per annum, much faster than irrigation water use, which is estimated to grow at about 1 percent per annum. Moreover, domestic water demand, which represents 25 percent of total demand, is expected to exceed irrigation demand by 2030. Domestic water demand is largely driven by increase in income and population, forecasted at 2.5 percent per annum. This rush in industrial demand is due to the growth in the tourism industry which has experienced a renewal since the end of hostilities against Lebanon. (Figure 3 and Figure 4)

Figure 3 Annual Water Demand 2003-2030 (Million Cubic Meters (MCM)/Year)



Source: World Bank 2003. MCM = million m3

Figure 4 Annual Water Demand 2003-2030 (share of total)



Source: World Bank 2003.

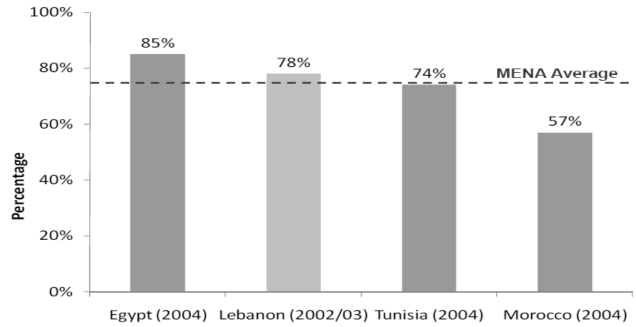
The inadequacy of public water supply to meet the country's growing water needs has led to a shift toward private solutions for water supply, and these widespread unregulated private sources of water supply has accelerated the depletion of water resources. It is estimated that about 70 percent of wells are currently illegal due the lack of enforcement of licensing requirements. (World Bank 2003) Therefore, in the absence of effective regulation end enforcement, reliance on private water supply has accelerated the depletion of water resources, and has led to over-abstraction of groundwater.

7.2Water Supply

Public water provision accounts for only 25 percent of total sector revenues and the largest share goes to private operators. Despite the critical role played by private operators, there is very limited reliable information that can be drawn upon to assess the private segment of the water market. It is known that all connected households in Lebanon rely on a combination of public and private water supply to meet their daily water needs.

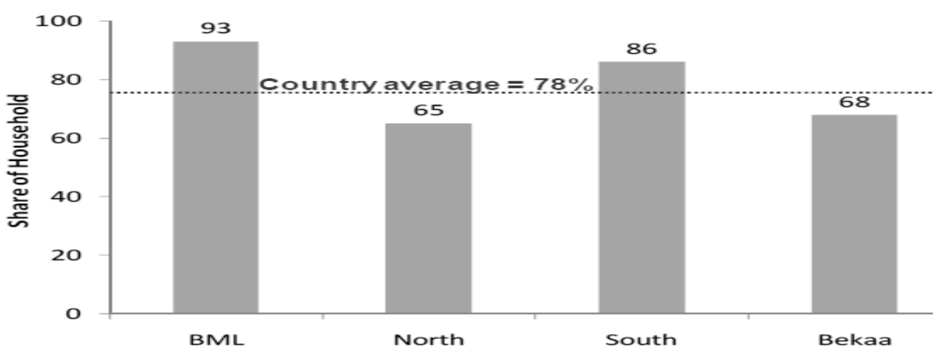
Public network coverage is relatively high where about 78 percent of the Lebanese population is connected to this network. Water service coverage in Lebanon is in line with the average in Middle East and North Africa (MENA) countries, excluding GCC countries. (Figure 5) Connection rates range from 93 percent in Beirut Mount Lebanon (BML) to 65 percent in the North. The BML RWA (Regional Water Authorities) is the largest public network, serving a population of 1.8 million, which is 60 percent of total connected households in Lebanon, but continuity of water supply is low.

Figure 4 Household Connection Rate, Selected MENA Countries



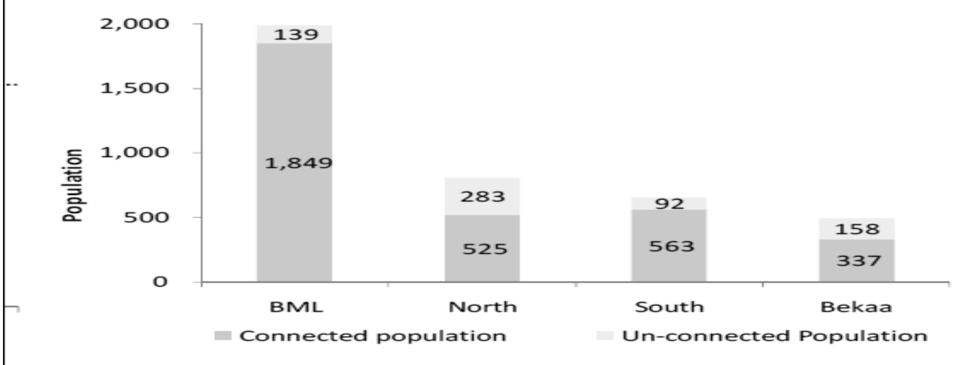
Source: Lebanon: CDR 2002/03. Other countries: WHO/UNICEF Joint Monitoring Programme. Note: MENA average does not include GCC countries.

Figure 5 Household Connection Rate, by RWA (2002)



Source: CDR 2002/03.

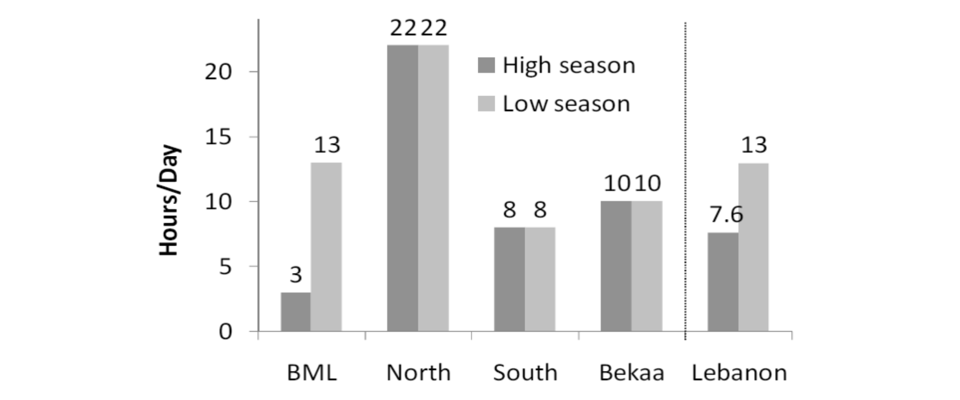
Figure 6 Connected Population by RWA



Source: 2008 population estimated based on CAS 2004 and WDI data; 2002/03 connection rate is based on CDR 2002/03 data.

In contrast with the relatively high connection rate, continuity of supply is low, ranging from 3 to 22 hours of daily water supply during the summer season. (Figure 4.7) The BML RWA, which has the highest connection rate, provides only 3 hours of daily water supply in the summer season; whereas, the North RWA has the highest continuity of supply which is 22 hours. Moreover, Tripoli is the only urban area that benefits from 24 hours of daily water supply which accounts for about half of the total population in the North region. This is a result of efficiency improvements delivered by the private operator of the North RWA under a 5-year management contract.

Figure 7 Continuity of Supply by RWA Low and High Season (2008)

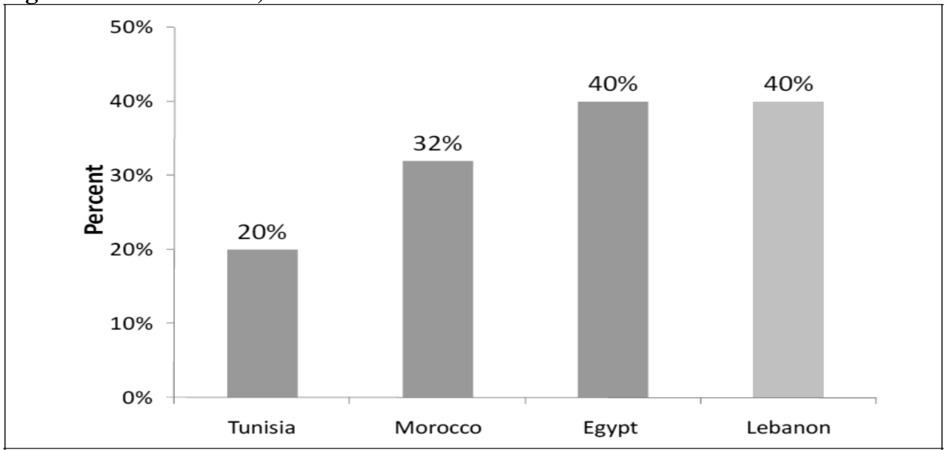


Source: World Bank 2007b.

An accurate estimate of physical water losses, which are above optimal level in Lebanon, is not possible due to the lack of metering. The average level of losses across the four RWAs is estimated at about 40 percent, significantly above losses in Tunisia, 20 percent, and Morocco at 32 percent (Figure 4.9).

The high water losses due to low operation efficiency and inadequate maintenance, as well as technical deficiencies due to lack of metering. Recently, successful attempts have been made by the North and South Water Authorities to reduce unaccounted losses where the North RWA has managed to reduce water losses in Tripoli by contracting out Operations & Maintenance, O&M, functions to a private operator during 2004-07. The four-year management contract with the private operator has led to great efficiency improvements and reduced water losses. Moreover, the South RWA has taken a different approach to water loss reduction through the piloting of domestic metering in the city of Saida. The metering program is expected to be rolled out from the city of Saida to cover 75 percent of the connected population by 2013 (South Business Plan, 2008)

Figure 8 Water Losses, Selected MENA Countries



Source: Lebanon: estimate; Other countries: World Bank 2008.

Collection efficiency of water varies to a significant extent across the four Water Authorities, from 11% of billed revenues by Bekaa RWA to 80 % by BML. It is on average 70 percent, slightly below the 80 percent MENA average. This relatively high country average masks the significant variations across the Regional Water Authorities.

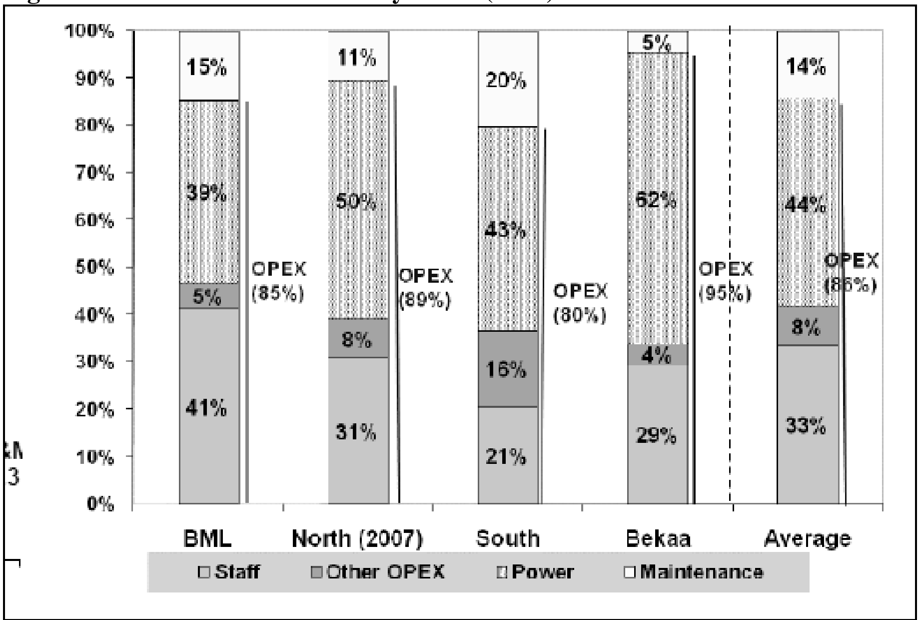
Despite the progress made since their establishment, the Regional Water Authorities are not yet performing as financially autonomous entities. Before the year 2003, water authorities were receiving precise government transfers to pay for their salary costs and were also not law-abiding on their electricity bills, with the exception of the BML RWA. Power charges were completely financed as no action was taken by the electricity provider to recover payment from the water authorities. Currently, water authorities are able to cover their salary costs and part of their power charges.

Based on the latest information available, the Bekaa RWA is the only authority which is still non-law abiding on its electricity payment; whereas, the BML RWA pays its electricity bill in full, while the other two water authorities have been able to pay a part of their power charges. The Ministry of Energy and Water (MOEW) is however indirectly subsidizing the O&M costs of the water authorities by managing service contracts for pumping stations under the jurisdiction of the RWAs.

In 2009, USD 2.4 million was paid by the MOEW for service contracts in three RWA the North, South and Bekaa. However, the service contracts managed by the MOEW in the RWAs' service areas are not reported in the balance sheets of the RWAs as subsidies, and are therefore not included in the financial performance analysis of the RWAs.

The BML RWA is the only utility that is able to recover O&M costs from its annual revenues .The BML RWA's working ratio compares favorably with other utilities in the MENA region .The North and South RWAs are able to recover O&M costs excluding power costs, which account for 43 and 50 percent of their total O&M costs respectively. Even by excluding power charges, the Bekaa RWA is unable to recover its O&M costs. Moreover, the Bekaa RWA has a working ratio of 7.5 including power costs, which is the highest working ratio among the MENA utilities for which financial information is readily available.

Figure 9 O&M Cost Breakdown by RWA (2008)



Source: Authors' calculations based on RWA submissions. 2008 data unless otherwise stated.

The BML Water Authority is the most efficient of the four Authorities. In spite of the relatively high water losses of 40 percent and the low continuity of supply, which is 3 hours/day in the summer season, the BML RWA is the best performing among the four Regional Water Authorities. It is the only agency that can fully recover its O&M costs from collected revenues, and partially recover an allowance for capital expenditure with a cost recovery ratio of 226%. Both connection rate and collection efficiency are in line with the average for MENA countries. However, significant improvements are necessary to bring the BML WA's performance in line with MENA utilities in the area of water loss reduction and continuity of supply.

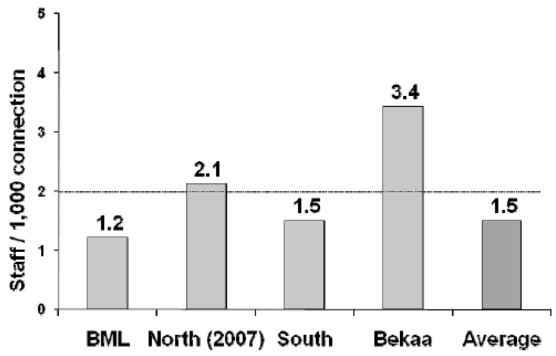
The Bekaa RWA is the worst performing Authority in all performance areas with low collection efficiency at only 11 percent, high water losses reaching 40 percent, and only 13 percent of recovered O&M costs through user fees. (Figures 4.10-4.13)

7.3Cost Structure

Power charges account for the largest share of O&M costs in three out of four RWAs, Power charges range from 0.2-0.4 USD/m3. Operational costs, staff and other OPEX, account on average for 41 percent of these costs. Moreover, power charges are the biggest cost items for the South, North and Bekaa RWAs. However, until recently the three Water Authorities were not paying their electricity bills. As aforementioned, the Bekaa RWA is the only Water Authority that is still fully delinquent on its electricity bill.

Whereas, staff costs represent the biggest cost item for the BML RWA, despite a relatively low staff per 1,000 connection ratio at 1.2.

Figure 10 Staff per 1,000 Connections, by RWA (2008)



Source: Authors' calculations based on RWAs' submissions. 2008 data unless otherwise stated. Note: staff per 1000 connection cannot be interpreted as a measure of productivity in the context of Lebanon, given that the Water Authorities do not have yet full discretion on the hiring of technical staff.

In the absence detailed financial statements, the study has relied on the utilities' business plans for this part of the analysis, which is done for illustrative purposes. The South and BML RWAs report in their business plans an allowance for capital costs, whereas the remaining Water Authorities do not factor in capital costs in their revenue requirements.

The BML RWA includes depreciation, debt service and a capital reserve fund allowance in its revenue requirement, for a total of 0.4 USD/m3. However, the South RWA adds a capital expenditure allowance to its cost base for a total of 0.1 USD/m3. Despite the overall good financial performance, the BML cannot achieve full cost recovery when depreciation and debt service are added to the revenue requirements as it averages about 82 percent when the capital cost allowance is included. Moreover, unit cost analysis suggests under-spending on maintenance and technical staff. Therefore, relative low maintenance cost combined with high water losses may indicate under-spending on critical expenditure items, in particular maintenance and technical staff.

Based on best practice, maintenance costs should represent about 20-30 percent of total O&M costs. Currently, maintenance expenditure represents the lowest cost item for the RWAs accounting for about 14 percent of total O&M costs (Figure 4.15). Inadequate maintenance has an adverse impact on the sustainability of the capital program, and eventually leads to a deterioration of the asset value and increased water losses. Moreover, the average number of staff per 1,000 connections is below the accepted norm of 2 staff/ 1,000 connections for the BML and South Water Authorities (Figure 17). The finding is consistent with the general consensus that shortage of technical staff is one of the main constraints to the efficient operation of the Water Authorities.

7.4Tariffs and Pricing Policy

The unit price per m3 of water sold is adequate to cover O&M costs. The current domestic tariff structure is based on a fixed annual fee for a contractual volume of water of 1 m3/day. This fixed annual fee varies between 140,000 LBP (Bekaa RWA) to 200,000 LBP (BML RWA) for residential customers. (Table 1)

Based on total billed revenues, a unit price per m3 of water sold is calculated taking into account the estimated level of water losses of 40 percent. The analysis shows that the unit price is sufficient to recover the unit O&M cost of service provision. Thus, suggests that low billing collection is the main contributor of the poor financial performance of the Water Authorities. A notional unit price is also calculated based on an efficient level of leakage, which is 20 percent. The difference between the actual and notional unit price represents the premium that customers are paying for the higher than optimal level of leakage. The highest premium is paid by customers in the BML region, where the difference between notional and actual unit price is USD 0.4/m3.

Table 1 Water tariffs by RWA (annual fees, LBP)

	BML	North	South	Beka'a
Annual fee (based on 1m3/day)	200,000	180,000	175,000	140,000
Gauge maintenance	35,000	10,000	25,000	20,000
Total	**235,000**	**190,000**	**200,000**	**160,000**

Note: does not include government VAT (10 percent) and stamp fee (1,000 LBP).
Source: RWA submissions.

Tariffs are de-linked from both consumer demand and the economic cost of service provision. Poor performance in the water sector is due to accountability failures. However, technical conditions such as the current pricing structure and the lack of metering have also contributed to uneven incentives in the sector.

Water tariffs are based on a flat fee and the current pricing structure creates a "double jeopardy" where the current tariff system does not provide incentives for demand management or irrigation efficiency improvements, nor does it provide commercial incentives for Water Authorities to reduce water losses and increase water production. Since, an increase in water production would not be associated with increase in revenues. This misalignment of incentives results in a rationed demand for a significant segment of the customer base, high water losses, and ultimately poor utilities' financial performance.

7.5Private Sector Participation

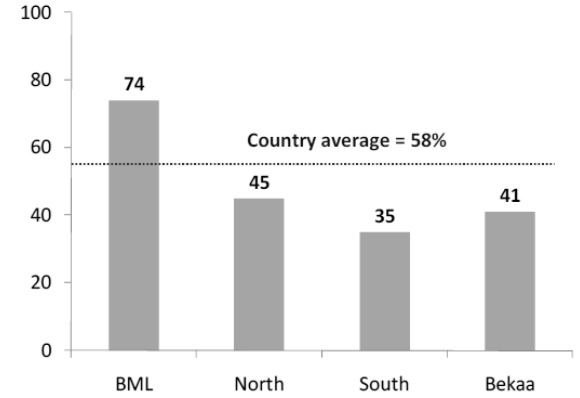
Private sector participation in the form of a management contract has delivered significant efficiency improvements in the Tripoli urban area. The North Water Authority has experimented with private sector participation to improve operational efficiency in this area and the Water Authority delegated to a French company the management of water distribution, O&M, and billings collection for the potable water system in Tripoli on a trial basis for the period 2003-2007.

The most remarkable achievement of the private operator has been the significant reduction of water losses and the extension of 24 hours of daily supply to the entire urban area of Tripoli due to upgrade and rehabilitation of the network. However, the private operator was unable to increase billings collection to the cost-recovery level, despite its effort to recover fee debts. The parties were unable to reach an agreement for the extension of the management contract, which ended in 2007. Failure to re-negotiate the contract was contributed to the difficulty of operating in an uncertain institutional environment.

7.6Wastewater

The development of the wastewater sector is still at a developing stage. Regional Water Authorities have yet to take full responsibility for wastewater collection and treatment. The un-finished reform agenda has contributed to institutional uncertainty and fragmentation of functions. Wastewater services are provided and financed by municipalities through own-source revenues and small private sector operators. Moreover, large municipalities generally have sewerage networks and where a large number of small cities lack such infrastructure. In addition, most of the networks are very old, either damaged or undersized. For these reasons, wastewater collection coverage is insufficient, averaging just 58 percent nationwide and widely varying across regions.

Figure 11 Wastewater Collection Coverage, by RWA (2002)



Source: CDR 2002/03.

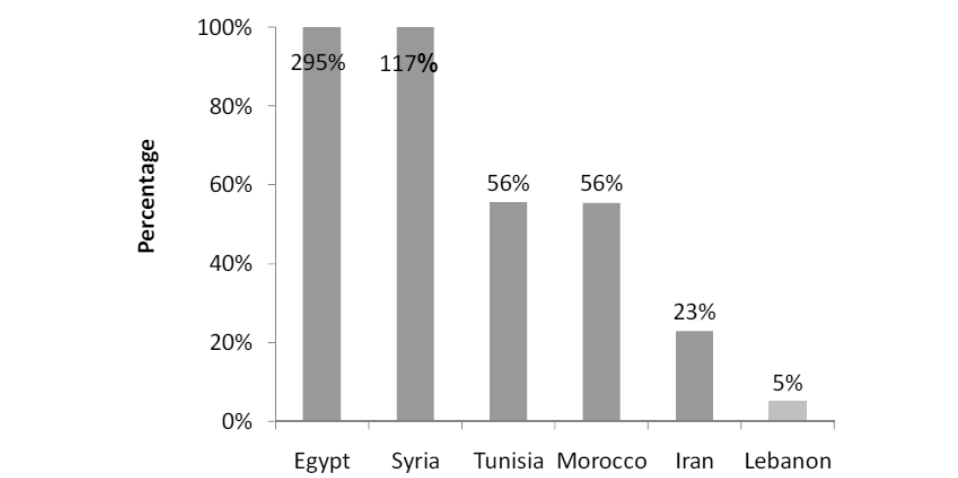
Wastewater treatment facilities are in severe shortage and most of the collected raw wastewater is discharged untreated. Despite efforts in the recent years to increase the amount of wastewater treatment facilities, there are still few treatment plants in operation, all of which are small. Several larger WWT (Waste Water Treatment) plants have been developed in coastal areas by the CDR (Council of Development and Reconstruction), but are not yet operational because of limited capacity and unfinished water supply network. It is the position of the CDR to hand over WWT plants, once they are completed, to the MOEW. The MOEW is responsible for managing the operation and maintenance of the plants, as the RWAs do not have yet the capacity to operate them. In practice, the MOEW contracts out operation and maintenance to the private sector or municipalities. Latest data from the RWAs suggests that there are currently 24 primary treatment plants in Lebanon, out of which only 12 primary are operational, 6 in Beirut-Mount Lebanon and 6 in the Bekaa. The Baalbek wastewater treatment plant financed by the World Bank to serve about 15,000 people was completed in 2000, but is not yet operational due to delays in the construction of the network. Secondary treatment is inexistent for the time being, although the pre-treatment plant of Ghadir, located South of Beirut is being currently upgraded for secondary treatment. The cost to the environment of wastewater discharges is high and no improvement measures have been taken. Due to the lack of treatment facilities, collected wastewater and industrial

wastes are currently discharged without treatments into rivers, vacant land and the Mediterranean. The cost of environmental degradation caused by untreated wastewater discharges is estimated at more than 1 percent of Gross Domestic Product (GDP) (World Bank 2004b). So far, no major measures have been taken to improve high environmental costs. Moreover, monitoring of water quality is not under-taken systematically, regulatory instruments are inadequate to meet the sector challenges, and enforcement capacity is low. (World Bank 2003).

7.7Irrigation

Water storage capacity is inadequate to meet irrigation water demand and is far below the level of other MENA countries. The dam capacity accounts for only 5 percent of total renewable water resources in Lebanon, against 56 percent in Morocco and almost 300 percent in Egypt. (Figure 4.17) The lack of adequate water storage capacity is a constraint for irrigation water demand, which accounts for more than 60 percent of total water consumption. The planned investments in water resource management are expected to increase irrigation potential by 30-50 percent by 2030, and to lead in turn to a significant increase in agriculture production. It is also expected to prompt an increase in high-value crops for the international markets. Concerns have however been raised about the feasibility of the planned investment program given the low absorptive capacity of the sector and the fiscal pressures faced by the country. If fiscal or implementation constraints become binding, the downsizing of the investment program will require a coordinated initiative to prioritize investments, as planning and execution responsibilities are shared between the MOEW and the LRA (Litani River Authorities).

Figure 12 Dam Capacity: Percentage of Total Renewable Water Resources (Km3/Year), Selected MENA Countries



Source: FAO ACQUASTAT 2003-2007.

There are several organizations responsible for O&M in the irrigation sector. About 50 percent of irrigation schemes suffer from lack of proper maintenance. Given the fragmentation of the sector, pricing policies vary to a significant extent depending on the scale of the irrigation scheme and the agency involved. A systematic evaluation of the scheme performance cannot therefore be conducted given the lack of accurate data. A review of 45 schemes conducted by the World Bank in 2003 provides however valuable information on the performance of the schemes. Large irrigation schemes operated by LRA achieve full cost recovery due to the surplus of revenues generated by the power business. About 50 percent of small and medium irrigation schemes suffer from lack of proper maintenance. Many small schemes, which are operated by Local Water Committees, do finance part of O&M costs, and are generally well maintained, especially when farmer groups are involved (World Bank 2003). The review suggests that the formal establishment of Water User Associations as a platform to involve farmers in the maintenance of irrigation schemes could significantly improve the sustainability of irrigation investments.

The financial autonomy of the LRA largely depends on a cross-subsidy between hydro-power and water supply. Revenues generated from irrigation are inadequate to cover their

O&M costs. Despite recent improvements, the working ratio is still close to 3, which is well above cost-recovery level. The power business is instead generating surplus revenues with an average working ratio of 0.2. Failure to recover irrigation costs is largely due to the pricing policy, as tariffs are currently set below cost recovery level. In 2007, the unit irrigation tariff amounted to less than half of unit O&M costs.

18. Conclusion

Despite Lebanon's diversified water recourses, its water has become an issue of major importance where more stress is placed on the quality and quantity of these resources with increasing demand for water, unsustainable water management, pollution, new climate change, inefficient wastewater treatment, scarcity of water in the MENA region, and high amount of water lost in the sea. Hence, the water sector in Lebanon will be exposed to chronic water shortages starting 2020 if proper actions are not taken to balance supply and demand.

Moreover, Lebanon's geographical location and climate made it one of the most important water sources in the eastern Mediterranean. The public water network is connected to 78% of the Lebanese population but represents only 25% of the total sector's revenues, while the private sector accounts for the remaining 75%; whereas, the main sources of private water are private bottled water with a 35% share of household expenditure, followed by delivery trucks and small water bottles with 21% and 16% respectively. Hence, households rely on the public and private water supply as the public water supply alone does not meet consumer needs. However, consumption of gallons and bottled water remained low despite the high level of expenditure as the unit price of private water are way above the average unit price for public water supply.

The Lebanese government, in its attempts to control the loss of water, has constructed many dams such as Qaraoun dam on the Litani River, one of the largest dams in Lebanon that is used to manage the flow of river water for agriculture and generation of electricity, Assi Dam, Damour Dam. Others are under implementation such as Basri Dam on the Awali River, and Khardali Dam.

Finally, fresh water resources are becoming ever scarcer in the world. As population growth and climate change takes its toll on available supplies, the world must look on to ways of effectively curbing these effects and securing their water resources. This is particularly the case with the Middle East, where the scarcity of the resource poses a problem and where the forecasts seem grim. To avoid any rising conflicts, regional cooperation must lead to the development of all available water resources and ensure that they are not wasted. The mismanagement of the resource by the government caused by a lack of financial and technical means is leading to an extremely valuable waste in water that could be easily transported and utilized elsewhere. Ultimately, water must be viewed for its worth, as a resource that creates and sustains life and as such must be managed properly to ensure that every bit of it is nourishing and sustaining life in the region, and more extensively on planet earth.

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