MIDLLE EAST WATER CONSERVATION AWARENESS PROJECT: BEST PRACTICES RESEARCH

ACADEMY FOR *EDUCATIONAL DEVELOPMENT*

BACKGROUND REPORT

Ra'ed Daoud
EnviroConsult Office
Amman - JORDAN

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I. JORDAN IN BRIEF

Jordan has a total area of 8.9 million hectares (89 thousand square kilometers), and a population of 4.1 million inhabitants (1994 census) The greater part of Jordan consists of an extension of the Arabian high plateau desert. Jordan's towns and villages are concentrated within a narrow triangle of land between the Syrian border, the Jordan Rift Valley and the Eastern Jordan hill range on which the capital Amman lies. Jordan's only port is Aqaba on the Red Sea, in the south of the country, about 350-400 km away from the major population centers.

Jordan consists of three distinct geographic regions, from west to east as follows:

The Jordan Rift Valley Region - This gigantic fault extends from lake Tiberias in the north to the Gulf of Aqaba in the south. This region has the unique distinction of being the lowest depression on Earth, where, in the Dead Sea area, it reaches a maximum of 400m below sea level.

The Mountain Heights Region - The central part of the country, east of the Rift Valley, with mountains reaching heights of 1200 - 1500 meters, and characterized by relatively mild weather and winter rains; this is the area where more than 90% of Jordan's population live.

The Eastern Desert Region (the Badia) - This extensive region comprises most of the country. It links with the Arabian Desert at the borders of three Arab countries, Syria, Iraq, and Saudi Arabia from the north, east and south, respectively.

These dissimilar physiographic regions explain a climatic variation that is found within the restricted area of Jordan.

Jordan is strategically located at the heart of the Middle East region and for centuries it served as a corridor connecting the three continents: Asia, Europe, and Africa. As a result, the country has a diverse and rich archaeological and historical heritage.

Jordan's natural resources on the other hand, are limited and in many locations appear to be insufficient to support its population in a sustainable manner.

Jordan experiences grave water shortages. Average rainfall is limited to 70-80 mm per year, with the mountainous region getting most of the rain. The country does not have rich regional or local rivers either. The River Jordan, which is the most historically well known river in the world, is polluted and saline, and runs almost dry for most of the year, while the flow of the Yarmouk River, which feeds the River Jordan, has been greatly reduced by activities upstream. Water shortages, in particular, led to grave environmental strains and also to water mining from renewable and fossil water sources, all this is already having very serious environmental implications. Preserving water quality has become as much challenge as increasing and procuring new sources. Thus, management of water resources is Jordan's main environmental challenge.

II. BACKGROUND

A. Current Water Demand and Future Projections

According to the 1994 official census, the total population of Jordan was recorded as being 4,095,579. Over 90% live in the North Western part of the country, and over half the population is concentrated in the two governorates of Amman and Zarqa.

Jordan's population growth has increased rapidly during the past four decades reaching up to 3.8% per year, and was greatly affected by the Middle East crisis during that period. These include the Palestinian refugees in 1948, followed by the additional population inflow in 1967, and the latest Jordanian and Palestinian returnees as a result of the Gulf War in 1991. This growth rate is almost double the world average. However, it is anticipated that the population growth rate in Jordan will tend to decline. According to National Population Commission (NPC), the projected natural growth rates in the year 2000 will be 2.7% (the difference between birth and death rates). Jordan's population in the year 2020 will increase to about 9.6 million and 16.1 million in the year 2040.

The Water Authority of Jordan (WAJ) provides the municipalities of Jordan with their water supply. In 1995, water produced by WAJ for all municipal users totaled 240 million cubic meters (MCM) including the unaccounted-for-water (water lost by leakage, metering errors, and illegal connections), which corresponds to about 147 liter per capita per day (l/c/d). Assessments made by WAJ and other studies concluded that the current average per capita demand in Jordan is 185 l/d. Table (1) provides analysis of current per capita demand in Jordan. The table shows that the current leakage at about 30 % (44 l/c/d of water production), water shortage per capita is 38 l/c/d (almost doubled during summer months), and per capita demand without losses is 142 l/c/d[1]. The table also shows that demands were not met and that residents experienced water shortages.

Table (1)
Per Capital Water Demand Analysis in Jordan

Total Population	4,095,579
Total water supply (produced during the year 1994 MCM / yr)	219.893
Water produced per capita per day	147
Unaccounted for water @ 55%	81
- Leakage @ 30%	44
- Metering errors & illegal connections @ 25%	37
Water consumption per capita per day (billed water) , l/c/d	66
Water shortage per capita per day, l/c/d	38
Per capita demand without losses, l/c/d	142
Per capita demand with losses, l/c/d	185

Source: Feasibility Study Report "The Water Conveyance System From Disi-Mudawara to Amman", , July 1996 (Approved by WAJ)

[1] Hurza Group, Sir Alexander Gibb & Partners Ltd., Dar Al-Handasasah, and Consolidated Consultants, "*The Water Conveyance System From Disi-Mudawara to Amman*", *Feasibility Study Report*, July 1996.

The current leakage from water distribution network is estimated at 30% of water production. The Water Authority of Jordan is concerned about the high amounts of leakage in Jordan, and have set targets to reduce leakage to 15% by the year 2015. Table (2) shows the current and target percentages of leakage in Jordan.

Table (2)
Leakage Reduction Targets

Year	Leakage %
1995	0.30
2000	0.25
2005	0.20
2010	0.18
2020	0.15
2030	0.15
2040	0.15

Note: Leakage reduction targets are according to the Water Authority of Jordan.
Source: Feasibility Study Report "The Water Conveyance System From Disi-Mudawara to Amman", July 1996.
(Approved by WAJ)

Currently, municipal water is scarce and is rationed during summer months in most municipalities. The annual average increase in per capita demand will continue to be suppressed by water shortages due to difficulty of obtaining new sources and the growth of population.

In general, the trend of increase in per capita demand is 1 to 2 liters per year. This increase is a result of improving levels of service and the standards of living. In suppressed cases, one liter increment in per capita municipal demands in Jordan is appropriate.

Table (3) presents projected per capita demands in Jordan which are based on current demand, demand increment, and leakage targets. The per capita demand in Jordan will increase from 185 l/d in 1994 to 192 l/d in 2020 and 215 l/d in 2040. However, these demands are considered suppressed and even very conservative compared to other Middle Eastern countries that are without water scarcity problems.

Table (3)
Projected Per Capita Demands in Jordan

Year	Demand (l/c/d)	Losses (Leakage)	Demands & Losses (l/c/d)
1995	142	30%	185
2000	147	25%	184
2005	152	20%	182
2010	157	18%	185
2015	162	15%	186
2020	167	15%	192
2020	177	15%	204
2040	187	15%	215

Source: Feasibility Study Report "The Water Conveyance System From Disi-Mudawara to Amman", , July 1996 (Approved by WAJ)

In the *Greater Amman Water Supply and Distribution Study*[2], WAJ and Dorsch Consult found that 80.7 MCM has been supplied to Greater Amman in 1994. Of this amount, 23% (18.6 MCM) was estimated as physical leakage. They estimated physical leakage from the only available field measurements of leakage in the Amman water system which were conducted by the French consultant Sogreah in the late 1980's. The population served by the Amman municipal water supply totaled 1,487,300 in 1994, as reported by Dorsch.

According to a study conducted by Harza[3] , the adjusted per capita consumption in Amman (water supplied minus physical leakage in transmission and distribution) was estimated to be 115 liter per capita per day (lpcd). Harza assumed that a nominal annual increase of 1 liter per capita per year is likely to occur due to a rising standard of living.

The water supply in the Zarqa Governorate was studied by the Japan International Cooperation Agency (JICA) in 1995. The total population served by the Zarqa municipality's water supply system was 532,700 in 1994. The JICA analysis of WAJ data showed that water supplied by WAJ had increased from 97 lpcd in 1989 to 113 lpcd in 1994. Metered consumption was between 50 and 55 lpcd, and unaccounted for water (UFW)* increased gradually from 49% in 1989 to 54% in 1993. The UFW was estimated to be 15-30% physical leakage (determined from field measurements) and 20-30% administrative, related to meter tampering, meter reading, and billing. A household survey found that summer consumption (metered) was 72 lpcd in Zarqa and 52 lpcd, under rationing, in Russaifa. In winter, consumption (metered) was 57 lpcd in Zarqa.

Future consumption was assumed to increase by 10-15 lpcd over 20 years, resulting in 90 lpcd (domestic water demand as metered) as the future average annual supply target for the year 2015. This was based on the present metered consumption of 52 lpcd with increments of increase due to :

1. Reduced household size (+2-3 lpcd)
2. Continuation of poor flush toilet (0 lpcd)
3. No change in laundry and bathing habits (0 lpcd)
4. Increase due to appliances such as washing machines (+8-12 lpcd)

JICA assumed that the unaccounted for water would decrease from 54% to 30% due to expected improvements in meter reading and billing procedures.

Table (4) shows the total water demands and deficits in Jordan estimated for the years 2000 and 2010. It can be observed from the table, that the deficit in water supply in Jordan could be over 30% of the total demands.

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[2] Dorsch Consult, "*Greater Amman Water Supply and Distribution*", *Working Paper No. 20*, October 1995.

[3] Harza in Association with Metcalf & Eddy International, Inc, CC Johnson & Malhotra, P.C. and Jouzy and Partners," *Master Plan and Feasibility Study for Rehabilitation, Expansion and Development of Existing Wastewater systems in Amman-Zarqa River Basin Area*", August 1996.

* UFW is the difference the volume of water supplied to municipal systems and the volume billed to consumer.

Table (4)
Total Water Demands & Deficits in Jordan (2000/2010)

Year	2000	2010
DEMANDS		
- Municipal (suppressed)[a]	340	476
- Industrial [h]	78	119
- Agriculture	1088	1088
Total Demands [b]	***1506***	***1683***
SOURCES		
- Groundwater (Safe yields) [c]	277	277
- Surface water potential other than Yarmouk[d]	237	237
- Wastewater Reuse[e]	87	141
- Yarmouk River & Peace Treaty Rights [f]		
- Yarmouk	245	245
- Lower Jordan	100	100
- Disi expected extraction [g]	105	175
Total Sources	***1051***	***1175***
DEFICIT	**455**	**508**

Source:Feasibility Study Report "The Water Conveyance System From Disi-Mudawara to Amman", , July 1996. *(Approved by WAJ)*
All Figures in MCM
NOTES:
(a): Projected by HARZA Group
(b): WAJ Projections
(c): PRIDE Report & UNDP study
(d): National Environment Strategy for Jordan
(e): PRIDE Report (Available for Agricultural demands only)
(f): Volume 2 , Section 4 (New Peace Treaty Water Rights)
(g): Estimated by HARZA Group (For Aqaba 15 MCM in year 2000)
and 25 MCM in year 2010, remaining 90 MCM and 150 MCM is mainly for Amman and Zarqa in Years 2000 and 2010 respectively

B. Water Conservation

B1. Potential Savings

Water savings are possible in Jordan by conserving unaccounted for waters and accounted for waters (supplies delivered to communities by WAJ), and by capturing precipitation and runoff.

Municipal water supplies in Jordan serve municipalities as well as many industries that do not pump their own water. Municipal water demands are greater than the available water produced. The gap between demand and available supply is projected to widen even after development of additional sources of water.

One approach to reducing this imbalance between demand and supply is municipal water conservation. Water scarcity and frequent rationing cause Jordanians to conserve water. Residents point out, and rightly so, that a liter of water conserved by one person will immediately be consumed by another. Thus, one cannot point to conservation as a way to

increase the total supply available to Jordanians. From the standpoint of the user who would not otherwise have that liter of water, the conservation of one liter has the same value as the addition of a liter to the overall supply. The water scarcity makes most Jordanians water savers, because of both the rationed availability and the cost.

An individual conservation measure can save only a small quantity of water, but a comprehensive program can achieve significant savings. Potential water savings in Jordan households through conservation of bath, laundry, and outdoor activities (watering gardens, washing pathways and cars) could make more water available for others. It is difficult to quantify and prove the value of conservation. Some analysts suggest that results might be similar to adding nearly 40 MCM for domestic sector use in the year 2000 and more with the higher demand by 2015.

B2. Supply Management Practices

Leaks Repairs and Illegal Connections

A major source of potential water savings is the unaccounted for water (UFW), which is the difference between the water supplied to municipal systems, and the volume billed to the users. The national average for UFW is 55% (Table 5).

Table (5)
Unaccounted For Water in Jordan, 1994*

Governorate	No. of Water Subscribers	Supplied Water (m^3/yr)	Billed Water	Unaccounted For Water (UFW)	UFW as % of Supply
Amman	250,700	93,668,000	44,124,079	49,543,921	53%
Zarqa	75,400	27,684,000	13,306,818	14,377,182	52%
Irbid	114,500	35,308,000	16,194,843	19,113,157	54%
Mafraq	20,900	13,628,000	3,796,947	9,831,053	72%
Balqa	35,700	20,425,000	6,868,427	13,556,573	66%
Karak	23,400	7,227,000	3,362,826	3,864,174	53%
Tafila	8,100	2,174,000	1,296,916	877,084	40%
Ma'an	25,500	19,779,000	8,937,969	10,841,031	55%
Total	***554,200***	***219,893,000***	***97,888,825***	***122,004,175***	***55%***

* *Approved by WAJ*

Factors that contribute to UFW include leaks, illegal connections, inaccurate meters, and under billings. Placing high priority on leak repairs throughout Jordan would accomplish savings in municipal water. Savings regarded as attainable by WAJ are estimated at 20 MCM by the year 2000 and an added 10 MCM by 2015. The cost of this work is estimated to be JD 110 million.

A portion of the UFW is attributed to illegal connections. The annual quantity of water that could be saved cannot be estimated with confidence. Removing illegal connections does not increase water supply, however, it merely makes water more available for those who pay.

Pressure Reduction

Reduction in water pressure among houses generally is not required in Jordan. Plumbing system with external storage tanks (the type used in the Kingdom) have moderate or low water pressure at the point of faucets and water-using devices. Typical water pressure in Jordanian homes is about 50 pounds per square inch (psi), well under the 80 psi recommended for pressure-reducing valves in homes.

Pressure reduction in supply mains in an area like Amman would be helpful, however. Without neighborhood water storage and with the pressure of long water lines down steep slopes, water hammers can occur that rupture distribution line and cause water leaks.

Pressure reduction is generally unnecessary in homes, but it could be as much useful as important on water distribution mains, especially in hilly areas.

B3. Local Reuse or Recycling

Besides reuse of cooling waters by some industries (e.g., electric power plants), wastewater offers the principal opportunity for recycling in Jordan. The total effluent from treatment plants is expected to increase to 66 MCM/yr in the year 2000. This annual amount could be doubled by 2015. By further upgrading treatment and effluent distribution facilities, the Kingdom could have an additional 30 MCM/yr of available water supply through reuse by the year 2000. The current end use of most of this treated wastewater is on Jordan Valley farms. The future volume of this wastewater and the current groundwater recharge in the uplands has strong implications for changed reuse patterns. Reuse of future wastewaters may be focused more in the uplands than in the Jordan Valley.

Urban reuse in the residential and commercial areas is currently limited (e.g., some car washers are recycling and reusing rinse water, and some hotels are recycling collected air conditioning water). Urban reuse has much greater potential during droughts, when non-septic water (e.g., wash water) can be reused for toilet flushes, vegetation watering, and other purposes. Extensive use of this gray water is unlikely among residences until separate plumbing systems are built for septic and non-septic wash water in homes. The construction costs of this option are likely to be prohibitive.

B4. Water-Saving Devices and Equipment

Water-saving devices and equipment have significant potential for reducing water use and increasing water availability. Actual amounts defy precise estimates, but the potential appears worth considerable attention with both private-sector firms and the general public.

In homes, hospitals, hotels, schools, and similar facilities the main potential for water savings is in bathrooms (i.e., toilets, showers, tubs, and lavatories) and kitchens (i.e. sinks). Detailed

estimates of water-saving potential of these devices in Jordan were made by PRIDE[4]. The analysis involved an assessment of domestic water fixtures, including prevalence, unit water use potentials, and program implementation costs. A summary of the water-saving findings follows.

An estimated 50% (553,000) of the toilets in Jordan are flush units. Jordan Ceramics Company's output of approximately 24,000 toilets per year covers about 70% of the Jordan market demand. The toilets presently produced by the Jordan Ceramics Company use an average of 10 liters per flush of water. Other, older imported models consume even larger quantities. Thus, and overall average consumption of at least 10 liters per flush was used in the water calculations.

A 6-liter per flush models were tested by the Jordan Ceramics Company. Importers, aware of the need for and marketing potential of water-saving toilets started promoting toilets that use 5-7 liters per flush. These low-volume units promise notable savings. Consumption by the older, imported models can be reduced by placing water-saving devices such as plastic dams and bottles in the tanks of toilets. There are limits to how much the quantity of flushing water can be reduced below that for which the units were designed and still have them perform acceptably.

Potential for savings from toilets is subject to at least two countervailing factors:

- The cost of replacing existing units is too high for many householders, thus conservationists will have to emphasize water-conserving units in new installations and remodeling.

- As a result of the rising standards of living, modern flushing units will replace many of the existing units that use only 1.5-3 liters. This means that even a 6-liter toilet will use 3 to 4 liters more per flush.

Other options are water-saving faucets, automatic clothes washers, and dishwashers with lower water requirements. Each approach has problems as well as the potential to conserve water.

Faucets that deliver 6 liters instead of 20 liters per minute, and washing machines that use less water (for example, 60-70 liters per load, instead of 100-120 liters per load) could save as much as 60% of the water used for washing dishes and laundry. However, water-saving faucets may not work well at lower pressure than they were designed for. (A WAJ study found a flow range of 2.8 - 20 liter/minute for faucets fully open in a wash basin. Low pressure in the in-house network, found in many homes, was thought to be the main reason). With some washing machines, the problem may be that the rinse cycle supplies less water than is needed to remove detergents, to which some people are allergic.

[4] *PRIDE Technical Report No.4 "A Water Management Study for Jordan". August 1992.*

The potential of water savings is there, however. Estimates for the Kingdom as a whole are more than 1 million toilets, over 500,000 bathtubs or showers, and over 2 million faucets (Table 6). The table shows a breakdown of water fixtures used in different categories of establishments (hotels, municipal offices, armed forces). About 110,000 of the water faucets in Jordan are in such public facilities. Many have water systems with sufficient water pressure to get good performance from low-volume fixtures. Changing or replacing those faucets with water-saving units could contribute immensely to water conservation. The estimated cost of an average quality water-saving faucet and its installation is approximately JD 10 (i.e., JD 1.1 million total).

Public education is needed on the water situation in Jordan and the advantages of installing water-saving plumbing fixtures. Existing flush-type toilets (an estimated 553,000 units) can be modified with water-saving fixtures, and other measures can be taken, such as installing shower head restrictors and water-saving dams or weighted bottles in the tanks of toilets. The average unit cost of such measures is no more that 0.4 JD/unit for an estimated total of the JD 221,200 required. That is the estimated public cost.

Therefore, the total cost for a municipal water conservation program is estimated at JD 1.3 million in 1992, a modest cost for the benefits expected[4].

During the information survey conducted for the purpose of this report, a follow-up investigation was carried out regarding the implementation of the new toilet flushes developed by Jordan Ceramics Company. The investigation revealed that the aforementioned Company did not pursue the development of such toilets. Their reasoning behind that was primarily the absence of the know-how in that regard. They attempted to seek help from companies abroad, in collaboration with the Royal Scientific Society in Jordan, to manufacture toilet flushes with a 3 - 5 liters capacity, but have not been met with any positive response. They understood from the lack of response by those companies that the know-how information was reserved and not for distribution.

Additionally, people in Jordan are still more inclined to buy the older/cheaper non-water conserving models. This is a clear indication of the lack of public awareness in Jordan regarding the crucial need for water conservation. It was also pointed out by the Jordan Ceramics Company that cheaper toilet flush models tend to wear out quickly and leakage problems arise relatively soon after their installation. The leakage problems were also attributed to the quality of water in Jordan, which tends to be high in dissolved salts, thus leading to wearing out rubber parts of such fixtures.

Table (6)
Domestic Water Fixtures

User Category	Number*	Unit	Toilets		Bath: Showers & Tubs		Faucet: Lavatory & Kitchen	
			#/Unit	Total	#/Unit	Total	#/Unit	Total
Classified Hotels	12,285	Beds	0.55	6,757	0.5	6,143	0.6	7,371
Unclassified Hotels	3,017	Beds	0.5	1,509	0.3	905	0.5	1,509
Hospitals	4,246	Beds	0.55	2,335	0.5	2,123	0.6	2,548
Health Centers (MOH)+	308	Unit	8	2,464	3	924	10	3,080
Village health Clinics (MOH)	212	Unit	2	424	0.5	106	3	636
M&C++ Centers (MOH)	161	Unit	2	322	0.5	81	3	483
Tuberculosis Centers (MOH)	15	Unit	10	150	5	75	12	180
Dental Clinics (MOH)	110	Unit	3	330	0.5	55	4	440
Municipalities	171	Unit	5	855	0.5	86	5	543
Village Councils	362	Unit	1.5	543			1.5	960
Development & Charity Organizations	480	Unit	2	960	1	480	2	13,180
Restaurants	3,295	Unit	3	9,885	1	3,295	4	512
Coffee Shops	256	Unit	2	512		3,975	2	15,900
Various Business Offices & Centers	7,950	Unit	2	15,900	0.5	10,621	2	53,105
Students & Faculty	1,062,108	No.	0.05	53,105	0.01	1,151	0.05	5,755
Government Employees (Civil)	115,105	No.	0.05	5,755	0.01	1,151	0.05	
Armed Forces, Security & Civil Defense		No.	0.28	5,755		515,250		
Households	3,453,000	No.		998,670	0.15		0.29 Lav 0.29 Kit.	998,670 998,670
Approximate Total				**1,106,000**		**546,000**		**2,110,000**

Source: PRIDE Technical Report No.4 "A Water Management Study for Jordan", August 1992. + Ministry of Health
++ Mother and Childcare

B5. Education

Education targeting public awareness may be the only conservation program for quickly reducing water demand during a water crisis. Education can encourage reductions in peak water deliveries, and the water savings can help municipalities avoid or delay new water developments.

The major disadvantage of education programs are that they are often too short in duration and lack continuity. Education can also lead to enhanced conservation, but revenues may decrease as consumption falls.

MIDLLE EAST WATER CONSERVATION AWARENESS PROJECT: BEST PRACTICES RESEARCH

ACADEMY FOR EDUCATIONAL DEVELOPMENT

FINAL SUMMARY REPORT

Ra'ed Daoud
EnviroConsult Office
Amman - JORDAN

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I. ABSTRACT

This report presents a review of the recently existing water conservation best practices in Jordan. It focuses on the implemented awareness programs targeting students in schools and other groups of the Jordanian society as being a primary step towards actual implementation of water conservation on all levels.

The effect of the use of water-saving devices on the conservation in water consumption was also studied as a part of the Awareness Project in Water within the Water Quality Improvement and Conservation Project (WQICP). Savings in water consumption ranging between 16-33% could be achieved with the installation of such devices in hotels, hospitals, schools and other public and private buildings. Installation of water saving devices is also presented as a best practice.

At the policy level, water conservation has been addressed as a recent practice. The Government of Jordan (GoJ) had stipulated certain policies to initiate water conservation programs. The municipal conservation practices are not yet assessed to determine their cost-effectiveness. The water conservation policies were reviewed and presented as a Best Practice Case. Those policies were collected from the National Economic and Social Development Plan 1993-1997.

The research on the project also looked into age-old conservation practices that could be applied now in Jordan. The most significant age-old practice, harvesting the rainfall in winter time and using it for marginal water supply, is investigated and presented as a Best Practice Case. This practice was actually applied in the rural areas which were not connected to the municipal supply networks. The potential for utilization of this practice in urban areas like Amman is also discussed. The implementation of urban and rural rainfall-runoff water harvesting would require a coordinated program with technical support. Its feasibility on the national level should be further studied in order to select the cheapest approach possible.

Also, the research looked into conservation practices that were not yet applied, but thought of in Jordan. Those include the recycling of grey water for marginal uses and the manufacturing of small-size flush toilets of 3-5 liters.

II. BACKGROUND

Water Resources in Jordan are scarce and the demands are outstripping the supply. The situation will be aggravated in the future in view of the limited water resources and the growing demands from different users. The Government of Jordan recognizes that water is a critical issue for Jordan's development, yet the cost of exploiting the country's remaining surface water resources and fossil groundwater is rising rapidly. Even with efficient management and utilization of the resources, it will be extremely difficult for the authorities to meet the minimum water requirements of the population.

The government realized that conserving and protecting these resources could prove more sustainable and cost-effective. The conservation issue, although has only recently become an important one on the municipal and industrial-user levels, gained more attention for irrigation consumption. The conversion of the irrigation systems in the Jordan Valley from the open canal irrigation to the pressurized irrigation has proven a successful practice. The reuse of the

treated wastewater for irrigation allowed the authorities to re-allocate the fresh water resources in the Jordan Valley to municipal uses in urban areas.

Water scarcity and frequent rationing of the municipal supply has actually forced Jordanians to save water involuntarily. Some people would even argue that conservation measures might affect the standard of living and the public health conditions. However, there is a potential to conserve water at the municipal level and comprehensive saving programs can achieve significant results in high consuming blocks. Those include hotels, hospitals, universities, schools, commercial centers, and large residential buildings. The potential savings at the municipal level could be attained in the Unaccounted for Water (UFW) and the Accounted for Water (AFW). The UFW is the difference between the volume of water supplied to municipal systems and the volume billed to consumers. High percentages of UFW exist throughout Jordan with an average of 56 %. Some estimates of the leakage in the municipal networks, before water reaches consumers are at 30 %. However, the rest is actually used by the consumers but not billed for. The Accounted for Water is the municipal water that is received, recorded, and billed to consumers. Potential saving in AFW exist at the household level, commercial centers, and industries which are connected to the municipal systems.

The Government of Jordan (GoJ) has stipulated certain policies to conserve water. In fact, water policies today are closely linked to environmental conservation, water reuse particularly from treatment plants for irrigation purposes, and maintenance of the existing supply networks. The GoJ has stipulated policies to improve the efficiency of water carrying systems and reducing the water loss. In its "Economic and Social Development Plan (1993-1997)" the government pledged to upgrade and develop primary and secondary drinking water networks. The implementation of these policies still needs a primary effort on part of the government to secure the funds and lay the action plans.

Water management in Jordan has been supply-driven, i.e. the authorities supply water according to the availability and try to secure resources to satisfy this supply. However, Demand-driven water management and exploring ways to reduce demand by water conservation practices on the municipal level is still in its very initial stages in Jordan. An important aspect with regards to the efficient and effective implementation of such practices, lies in the awareness of the Jordanian people, so as to consider water conservation a part of everyday living, and an issue of constant awareness throughout the society, among political, public, and private sector groups and firms, and all adults and children in Jordan's homes. In this regard, the GoJ should create real incentives to encourage efficient water conservation and to discourage waste.

III. METHODOLOGY

The research on the project was conducted with close cooperation with the Water Authority of Jordan (WAJ) and the Non-Governmental Organizations that have implemented water conservation programs. The institutions that implemented the conservation programs were visited and their programs were investigated. The main public institutions that have implemented the water conservation and rationing programs are the Water Authority of Jordan (WAJ) and the Jordan Valley Authority (JVA). The latter has implemented its programs on a large-scale level. Their program of converting the open canal systems to pressurized pipes systems have been in place for some years now and proven a great success.

Aqaba Region Authority (ARA) considers the reuse of gray water for marginal uses within Aqaba municipality. The touristic area of Aqaba has a potential of collecting the grey water from the hotels and reusing it for landscape irrigation within the area. In this research, contacts with ARA on this issue revealed their interest to study this issue.

Also, this research investigated private sector endeavors in manufacturing water saving devices. A follow-up investigation was carried out regarding the implementation of the new toilet flushes studied by Jordan Ceramics Company.

The industrial water consumption and the potential water conservation was studied with the Water Quality Improvement and Conservation Project (WQICP) in the Ministry of Water and Irrigation. The industrial Audits program investigated the potential of water savings within industries in Jordan. Irrigation and industrial programs were not investigated within this research.

IV. CASE STUDIES OF BEST PRACTICES/ PROGRAMS

A. Water Conservation at the Policy Level

In its "Social and Economic Development Plan (1993-1997)", the government stipulated several policies to encourage water conservation and enhance water availability. Those policies include:

I. Improving the Efficiency of Water Carrying Systems and Reducing Losses.

- Progressive integration of water supply and delivery systems so as to optimize the management of the total resources in a flexible and efficient manner.
- Replace water carrying systems in the Jordan Valley by pipe networks and improve the real-time response system to meet the water requirements of crops.
- Prepare systematic water audits and master plans for municipal systems, and upgrade and develop municipal networks to minimize unaccounted for water and to improve and extend the water delivery service in an efficient manner.

II. Raising Efficiency and Water Saving Practices on the User Level:

- Encouragement of cropping patterns that provide a high return to water, or which can make use of brackish water and/or treated wastewater, taking into account other constraints such as soils, input costs and marketing.
- Promotion of modern irrigation techniques that achieve on-farm water savings while optimizing crop returns and farm incomes.
- Promotion of water saving devices at the household and industry level, including the promotion of re-circulation technologies.

III. Raising Public Awareness of the Importance of Water Conservation:

- Conducting systematic public education and awareness programs, through the academic institutions, multi media approaches and other appropriate means.

- Involvement of stakeholders in policy discussions at the various levels of government through public hearings, discussion meetings, committees and other participatory programs.

B. Age-old Conservation Practices (Rainfall Harvesting From Household Roofs)

This is an age-old practice that used to sustain populations, mostly in arid areas of the world, but also in areas were water distribution systems are not available. The collection of rainfall from households roofs was a successful mean of collecting the rainwater and augmenting the water supply in rural areas in Jordan. It is a small scale water conservation approach for catching/storing rainfalls and certain runoff waters in localized areas, before the water enters into the usual hydrological cycle. Generally, the methods are small basic impounding concepts as compared with larger-scale river dams and reservoirs. Catchment of rainfall drainage of a building roof with tank storage was the commonly used practice.

People in urban and rural areas used to collect rain water in cisterns for one-third or more of their domestic usage. There is a much greater potential for rainfall harvesting in certain urban areas. Rainfall-Runoff Water Harvesting (RRWH) is also possible from impervious areas in certain commercial districts, parking lots and industrial complexes. Generally, it is considered that RRWH waters would be used for secondary purposes, augmenting the basic supply in urban areas having approved water distribution systems. In more remote areas, RRWH may constitute a primary water supply.

Greater Amman Area (Jordan's capital) has the highest potential for this practice. The area is mostly urbanized, with a relatively high rainfall intensity. It is recognized that the net water conservation gains are partly hydrologic tradeoffs, to the extent that these waters would otherwise run off into the streets and overland as a part of the usual hydrologic cycle. Part of the harvested water would reach streams and wadis finding its way to King Talal Reservoir. This reservoir is constructed on the Zarqa River; the main running surface water in the catchment collecting the water from Amman-Zarqa area. The advantages of water harvesting lies in collecting the rainfall and the runoff before entering the hydrologic cycle, thus avoiding certain losses mainly in the form of evapotranspiration and infiltration. The waters, thus collected in roofs harvesting, would be used within the households and would enter the hydrologic cycle after reuse. The estimates of net conservation gain from harvesting water at households level in Amman is about 2.4 MCM/yr. The figure could go up to 4.9 MCM/yr by the year 2005[1].

The implementation of the urban and rural rainfall-runoff water harvesting would require a coordinated program with technical support. Architectural regulations would be a starting point. The household owner would bear the cost of constructing the cistern (Storage tank), which could be underground or above ground. The cistern should be properly-sized according

[1] Herbert C. Preul, F. IWRA, "Rainfall-Runoff Water harvesting Prospects for Greater Amman and Jordan", International Water Resources Association, Volume 19, No. 2, June 1994.

to the anticipated usage and prevailing average annual rainfall in the area. The feasibility of cisterns' construction should be further studied to select the cheapest way possible.

In conclusion, water harvesting from roofs in urban areas, Amman for example, could provide about 36 cubic meters per household per year[2]. This translates into about 98 liters per household per day or roughly about 15 l/capita/day, which is about 12% of the domestic water demand. In towns and villages where the domestic usage is low, water harvesting from roofs could provide higher percentages. The Water Authority of Jordan has reported that in the Governorate of Irbid, where house connections are not available, rain water collection represents about 32% as a source of water commonly used [2].

In some areas of the kingdom Old Roman Cisterns were used to collect rain water in winter and use it in summer. Some community groups and NGO's are rehabilitating those cisterns and use them for collection. Irbid Women Group, awarded a grant from the Global Environment Facility (GEF) to set up a park in Irbid area, rehabilitate some roman cisterns exist in the area to use the water for supplementary irrigation during summer time. The benefits gained from this practice (rehabilitation of existing cisterns) outweigh the cost rehabilitation. Irbid Women experience could be expanded to include other old cisterns.

C. Water Conservation and Rationing Practices by the Water Authority of Jordan (WAJ)

The Water Authority of Jordan realizes the immense physical losses in the municipal supply network systems. The losses are due to the physical losses, high pressures required to satisfy the demand, inefficient maintenance of the system, fault metering, and illegal connections . In its pursuance of the government policy to reduce the physical losses, WAJ initiated several hydraulic studies of the system to re-zone those systems on gravity basis and thus reduce the pressures in the main pipes. Also WAJ has secured some funds to rehabilitate the supply systems based on the hydraulic studies mentioned earlier. The rehabilitation program aims at reducing the high percentage of water currently being lost through leakage. It started this program in some zones in Amman and other cities in kingdom. With more efficient operation and maintenance of supply system through management contracts for Amman currently under negotiations with the World Bank, non-physical losses through administrative improvements as well as physical losses through proper operation and maintenance would be reduced.

On the other hand WAJ is also implementing summer time unwillingly water rationing in all municipalities in Jordan, to ensure the availability of sufficient water as a result to the additional imposed demand in the summer months. The consumption of water is greatly increased during summer time, due to the hot and dry weather in Jordan. People need more water for drinking, bathing, gardening and other summer activities. In addition, there is a great number of people that come to spend the summer in Jordan, whether Jordanian returnees who work abroad, or foreign and Arab tourists. Hence, a water rationing approach becomes a necessity to make sure that the available supply satisfy the suppressed demands.

In its effort to cover the operation and maintenance costs of the supply systems, WAJ has recently raised the water tariff in Jordan. The raise, which will be effective as of October 1st of this year and will affect the high consuming groups and will discourage waste in the municipal

[2] Water Authority, "Feasibility Study for Wastewater Collection and Treatment Systems in the Greater Irbid Area," Ministry of Water and Irrigation, Joint Venture by RheinRuhr Ingenieur-Gesellschaft mbh/Deutsche Abwasser Reinigungs Gesellschaft, 1992.

water. The high consuming groups (connections that consume more than 50 cubic meters in a quarter - 3 months) will pay about 0.85 JD for the every cubic meter above the 50. The hotels, hospitals, and other private enterprises will pay a flat tariff of 0.85 JD. This new tariff structure will secure about 20 million JD annually and will help WAJ implement the rehabilitation programs mentioned above. It will also encourage high consuming groups to reduce their consumption and consider installation of water saving devices. This set might also promote the idea of grey water reuse within hotels and commercial centers for marginal uses.

D. Municipal Wastewater Reuse for Irrigation Purposes

Wastewater reuse in Jordan has become increasingly an important source for irrigation. About 70% of the wastewater collected and treated in the kingdom is used for irrigation purposes. It is either stored in the main reservoirs, mixed with fresh rain water, or applied directly on certain crops (restricted irrigation). The major treatment plant in the kingdom, As-Samra Waste Stabilization Ponds, treats about 170,000 cubic meters per day which amounts to about 60 MCM (Million Cubic Meters)/year. This is considered the second major source for irrigation in the Jordan Valley (the main agriculture producer in the kingdom). The other wastewater treatment plants either treat their wastewaters and reuse on the site, discharge their treated effluents in the wadis to be reused downstream for irrigation, or convey their treated effluents via pipeline to be reused for parks and afforestation. Treated wastewater is currently used in Aqaba to irrigate 250 dunums (25 hectares) in the green belt forest and for irrigation of palm trees covering an area of 500 dunums. Aqaba Region Authority (ARA) have some ambitious plans to expand the reuse practice of their increasing treated wastewater to include other afforestation projects.

Treated wastewater will gain more significance as a major source for irrigation and thus allow the authorities to re-allocate some fresh water resources for higher value uses i.e. municipal and industrial uses. The projected wastewater quantities in the kingdom are 237 MCM in the 2025. This is regarded as a major water source for Jordan. The issue is the capital investment needed to construct wastewater treatment plants that can meet the standard and reduce the health hazards.

E. Water Conservation Education Project

In 1994 and 1995, the Royal Society for the Conservation of Nature (RSCN) developed, implemented and evaluated a water conservation curriculum (Water Conservation Education Project) in secondary school environmental youth clubs (eco-clubs) in Jordan. Technical assistance was provided by the Environmental Education and Communication (GreenCOM) Project. GreenCOM assisted RSCN with the design of a curriculum using interactive teaching methodologies in order to promote water conservation by teachers, students and their families. RSCN trained participating teachers and provided them with a self-instructing manual on the use of these participatory teaching methods.

The curriculum had three specific objectives:

1. To increase the knowledge and influence the behavior and practices of teachers and students regarding water conservation,

2. To provide a mechanism for the dissemination of information about water conservation to the general public,

3. To build capacity of RSCN for the creation of other curricula on conservation issues in Jordan.

The school-based eco-club system was initiated by RSCN several years ago. The clubs were supported by RSCN staff visits twice a year to provide education in the form of lectures and slide shows. Currently, RSCN supports over 300 eco-clubs in many of Jordan's public primary and secondary schools. The public schools in Jordan are all single-sex and two-thirds of the clubs in the eco-club system are in girls schools. One-third of the clubs are in high schools. Most of the clubs were founded in schools clustered geographically in the central area of the country, around the principal cities of Amman, Zarqa, and Irbid, with a few in the port of Aqaba.

The Water Conservation Education Project (the Project) offered an opportunity for RSCN to experiment with a number of new initiatives. The first opportunity was moving from offering conservation-related information, focusing exclusively on biodiversity, to providing information about a range of environmental themes, including water, Jordan's most pressing environmental issue. Several initial visits by GreenCOM and RSCN staff to schools in preparation for the Project suggested that interest in improving the eco-clubs was high among both students and teachers.

Teachers were generally assigned to the eco-clubs by principals without any particular selection criteria. Hence, teachers' backgrounds varied from science, to language arts, to mathematics, to religious instruction and art. Teacher's training initiated through the Project suggested that teachers without a science background had difficulty comprehending the material, even though the curriculum was designed at a 9th grade level.

The Project provided initial training, through guided practice, informative and descriptive research with ten schools. Schools were selected to participate in the Project based on several criteria; eco-clubs had to be at least two years old, and were stratified regionally to ensure an urban/rural and gender mix. Because of Jordan's high literacy rate, high schools were selected over primary schools for the initial phase of the Project; the testing of the efficacy of the water conservation curriculum. It was hoped that in the second phase, high school eco-clubs would adopt elementary school eco-clubs and nurture them, further decentralizing the educational process, taking the responsibility out of the hands of the RSCN, and empowering all schools, both within and outside of the eco-club network.

The water conservation curriculum was adapted from existing curricula and incorporated interactive teaching techniques. The curriculum was developed by a group representing concerned stakeholders, including teachers, experts and officials from the Jordanian Ministry of Education, in the context of a participatory materials development workshop.

The curriculum development team members participated in a series of "train the trainers" sessions, so that they could train other eco-club teachers at a special series of training workshops. Teachers from participating schools were randomly selected by RSCN, along with alternate teacher from each school, and invited to attend one of the two-day teacher training

workshops. This was to ensure back-up information bank existed in each school in the event that one teacher was transferred or withdrew from the project.

Units in the curriculum were:

Unit 1: The water cycle in nature and water sources in Jordan;
Unit 2. Conservation of water in domestic use;
Unit 3: Ground and surface water;
Unit 4: Ground and surface water pollution; and
Unit 5: Home gardens and irrigation.

An evaluation study of the impact of the water conservation curriculum on participating teachers and students was conducted by RSCN, in cooperation with GreenCOM research staff. A post-only experimental design was used, which entailed a comparison of participating eco-club teachers and students (experimental groups) with teachers and students from eco-clubs that did not participate in the project (control groups). The evaluation addressed the impact of the curriculum on teachers' and students' attitudes, beliefs and practices pertaining to water conservation. It also assessed the level of student knowledge about water conservation issues.

The results of the analysis of the conducted surveys indicated that participation in the curriculum had a positive impact on both teachers and students. Participation altered the way teachers conducted eco-clubs, both in the content and the format. Participating teachers implemented a greater number of variety of activities devoted to water use, conservation and pollution, and used more interactive teaching methods, compared with non-participating teachers. Sixty percent of teachers who participated in the curriculum implemented the majority of activities from all five units. More female teachers implemented the majority of activities associated with Unit 2 (Conservation of water in domestic use), than male teachers.

Participating students had greater knowledge about selected aspects of the water conservation curriculum than students from non-participating clubs, and expressed more positive attitudes and beliefs about household water conservation behavior. They performed more water conservation behaviors and more social behaviors to encourage others to reduce water consumption in the home. The curriculum had some differential impact by gender on students' knowledge and social behavior; the effects were more positive for boys than for girls. Overall, an interactive teaching approach to water conservation education, and possibly ecology education in general, appears to be an effective way to impact students' attitudes, beliefs and behaviors, as well as influence the behaviors of their parents.

The Project also developed a set of water conservation education materials which can serve as an important resource for eco-clubs students and teachers in the future. It also played an important role in enhancing RSCN's institutional capacities in several areas, including; teacher training; use of participatory teaching methodologies; material development; and social science research and evaluation skills. Additionally, RSCN improved its capacity to effectively design and implement gender sensitive programs in the future.

In its follow-up program, RSCN in cooperation with the Canadian International Development Agency (CIDA) designed and presented several television advertisements to address water scarcity in Jordan and the need to conserve water. The televised messages presented conversation measures at the household level.

F. Awareness Project in Water (APW)

The Awareness Project in Water (APW) is a part of the Water Quality Improvement and Conservation Project (WQICP), which is funded by the United States Agency for International Development (USAID) and the Government of Jordan to improve the quality and the quantity of water in Jordan. The APW was a three-year grant signed between the Jordan Environment Society (JES) and USAID in June 1994, and a two-year extension is currently being awarded.

The objectives of the APW were:

- To strengthen capacity of the Ministry of Water and Irrigation (MWI) and JES staff to plan, supervise and implement public awareness activities that will encourage people to adopt practices which will maximize the efficient use and protect water quality.

- To develop, coordinate, implement, and monitor water use campaigns aimed at policy makers, educational institutions, public and privates sector, industries, agriculture, local organizations and communities, and individuals.

Accomplishments of the Project related to its pre-assigned tasks were as follows:

1. Establishment of Information, Education and Communication (IEC) Capability in the MWI and JES:

This involved selection and hiring of staff from MWI and JES, assignment of offices and purchasing of equipment, as well as the appointment of an advisory and a working group committees for the program.

Other tasks under the umbrella of this activity included:

Out-of-Country Training: where five JES staff and JES executive director attended two and half week training in the United States to observe development of public awareness campaigns in local communities. Additional candidates from JES are scheduled to attend training in 1997.

In-Country Training: Staff received training in Jordan in the following aspects:

- Computer training;
- Development of public awareness campaigns;
- Communication skills and facilitation training;
- Training to develop audio-visual skills and techniques for WQICP staff and volunteers. A film is being produced on water saving devices as a result of this workshop.

2. Develop Follow-up Campaigns Based on the Results of Specific Studies through the WQIC Project:

A Water Use Behavior Study and a Water Saving Devices and Methods Study were conducted and the results are being used in project campaigns.

The Water Use Behavior Study showed consumers who tend to use large quantities of water. Savings in water consumption ranging between 16-33% could be achieved with the installation of Water Saving Devices (WSD)[3]. Seminars and workshops were held to encourage engineering firms, hotels, hospitals, private schools and universities to use such devices.

Besides its importance to conserve water resources to meet the country's future demands, the use of water-saving devices, will affect the quarterly and yearly payments of the consumers especially at locations where large quantities of water are consumed. The Forte Grand -a five-star hotel in Amman- where WSD have been installed for the purpose of this study, has a total monthly water consumption of 10,000 cubic meters, at a total cost of JD 10,300. Water restrictors were installed at the residents' bathrooms fixtures only (showers, sink tabs, and bidet tabs). The total quarterly saving was around JD 5000, with an actual pay back period of nine months regarding the total cost of restrictors.

The water saving percentages could be raised by improving the operational conditions under which WSD's can operate more efficiently. These improvements should be carried out at the sites of installation of WSD, and shall raise the total water saving to about 35-40% of the total water consumption. These improvements include:

- Continuous working pressure of 1 bar minimum, either with the assistance of a small booster pump or by connecting the water network of the site with an elevated distribution tank (around 10 meters high).
- Clean and filtered water supply.
- Introducing the Jordanian public to the built-in water-saving devices in washing machines, dish washers, and other indoor water-consuming machines.
- Other standard water-saving procedures such as periodical checks and continuous maintenance of the water networks.

3. Implementation of Information, Education, and Communication Campaigns and Activities

This task included the different levels of creating awareness, developing knowledge, and changing attitudes and practices.

Level One is related to developing and creating general awareness of the need to conserve water through the mass media campaigns. Levels two and three are aimed at establishing more personal contact. Level two is focused on human resource development especially training for trainers of public and private organizations to plan and implement the development of community campaigns. Level three is concerned with the implementation of community campaign activities in cooperation with the people trained in Level two to facilitate a change in water conservation practices of the general population in water use.

The Accomplishments of the Design, Implementation, and Monitoring of the Awareness Project in Water (APW) Campaign at Different Levels are:

[3] UNIVERSAL Engineering Consulting, Jordan, "Study on the Use of Water-Saving Devices in Jordan". Final report, June 1996.

Level One: Raise General Awareness by Mass Media.

The project conducted special activities celebrating special national and international events such as the International Water Day, the World Environment Day, Science Week organized by Higher Council of Science and Technology (HCST), the Arab Environment Day, Balqaa Environmental Week, and the Crown Prince Hassan Awards. On one Friday, every mosque in Jordan gave a lecture at prayer time on the importance of conserving water.

The project has produced 10 fact sheets, 10 pamphlets, 12 posters, 17 stickers, a film on water resources in Jordan in Arabic and English, 3 computer displays, announcements in the radio and television as well as media coverage of all activities carried out by the project. Two water competitions for school children were organized in cooperation with the Ministry of Education. Two "Water Walks" and one festival drew over 2,000 participants each time.

Level Two: Develop Human Resources to Plan and Implement Campaigns

Over 1,000 leaders were trained to implement public awareness programs. These leaders were selected from JES branches, universities and schools, religious organizations, other Ministries, NGO's, and the local community.

Level Three: Implement and Follow-up Community Programs

Over 38,000 people have participated in the project activities, in seminars, forums and lectures in the local communities as well as special events and exhibits. Many of the activities were organized in cooperation with JES branches, Women's Committee, Ministry of Awqaf, and Ministry of Education.

G. Other Individual Practices in Water Conservation

Some hotels are becoming more aware of the importance of water conservation both to Jordan's water resources and to their expenditure on water bills. The installation of water saving devices in the showers and faucets in some hotels is a definitive indication of such awareness. Savings in water consumption ranging between 16-33% could be achieved with the installation of Water Saving Devices (WSD).

The Forte Grand -a five-star hotel in Amman- where WSD have been installed, has a total monthly water consumption of 10,000 cubic meters, at a total cost of JD 10,300. Water restrictors were installed at the residents' bathrooms fixtures only (showers, sink tabs, and bidet tabs). The total quarterly saving was around JD 5000, with an actual pay back period of nine months regarding the total cost of restrictors.

With the recent increase on the water tariff mentioned earlier, the use of Water Saving Devices will gain more significance, and will prove feasible to large consumers. It is anticipated that engineering firms, hospitals, schools, universities, and even large household consumers would consider the use of those devises to save on their water bills.

- Other hotels, however, still took a less costly initiative by leaving awareness cards in each and every room with statements pleading to save water such as:

Please help Jordan save precious water

⇒ *Please, use water sparingly and turn off the taps after use.*
⇒ *Report any dripping taps to the Management.*
⇒ *Consider having a shower instead of a bath - this is one of the most effective ways to save water.*
⇒ *Return your towels to the towel rack if you intend to reuse them. However, if you would like your towels changed please place them in the bath tub.*

- On an individual basis, some people are reusing grey water (water collected from showers, washing machines and sinks) for marginal uses such as gardening and car washing. The collection of grey water requires a separate plumbing system, therefore, it is of limited implementation at the time being on a household basis. However, it is a good sign of people's increasing awareness of the importance of water conservation in Jordan.

IV. RECOMMENDATIONS

Water scarcity is an increasingly serious problem in Jordan, where annual renewable water resources per capita is amongst the lowest nations in the world. The situation will be aggravated in the future as a result of population growth and industrial development in the country. The incremental cost of exploitation of the remaining surface water resources and the fossil groundwater is becoming more costly. Moreover, Jordanians can not afford high water prices at their current Gross Domestic Product (GDP). It is indeed the government's responsibility to plan and implement water conservation and awareness programs to optimize the use of the current resources. However, the effectiveness of such programs lies within the hands of Jordanian people.

Water conservation practices are essentially very recent in Jordan, however, due to their important implications with regards to water availability, it is crucial to pursue such practices on a much wider and more intensive basis.

The following are recommendations constituting a beginning for water conservation in Jordan:

- The Water Authority of Jordan (WAJ) should continue its efforts to secure the funds and implement the urgent program to reduce the UFW (the difference between the volume of water supplied to municipal systems, and the volume billed to users) in the water supply systems. This would include the rehabilitation of the existing water supply systems to reduce the large quantities of wasted water as a result of leakage, and continuous maintenance of production and distribution systems. The Water Authority of Jordan should implement an effective program to repair defective meters and replace the old inaccurate ones.

- The concerned governmental authorities and the NGO's should expand the scope and target groups of water awareness programs. Such programs should include a wider range of age-groups of students, housewives, and general public. Awareness programs could be implemented through informative educational programs, radio and television by making people aware of the water situation in Jordan and the crucial need and importance of water conservation, while clarifying and stressing their important role in achieving that.

- Establish policies and legal requirements for manufacturers and importers of plumbing fixtures and home appliances to display water use and water saving characteristics of their products.

- Elimination or reduction of the customs and taxes on imported water-saving devices would be an encouraging incentive for their use at residential, commercial, industrial and governmental agencies levels, wherever possible.

- Encouragement of the local industries specialized in plumbing fixtures and/or new investments to manufacture water-saving devices locally.

- Amend building and plumbing codes and specifications to require installation of water-saving plumbing fixtures such as low-flow toilets, showers, faucets, and pressure reducing valves in all new building.

- The potential for roof capture and tank storage of the runoff is considerable in Jordan. Thus, the concerned authorities should encourage precipitation and runoff water harvesting where possible. On the other hand, the expansion of urban water reuse practices and recycling of gray water in residential and commercial areas could also be a beneficial aspect in water conservation.