Towards a Living Jordan River:

An Economic Analysis of Policy Options for Water Conservation in Jordan, Israel and Palestine

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EcoPeace/ Friends of the Earth Middle East (FoEME) is a unique organization at the forefront of the environmental peacemaking movement. As a tri-lateral organization that brings together Jordanian, Palestinian, and Israeli environmentalists, our primary objective is the promotion of cooperative efforts to protect our shared environmental heritage. In so doing, we seek to advance both sustainable regional development and the creation of necessary conditions for lasting peace in our region. FoEME has offices in Amman, Bethlehem, and Tel-Aviv. FoEME is a member of Friends of the Earth International, the largest grassroots environmental organization in the world.

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Regional Terminology and Abbreviations

The challenges of geo-historical terminology are particularly serious, since no single geographical name applies to all periods and to the same extent of land including the area of modern Israel, Palestine, and Jordan. Therefore, we have used the general term "region" when referring to the whole area of Israel, Palestine and Jordan. Where names have been used the local term in Arabic and/or Hebrew has been applied, while the English has acknowledged alternative names if they exist in different forms. In the case of the Lake Tiberias/Kinneret/Sea of Galilee we have utilized 'Sea of Galilee' for simplicity purposes as all three names are accepted in the scientific literature. Furthermore, in the case of English spellings of place names we have tried to select the most common spellings.

Abbreviations

EFS – Environmental Flows Study
FoEME – Friends of the Earth Middle East
INPA – Israeli Nature Parks Authority
IOJoV – Irrigation Optimization in the Jordan Valley
IWA – Israel Water Authority
JVA – Jordan Valley Authority
KAC – King Abdullah Canal
LJR – Lower Jordan River
JMWI – Jordanian Ministry of Water and Irrigation
PWA – Palestinian Water Authority
m^3/Y – cubic metres per year
mcm – million cubic metres
RDC – Red Sea to Dead Sea Conduit
UJR – Upper Jordan River
YA – Yarmouk River

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Executive Summary

The Lower Jordan River (LJR) has witnessed a 98% reduction in its flow and a severe decline in its water quality with overwhelmingly negative impacts on the river's ecosystem and the livelihoods of the adjacent communities. Furthermore, the massive diversion of LJR's water resources is the most significant factor in the demise of the Dead Sea, the LJR's terminal lake.

Today it is widely acknowledged that the LJR is in urgent need of rehabilitation undertaken by the river's riparians in accordance with the level of damage caused by each country. EcoPeace/Friends of the Earth Middle East (FoEME) has therefore embarked on an ambitious project to foster political will and concrete action towards the rehabilitation of the Lower Jordan River by identifying the means for an integrated rehabilitation approach to be initiated by the region's decision makers. To that aim, FoEME has undertaken two studies, an environmental flows study and an economic analysis of water conservation options.

The environmental flows study[1] indicates that 400 million cubic meters (mcm) of water, increasing to 600 mcm over time, including 75% fresh and no more than 25% highly treated wastewater, is required annually to rehabilitate the LJR.

This complementary economic analysis concludes that the quantities of water required to rehabilitate the river are feasible at prices lower than the current marginal cost of water, in Israel that being at prices lower then seawater desalination and in Jordan at prices equal to or lower then treated sewage water.

This report presents the summarized findings of the economic studies for the three countries' water conservation options. It estimates the water savings from a range of different policies. The water savings identified from each individual policy can be considered as a "wedge" or piece of a pie towards a given conservation goal. This methodology of identifying conservation wedges has been developed by researchers at Princeton University in the context of greenhouse gas reduction and has been employed by numerous academic, government, private sector, and non-governmental researchers[2] .

The findings identify possible "wedges" that in total will provide guidance to decision makers and the general public with regards to realistic economic and environmental options available to allow water to flow back into the Lower Jordan River, if there is political will to do so. FoEME has chosen not to include the more controversial and less sustainable options of seawater desalination and the building of the proposed Red Sea to Dead Sea Conduit in the analysis of supply side options. While recognizing that these options exist and in the case of seawater desalination are in operation today, the study has chosen to highlight that there are considerable water savings possible for all three water economies at prices well below the costs of these more controversial projects.

[1] Gafny, S., Talozi, S. & Al Shiekh, B. (2010) Towards a Living Jordan River: Strategy to Rehabilitate the Lower Jordan River. In Ya'ari, E (Ed.). Tel Aviv, Amman, Bethlehem, EcoPeace/FoEME.

[2] Pacala and Socolow (2004); Mui et al (2007); Nicols et al (2009); http://cmi.princeton.edu/wedges; http://www.wri.org/project/climate-wedges.

Based on the analysis of the present status of water supplies in Israel, Jordan and Palestine the consultants identified the possible potential alternatives for water savings in each sector of the national water economies of the three countries. The alternatives were then evaluated for their feasibility including cost-effectiveness.

This report concludes that in Israel an estimated 517 mcm of water could be conserved for other purposes, including for reallocation to the River Jordan, through better water management efforts at prices lower then desalination of seawater.

Likewise, in Jordan an estimated 305 mcm of water could be conserved for other purposes, including for reallocation to the River Jordan, through better water management efforts at prices lower then treated sewage water.

And in Palestine an estimated 92 mcm of water could be made available to improve domestic water needs in Palestinian communities, through better water management efforts.

The overall summary of the findings of the study are as follows:

<u>Jordan</u>

The summation of water conservation options in Jordan produces potential water savings of nearly 360 mcm per year. This is likely to be an over-estimate, as certain options overlap or partially crowd out others. In order to compensate for potential overlap between options, adjusted figures are given which are 15% lower than the unadjusted figures. From these adjusted figures, over 300 mcm of freshwater per year was identified as being available for conservation, at prices lower than the marginal cost of water in Jordan. For Jordan the following wedges were identified:

Supply Side:

- Municipal wastewater reclamation in agriculture
- Municipal rainwater catchment
- Reduction of water conveyance loss
- Farmland renting by JVA
- Accountability of supplied water

Demand Side:

- Public awareness
- Gardening reform
- Grey water for domestic use/double toilet flushing system
- Improved efficiency of irrigation
- Reform of agricultural water tariffs

Israel

The summation of the water conservation options in Israel produces potential water savings of nearly 800 mcm per year. This is likely to be an over-estimate, as certain options overlap or partially crowd out others. In order to compensate for potential overlap between options, adjusted figures are given which are 15% lower than the unadjusted figures. From these adjusted figures, over 670 mcm of freshwater per year was identified as being available for conservation, of which over 500 mcm is below the cost of seawater desalination. The identified "wedges" for Israel are:

Supply
- Reduced water losses from leakages
- Reduced water losses from reservoirs
- Rooftop rainwater collection

Demand
- Awareness raising
- Change in plant use in gardens
- Price increase in the agriculture sector
- Grey water use (irrigation)
- Grey water use (toilets)
- Removal of trade restrictions

Palestine

The summation of water conservation options in Palestine produces potential water savings of nearly 105 mcm per year. This is likely to be an over-estimate, as certain options overlap or partially crowd out others. In order to compensate for potential overlap between options, adjusted figures are given which are 15% lower than the unadjusted figures. From these adjusted figures, over 92 mcm of freshwater per year was identified as being available to improve domestic water needs in Palestinian communities. For Palestine the following wedges were identified:

Supply Side:
- Reclamation of municipal wastewater for agriculture
- Reduction of water conveyance loss
- Roof rainwater harvesting

Demand Side:
- Public Awareness
- Domestic savings due to the introduction of new technologies
- Improved efficiency of irrigation

1 Introduction

EcoPeace/Friends of the Earth Middle East (FoEME) has embarked on an ambitious project – the Lower Jordan River Rehabilitation project. The project incorporates two components: an environmental flows study and an economic analysis of water conservation options. The main goal of the environmental flows study was to determine a flow level necessary to support the unique ecosystem of the LJR. The economic analysis, detailed in this report, focuses on opportunities to redirect suitable water resources to the LJR through strategic water savings from within the national water economies of Israel and Jordan. The study aims at providing decision makers with key policy tools and guidelines necessary to rehabilitate the Lower Jordan River.

The following analysis attempts to identify opportunities to conserve freshwater within national economies of the three countries. It estimates the water savings from a range of different policies. The water savings identified from each individual policy can be considered as a "wedge" or piece of a pie towards a given conservation goal.

The main goal of the study is the identification of the cost-effective savings of water in the national economies that could potentially be transferred to the Lower Jordan River to restore the river's flow to a sustainable level.

The objectives of the economic analysis study are:

- Identify possible water savings in the national economies of Jordan, Israel and Palestine
- Propose cost-effective measures for water savings in all economic sectors including changes in the regulatory tools.

2 Methodology

A unified methodology to identify opportunities to conserve freshwater within the Israeli, Jordanian and Palestinian national water economies was applied by three expert consultants hired by FoEME. This report estimates the water savings from a range of different policies. The water savings identified from each individual policy can be considered as a "wedge" or piece of a pie towards a given conservation goal. This methodology of identifying conservation wedges has been developed by researchers at Princeton University in the context of greenhouse gas reduction and has been employed by numerous academic, government, private sector, and non-governmental researchers.[3]

The study addresses water demand measures, focusing mainly on the cheapest, technologically easiest and environmentally beneficial measures and on supply augmentation measures, which would result in more efficient use of available water resources. Estimates are based on available data, literature reviews, and interviews with experts in their respective fields.

The proposed measures on the water demand side are applied with three main components in mind: (1) reducing the quantity or quality of water required to accomplish a specific task; (2) adjusting the nature of the task so it can be accomplished with less water or lower quality water; (3) reducing losses in movement from source, through use, to disposal.

The potential savings "wedges" are identified in the major sectors of the national economies of the three countries, but mainly address the municipal / domestic, and agricultural sectors and to a lesser extent the industrial sector.

Additionally, the study estimated the cost-efficiency of each identified wedge. It must be noted that a different marginal cost of water was used as a basis for the evaluation of cost-efficiency of water savings in the three different countries due to the differences in policies in water pricing and use of water resources. In Israel, the marginal cost of desalination of seawater was used, in Jordan – wastewater treatment cost, and in Palestine – the cost of water provided by the Israeli National Water Carrier. Justification and detailed explanation of the evaluation of the proposed measures are presented in the individual reports for each country. The scope of the present report includes the summary of findings in water demand and supply and potential water savings.

[3] Pacala and Socolow (2004); Mui et al (2007); Nicols et al (2009); http://cmi.princeton.edu/wedges; http://www.wri.org/project/climate-wedges.

3 Overview of the Water Resources in the Three Countries

3.1 Overview of the Water Resources in Jordan

The Hashemite Kingdom of Jordan is considered to be the fourth poorest[4] country in the world in terms of water resources due to both physical water scarcity and high demographic growth during most of the second half of the twentieth century. In addition, the limited water resources are exposed to pollution and high rate of population growth is expected to increase the pressure on available water resources.

Conventional water resources in Jordan consist of groundwater and surface water. Additionally, treated wastewater is being reused.

Twelve groundwater basins have been identified in Jordan. Some of them are exploited to their maximum capacity, and others are overexploited, threatening their future use. The long term safe yield of renewable groundwater has been estimated at 275 mcm/year[5].

The major surface water sources are the Jordan River, the Yarmouk River and the Zarqa River. The Jordan River is used by more than one country and the pressure on it increases annually. According to the Israel-Jordan Peace Treaty Annex II Water and Related Matters, the Jordan receives 50 mcm from Jordan and Yarmouk rivers.

The Zarqa River is severely polluted by industrial and municipal wastewater and other non-point pollution sources. The King Talal Dam, Jordan's largest surface water reservoir, faces low water levels and pollution. The total renewable water resources, including surface water and rechargeable aquifers, have been estimated at 750 mcm/year. Furthermore, approximately 100 mcm of treated wastewater is currently reused, mainly for agricultural use. It is estimated that non-renewable groundwater can be extracted at a rate of approximately 140 mcm/year mainly through implementation of Disi-Amman Conveyance system. Brackish aquifers are not yet fully explored, but at least 50 mcm/year is expected to be accessible for urban use after desalination. Also, the controversial but nevertheless proposed project, the Red Sea Dead Sea Conduit would reduce the water balance deficit by the year 2022 if implemented.

The total number of treatment plants in Jordan is currently 22, treating about 107 mcm/year, or about 98% of the collected wastewater. The Jordanian Water Standard restricts the re-use of treated wastewater. Water is reused mainly for irrigation in the Jordan Valley, though a small share is allocated to industry. The Jordanian Ministry of Water and Irrigation plans to increase the amount of reused wastewater to 223 mcm/year by 2020. Many of the treatment plants exceed their capacity, resulting in a reduced quality of the treated wastewater. The available water resources (supply side) and future developments as prepared by the Jordanian Ministry of Water and Irrigation are presented in the table below:

[4] Review of World Water Resources by Country, FAO, 2003
[5] Water for Life, Jordan's Water Strategy 2008-2022

Table 1: Water Balance in Jordan according to JMWI

	2007		2010		2015		2020		2022	
Population in million	5.73		6.09		6.81		7.52		7.81	
Population Growth Rate	2.2		2.2		2.2		2		1.9	
Water Demand	**2007**		**2010**		**2015**		**2020**		**2022**	
	MCM	**%**	**MCM**	**%**	**MCM**	**%**	**MCM**	**%**	**MCM**	**%**
Municipal	366	24	382	26	418	27	463	28	481	29
Industrial	72	5	101	7	130	8	156	9	163	10
Touristic	8	1	13	1	21	1	26	2	29	2
Irrigation	1080	71	1000	67	1000	64	1000	61	1000	60
Total Water Demand	**1526**	**100**	**1496**	**100**	**1569**	**100**	**1645**	**100**	**1673**	**100**
Water Sources	**2007**		**2010**		**2015**		**2020**		**2022**	
	MCM	**%**	**MCM**	**%**	**MCM**	**%**	**MCM**	**%**	**MCM**	**%**
Groundwater Safe Yield	275	32	275	29	275	25	275	24	275	17
Artificial Recharge	55	6	55	6	55	5	55	5	55	3
Developed Surface Water	295	34	325	35	350	32	360	31	365	22
Treated Waste Water for Irrigation	87	10	110	12	150	14	200	17	220	13
Treated Waste Water for industry	4	0	7	1	15	1	23	2	27	2
Peace Treaty with Israel	50	6	50	5	50	5	50	4	50	3
Non-Renewable Groundwater (Disi+Hisban)	66	8	66	7	142	13	140	12	135	8
Non-Renewable Groundwater (Jafr+ Lajjoun)	25	3	30	3	30	3	20	2	15	1
Desalinated Water (Abu Zeigan+Aqaba)	10	1	15	2	18	2	20	2	20	1
Red-Dead Canal									500	30
Total Water Supply	**867**	**100**	**933**	**100**	**1085**	**100**	**1143**	**100**	**1662**	**100**

*Source: Water for Life, Jordan's Water Strategy 2008-2022

3.2 Water Resources in Palestine

The scarcity of water resources in Palestine is primarily a result of the inequitable and unreasonable water allocation as Israel controls the available water resources (surface and ground waters) in the West Bank. Thus, the area's natural arid conditions are further aggravated by the current political situation. Water resource use, allocation and availability from shared water resources is one of the final status issues between Palestine and Israel that will be resolved through final negotiations.

The dominant aquifers in the West Bank, from which existing water resources are derived, are the Western Groundwater Aquifer Basin (called Yarkon – Tananim in Israel), the Northeastern and the Eastern aquifers. The three groundwater basins are recharged directly from rainfall on the outcropping geologic formations in the West Bank Mountains, about 90% of recharge quantity is originated inside West Bank, while the greatest part of the storage areas is located in the confined portions.

Around 679 (PWA, 2010) mcm of the annual rainfall on the West Bank is estimated to infiltrate the surface layers of the fractured formations recharging the groundwater aquifers. The remainder is lost either through surface runoff (100-110 mcm, PWA, 2010) or evapo-transpiration.

The Western Basin of the aquifer is the largest among the three basins and its annual sustainable yield is estimated at 365-400 mcm/y. It extends from the mountains of the West Bank in the east towards the coastal plain in Israel to the west, and from an area south of Be’r Al Saba’ (Beer Sheva) to the foothills of Mount Carmel in the North. Groundwater flow is towards the coastal plain in the west, making this aquifer shared between the Palestinians and the Israelis. About 90% percent of the recharge area of this basin is located within the West Bank. Its water is of good quality and mainly used for domestic purposes. Israel exploits this basin through more than 500 deep groundwater wells located outside the West Bank, pumping an estimated 360-560 mcm/y. Meanwhile, Palestinian are pumping only about 22-24 mcm/y. Of concern is that Israel has repeatedly over pumped from this water resource beyond the estimated safe yield (Abed & Wishahee, 2000, p.391, World Bank, 2009).

The Northeastern Basin consists of the Nablus-Jenin basin and has an annual sustainable yield of 80-100 mcm/y. It is estimated that Israelis consume more than 75% of its annual safe yield, whereas Palestinians consume less than 25% for both domestic and irrigation purposes from wells and springs in the Jenin Governorate and East Nablus. The groundwater flows to the north and northeast towards Israel.

The Eastern Basin has a sustainable yield of 70-90 mcm/y. This basin lies almost entirely within the West Bank. Until, 1967, the Palestinian villagers and farmers used this basin. After

1967, Israel expanded its control over this aquifer and began to tap its water mainly to supply the Israeli settlements established in the area.

Table 2 below presents the allocation of water resources of the three shared basins of the Mountain Aquifers under Article 40 (mcm) of the Oslo B Agreement for the interim period.

Table 2: West Bank: Allocation of Water Resources of the three Shared Aquifers Under Article 40 (mcm) for the interim period

Oslo Agreement Article 40 Allocations			
Basin	**Estimated Renewable Recharge**	**Palestinian Allocation (mcm)**	**Israeli Allocation (mcm)**
Western	**362**	**22**	**340**
Northeastern	**145**	**42**	**103**
Eastern	**172**	**54**	**40**
Total	**679**	**118**	**483**

Surface water in the West Bank consists mainly of the Lower Jordan River along with its tributaries and wadi floods in high rainfall years. The total surface runoff in the West Bank is estimated at 100-110 mcm/y (PWA,2010).

Table 3 below summarizes the Palestinian water consumption in the West Bank for both domestic and agricultural purposes as provided by the PWA.

Table 3: Water Budget for West Bank, Palestine, 2009, PWA

Source	For Domestic Use Only (mcm)	Produced Quantities (mcm)
Domestic Wells (mcm)	35.284	35.284
Agriculture wells (mcm)	2.71	28.846
WBWD Wells (mcm)	7.098	7.098
Mekorot Wells (WB) (mcm)	10.785	10.785
Purchased from Mekorot (from Israel) (mcm)	30.722	30.722
Springs(mcm)	3.864	25.238
Mekorot (Agricultural) (mcm)	0.20	5.10
Total (mcm)	**90.663**	**143.07**
Sold to Settlements(mcm)	-1.884	-1.884
Net For Palestinian (mcm)	88.779	141.19
Total Population (thousands)	2212.26	2212.26
Per Capita	40.13 CM/year	63.8 CM/year

***Total Purchased from Mekorot = 51.02 mcm/y**

The figures above do not include the water resources of the Gaza Strip nor the demanded Palestinian water rights of the shared water resources and subject to the following essential aspects:

1- End of Israeli occupation of Palestine and PA gains full control over its land and resources.

2- Palestinian historical water rights in the Jordan River Basin (Around 250 mcm/y) are defined and agreed upon.

3- Palestinians have the right to be one of the Jordan River riparians, and this should be recognized by Israelis. The Palestinian Authority and farmers gain free access and movement to the Lower Jordan River.

4- Donors support to the PA to clean the river embankments from landmines and any other military equipment that might endanger the lives of the people reaching the banks of the river.

5- The Palestinian Authority secures the funding required to develop its water resources and the infrastructure including the wastewater collection and treatment systems.

6- Farmer's willingness, capability of reusing the treated wastewater and consumers willingness to accept products irrigated with treated sewage.

7- Palestinian economy is strong enough to enhance the beneficiaries capacities to pay for the water and wastewater services.

8- PWA is further strengthened to monitor, manage and develop the water resources of Palestine.

3.3 Water Demand by Sector in Palestine

Municipal consumption includes domestic, commercial, touristic and public consumption, and in some cases for livestock needs. The current Palestinian water consumption is about 290 mcm/y including West Bank and Gaza, considering that 90% of Gaza water is not suitable for human use. The municipal water consumption in Palestine is hard to differentiate according to the sector it consumes; in fact it includes all water used for households, public buildings, institutions such as schools, universities and hospitals, business and commercial properties, both within the urban area and in specific industrial estates and tourism. The demand for public, industrial water use is estimated at around 20% of the total non agricultural demand. The remaining 80% is counted for domestic demand (PECDAR, 2001). Table 4 below shows the projected water demands for the various sectors in Palestine.

Table 4: Projected Water Demand in Palestine by Sector, PWA (mcm)

Year	**2010**	**2015**	**2020**	**Current Available 2010**
Municipal	165	218	268	
Industrial	24	31	39	
Irrigation	200	370	552	
Total Palestine	**389**	**619**	**859**	**290**

Source: Jayoussi, 2009

3.4 Water Resources in Israel

Past estimates of Israel's average renewable water supplies are in the range of 1500-1800 million cubic meters (mcm) per year. Rainfall is highly stochastic with high year to year variance, however, and so actual rainfall in any given year may be several hundred mcm more or less than the annual average. Due to climate change impacting the whole region annual rainfall is on a downward trend.[6]

In addition to water abstraction from the shared Mountain Aquifer with Palestine, Israel diverts practically all the flow of the upper Jordan River. Water resources in Israel include also large scale desalinated sea water and reuse of the treated wastewater.

The table below shows Israeli water consumption figures by sector, as provided by the IWA.

Table 5: Israeli Water Consumption by Sector

Year	Total	Domestic	Agriculture					Industry		
		Total	**Fresh-water**	**Reclaimed Wastewater**	**Brackish**	**Flood-waters**	**Total**	**Fresh-water**	**Marginal**	**Total**
2007	2071.7	767.3	551.1	386.6	201.5	46.0	1185.2	89.6	29.6	119.2
		54%	39%					6%		
2008	2000.8	758.5	490.7	399.3	188.2	43.2	1121.4	87.9	33.1	120.2
		57%	37%					7%		

Source: Israeli Water Authority (IWA), 2009.

Note: Percentage figures represent share of freshwater consumed annually.

[6] IWA, 2009

Table 6: Projected Water Balances in Israel by Sector (in mcm), IWA[7]

		2010	2020	2040
Supply	Available Recharge	1170	1170	1170
	Brackish	150	150	150
	Desalination – seawater	277	750	873
	Desalination – brackish	34	70	70
	Increased production	70	0	0
	Treated Wastewater	385	480	650
	Total Supply	1856	2620	2993
Demand	Domestic	708	946	1274
	Industry	88	95	105
	Agriculture	989	1080	1265
	Transfers to neighboring countries	139	205	449
	Deficit Reduction	-68	294	-
	Total Demand	1856	2620	2993

Notes:

1. Recharge is based on 20 year averages with 10% reduction for climate change and 10% reduction for losses to the sea.
2. The rate of wastewater reclamation is expected to increase until near full recovery by 2020, after which amounts are expected to increase as a function of population.
3. Domestic consumption is estimated at 107 m^3 per capita in 2007, 92 in 2010, and 104 in 2020 and 2040.
4. Water transfers to neighboring countries include 72 mcm transferred to the Palestinian Authority (PA) and 55 mcm transferred to Jordan in 2007. In following years the amount transferred to the PA is estimated to increase at 4% annually.
5. Water supply figures for desalination in 2040 are based on amounts calculated as necessary to balance demand in that year. In addition, up to 300 mcm capacity may be added to provide reserves for drought periods.

[7] ***Sources*:** Based on figures from IWA, http://www.water.gov.il

4 Relevant Policies and Legislation

The chapter below presents discussion of the water tariffs and pricing policies in the three countries. The common deficiency in legislation in the three countries is that a number of laws and regulations currently govern water management. Regulatory oversight is split among several governmental ministries and agencies, leading to overlapping jurisdiction and institutional conflicts of interest in national water management. Additionally, in Palestine the laws and regulations were introduced by the Israeli Military Orders giving preference to the interests of Israelis over the needs of the Palestinian citizens.

4.1 Water Pricing Policy in Israel

Pricing of water is a critical element in demand management. Israel currently prices water differently according to sector and water type (e.g., fresh, brackish, treated wastewater), and according to region in the case of agricultural use. For all sectors there is an increasing block rate tariff structure. The prices for the different sectors[8], as of January 2010, are presented in Table 12. The prices for agriculture and industry are lower than that of the domestic sector. Thus, these sectors can be seen as receiving a subsidized water rate. In addition, the difference in marginal water prices among competing sectors indicates that water is currently inefficiently allocated.

[8] IWA, 2010 http://www.water.gov.il/NR/rdonlyres/CB9F8AC6-B1DE-48F0-A0ED-82DA9C551FBE/0/TarifaiMaim1110.pdf

Notes:

1. The prices listed above include the cost of delivery only and do not include wastewater treatment costs.

2. Prices as of 1 January 2010, using the interbank exchange rate on this day.

3. Prices for agriculture can vary by region. The prices listed above are representative of typical costs.

4. The prices for treated sewage are for wastewater treated to quality necessary for unrestricted use. Wastewater for limited uses is slightly cheaper, while higher quality wastewater from the Shafdan treatment center is slightly more expensive.

Table 7: Water Pricing in Israel

Freshwater		**Price (including VAT)** in US$/$m^3$
Agriculture	Up to 50% of allocation	0.495
	50-80% of allocation	0.568
	80-100% of allocation	0.716
	100-108% of allocation	0.874
	>108% of allocation	1.032
Industry	Up to 100% of allocation	1.177
	100-108% of allocation	1.471
	>108% of allocation	1.765
Domestic	Up to 5 cubic meters per 2 month period	1.220
	> 5 cubic meters per 2 month period	2.230
	Hospitals and other recognized uses	0.777
	All other non-household uses	2.230
Treated Wastewater & Brackish Water		
Treated Sewage	Up to 100% of allocation	0.226
	100-108% of allocation	0.282
	>108% of allocation	0.338
Brackish	Up to 100% of allocation	0.300
	100-108% of allocation	0.375
	>108% of allocation	0.450

4.2 Water Pricing Policies in Jordan

In the early 1990s, the Government of Jordan evaluated the coming water crisis and began shifting the policy from supply augmentation towards demand management that include instruments to encourage efficient water use, transfer water to non agricultural higher value uses and reduce groundwater overexploitation. Pricing of irrigation water was chosen as an instrument to reduce demand for water.

The Groundwater Control Bylaw No. 85, passed in 2002 and further amended in 2004, was designed to regulate groundwater abstraction through establishment of a quota of 150,000 m^3/yr/well and a block-rate tariff system to be operative beyond the quota.

In the Jordan Valley, a block-rate tariff system is associated with the crop based quotas, presented in the table below.

Table 8: Crop Based Quotas in the Jordan Valley[9]

<table>
<tr><th rowspan="2">Period of the year</th><th colspan="3">Quotas (m^3/ha/day)</th></tr>
<tr><th>Vegetables</th><th>Citrus</th><th>Bananas</th></tr>
<tr><td>16/3–31/3</td><td>15</td><td colspan="2">On-demand but ≤ 20</td></tr>
<tr><td>1/4–15/4</td><td>15</td><td rowspan="2">20</td><td rowspan="2">30</td></tr>
<tr><td>16/4–30/4</td><td rowspan="2">20</td></tr>
<tr><td>1/5–15/6</td><td>30</td><td>50</td></tr>
<tr><td>16/6–15/8</td><td>On-demand but ≤ 10</td><td rowspan="2">40</td><td rowspan="2">70</td></tr>
<tr><td>16/8–15/9</td><td>10</td></tr>
<tr><td>16/9–15/10</td><td>15</td><td rowspan="2">30</td><td rowspan="2">50</td></tr>
<tr><td>16/10–31/10</td><td rowspan="2">20</td></tr>
<tr><td>01/11–15/12</td><td colspan="2" rowspan="2">On-demand but ≤ 20</td></tr>
<tr><td>16/12–15/03</td><td>10</td></tr>
</table>

The current pricing and proposed increase of water tariffs for irrigation in the Jordan Valley is presented below:

[9] Irrigated Agriculture, Water pricing and Water savings in the Lower Jordan River Basin in Jordan; J.P.Venot, F. Moille, Y.Hassan

Table 9: Changes in Water Tariff Structure in the Jordan Valley[10]

Water quality	Usage block (m³/month/3.5 ha maximum)	Irrigation tariff (per 1,000 m³)	
		Current	Proposed
Freshwater	0–2,500	\$11.5 (JD 8)	\$21.6 (JD 15)
	2,501–3,500	\$17.3 (JD 12)	\$43.2 (JD 30)
	3,501–4,500	\$28.8 (JD 20)	\$64.8 (JD 45)
	Over 4,500	\$50.4 (JD 35)	\$79.2 (JD 55)
Low-quality water (freshwater mixed with treated effluents or highly saline water)	0–2,500	\$11.5 (JD 8)	It is proposed to maintain the current tariff structure
	2,501–3,500	\$17.3 (JD 12)	
	3,501–4,500	\$28.8 (JD 20)	
	Over 4,500	\$50.4 (JD 35)	

The pricing in different sectors in Jordan are as following:

- The Jordan Valley Authority (JVA) charges an average of JD 0.012 per m^3 for water
- The Water Authority of Jordan (WAJ) charges farmers pumping from private wells nothing for the first 150,000 m^3, JD 0.005 per m^3 between 150,001 m^3 and 200,000 m^3, and JD 0.060 per m^3 greater than 200,000 m^3. (Groundwater Control Bylaw (No. 85) 2002)
- Industrial water tariffs range from JD 0.250 per m^3 pumped from private wells up to JD 1.800 per m^3 within Qualifying Industrial Zones and for the Potash Industry.
- Domestic water tariffs also based on the rate block system, the average is about JD 0.480 per m^3

4.3 Water Pricing Policies in Palestine.

Currently, there is no unified tariff structure in Palestine. The municipalities set the water tariffs to cover either the cost of abstraction and transfer, or to cover expenses of water purchased from Mekorot (Israel Water Company). Therefore, the water prices differ for each municipality, the average rate is about 5 NIS/m3 (0,70 US $). The block rate system is applied, but the blocks are different for each municipality.

However, the water tariffs do not differentiate between the domestic, municipal, industrial and agricultural uses. The unified tariff is applied to all sectors of economy.

[10] Irrigated Agriculture, Water pricing and Water savings in the Lower Jordan River Basin in Jordan; J.P.Venot, F. Moille, Y.Hassan

Table 10: Water Prices from Different Vendors by Locality [1$=3.73NIS, rate on February 12, 2010].

Type of Use	Territory/Sub-territory	Cost in NIS/CM	Cost in $/MC
Water purchased from the Mekorot			
Domestic	Palestine	2.56	0.69
	West Bank	2.6	0.7
	Jerusalem	3.96	1.06
	Gaza Strip	2.12	0.57
Water purchased from a private vendor (Tanker Water)			
Domestic	Palestine	14.23	3.82
Domestic	West Bank	14.23	3.82

Source: Water for Life, 2006, p.47.

5 Potential Water Savings "Wedges"

The evaluation of the water potential savings "wedges" for each country primarily addresses water demand management, and non seawater desalination water supply augmentation. The proposed water savings in different sectors of the national economies took into consideration several factors: behavioral changes – including raising public awareness on the economics of water consumption; technological improvements and innovations that significantly reduce water consumption; changes in cropping patterns in agriculture; reallocation of water to the sectors with the higher economic returns; improvements in conservation of the available water resources; political and socio-economic factors.

In sum, a broad range of policy options, or wedges, exist to reduce water demand or augment supply. These options vary greatly in terms of cost per cubic meter of water conserved, and in terms of there political feasibility. Feasibility has here been defined as a function of economic costs, likely opposition by negatively affected stakeholders, and of the technological ease of implementation.

The policy options for potential savings were analyzed in the following sectors of the national water economies of the three countries:

- Domestic and Municipal
- Agriculture

Based on the required effort in terms of technological improvements, materials used and required investments; the costs were categorized as minimal, low, medium and high.

5.1 Water Savings in the Domestic and Municipal Sector

Several options exist for reducing water consumption and for improving efficiency of water used in the domestic and municipal sector. Options explored in this study include awareness raising, alterations to types of plants in gardens and parks, reduction in water losses due to leakages, rainwater collection, and reuse of grey-water (water recycled within the household).

Slight differences exist between the assumptions of the Israeli experts and Jordanian and Palestinian experts. The Israeli experts considered the same option, such as awareness raising in different scenarios based on the technologies to be applied, while Jordanian and Palestinian experts categorized the proposed options and considered the different scenarios based on the level of effort and willingness of the relevant stakeholders for implementation of the proposed measures.

5.1.1 Composition of the Water Consumption in the Domestic and Municipal Sector

Domestic and municipal water consumption now represents the largest consumer of freshwater in Israel. For the 2005-2007 period, water consumption for household use amounted to roughly 66 cubic meters per capita. Of this, toilet flushing and showering represent the largest individual uses, accounting for 35% each of household use. Household consumption represents over 62% of urban water consumption. Other urban water uses, such as irrigation of public parks and gardens, commercial and other non-residential urban uses, account for an additional 31 cubic meters per capita, or roughly 29% of urban use. Water losses from leakage in the urban sector account for 10-15% of water delivered. (Figures for water losses are debated, and are believed to be highly variable across municipalities).[11]

[11] Eilon, 2009.

Table 11: Domestic and Municipal Water Consumption by Use in Israel

Uses	%	liters/cap/day	m^3/cap/year
Toilet Flushing	35%	60	21
Drinking, cooking, and dishwashing	20%	30	12
Bathing	35%	60	21
Laundry and cleaning	5%	8	3
Home gardening	5%	8	3
Total Household	100%	166	66
Municipal gardening			17
Commercial and other non-domestic urban uses			9
Leakage and losses			16
Miscellaneous			5
Total Domestic and Municipal			107

Source: IWA website, http:www.water.gov.il.

Note: Based on 2005-2007 figures

Water supply in Jordan is generally intermittent. Water is delivered once a week in big cities like Amman and once every twelve days in rural areas. Jordanians store the water in tanks. The water consumption is estimated by the use of individual water meters for each household. Despite the negative impacts it has on the piped network the intermittent water supply is used as a tool to limit the water usage in Jordan. On the other hand, continuous water supply and accessibility are considered the highest priority in the Jordanian water sector.

The municipal water supply, such as water supply to public buildings, parks, roads, etc., comprises almost 35 % of domestic and municipal water supply[12]. The actual present per capita daily water use is about 96 liters in Jordan.

The composition of daily domestic water consumption in Jordan on average is presented in the table below:

[12] Ministry of Water and Irrigation, Year Book, 2006

Table 12: Current Domestic Water Use Composition[13] in Jordan

Household Use	Amount (Liter/person/day)	Percentage
Toilet Flushing	33.6	35 %
Bathing	24.9	26 %
Cooking, Drinking, Dishwashing	20	21 %
Laundry	9.6	10 %
Home garden	3.8	4 %
Miscellaneous	3.8	4 %
Total	96	100 %

Water consumption in Palestine does not differentiate between the different sectors. The domestic water supply in Palestine is intermittent and highly irregular. According to the 2009 PWA figures, for the West Bank, per capita annual domestic consumption was 42.4 cubic meters. It is estimated that the conveyance loss through leakages and theft in the water distribution network could be as high as 40 – 50%. Though water loss figures vary greatly from municipality to municipality due to the age of existing infrastructure, PWA average estimates are that there exists a 34% water loss due to leakages. The assumptions for the water savings from increased awareness in domestic and municipal sectors in Palestine are based on the best practices in Jordan, since there are similar cultural and behavioral patterns.

5.1.2 Summary of Water Savings in the Domestic and Municipal Sectors

Public awareness raising regarding the need for water conservation include campaigns such as use of celebrities in television, radio, newsprint, and billboard ads, classroom learning units in schools, distribution of materials for posting in workplaces and public buildings, and more.

The costs involved in changing of plant varieties used in home gardens and municipal and public parks from water intensive varieties to varieties with low water needs include an information campaign, transmission cost and the costs of purchase of new plants and labor.

Water losses in delivery, measured as water pumped into the delivery system minus metered water consumed at the final destination, accounts for 10-15% of domestic water consumption in Israel[14] and as high as 40 – 50% in Jordan and Palestine. Most of this is due to leakages in the system, although some portion may be attributed to illegal connections and other non-metered uses. The cost involves the upgrading of infrastructure.

Rainwater collection and storage: Capture of runoff in urban areas requires both infrastructure and areas for storage. Given that large storm events generating large amounts of runoff are infrequent, that appropriate areas for storage are not always available in built environments, and the opportunity cost of land in urban areas is often quite high, many believe that large-scale urban storm water retention facilities in Israel are still not economically justified.[15]

[13] Department of Statistics, 2005
[14] Eilon, 2009
[15] Shmueli, 2008B.

Due to the fact that in Jordan, the street drainage system exists only in large cities and not covering the whole city and the water is simply diverted to the wadis that lead to the nearest dam, the amounts of rain water street catchment are not available.

In Palestine, storm water retention facilities are non-existent, which will require major investment in providing such facilities. Also, there is a political factor involved, in that the Israeli water authorities might view establishment of such facilities as infringing on the water catchment in Israel and therefore, the Joint Water Committee might not license the establishment of such facilities.

Rather than large-scale centralized storm water retention systems, in many countries, rainwater is collected using rooftop or garden systems. As the amount of potential water conserved is relatively small and costs are relatively high, such a decentralized rooftop collection system does not seem to be an efficient means of large-scale water conservation, although it may be efficient for certain households.

It should be noted that not all buildings are appropriate for such storage systems, and costs will include additional costs that would be necessary to treat the water or the costs of any hazards or nuisances that might occur, such as mosquito breeding, damage to rooftops, etc. Assumptions are made that all new buildings are required to be built in such a manner as to collect rainwater and that a share of existing buildings are equipped with rainwater collection systems, and roughly 350 – 400 millimeters (mm) of rainfall captured yearly.

Reuse of water within a household – so called grey water – is another possibility for water conservation. Such systems recycle water from uses such as bathing and cooking to uses such as toilet flushing and gardening, which do not need water of drinking quality. Such systems not only offer potential water savings for households, but also reduce the need for sewage transport and treatment, and save the associated direct and environmental costs. There are several challenges in the reuse of the grey water within the household.

Currently most household wastewater is reused in agriculture in Israel and Jordan. By reducing total quantities of sewage produced, grey water systems would save households the costs of water delivery and treatment, but would reduce the amount of sewage available for treatment and reuse by farmers.

Several systems for grey water reuse exist. This study examines two such systems:

- A system in which grey water is used within the household itself by channeling water from showers and sinks into toilets so that no freshwater is used for toilet flushing.
- A system in which grey water is used to irrigate gardens.

Of the options examined, the following appear to offer genuine cost savings: awareness raising, change in plants and gardening techniques, and water loss reductions. Thus, these should be prioritized for implementation as they offer both environmental and economic benefits.

Table 13: Summary of Potential Water Conservation in Domestic and Municipal Sector in Israel

Cost Grouping	Policy Wedge	Water Conserved by 2020 (mcm/year)			Cost (US$/m3)	
		Low	Medium	High	Gross	Net
Low Cost	Awareness Raising	76	81	101	0.12	-1.22
Moderate Cost	Water-conserving Plants	23	46	68	0.61	-0.39
	Reduced Water Losses	29	51	73	0.45	-0.6
High Cost	Rooftop Rainwater Collection	4	7	13	2.14	1.14
	Grey water Use (Toilets)	13	27	55	2.21	1.34
	Grey water Use (Irrigation)	36	76	116	1.32	0.45

In addition to the discussed options common for all three countries, in Jordan there is a high percentage of unaccounted for water, meaning unpaid bills, faulty water meters and in some cases illegal connections to the network. This would require law enforcement and replacement of the faulty equipment.

Also as mentioned above, the network losses in Jordan are very high and this will require major cost in terms of upgrading infrastructure.

The summary of potential water savings in municipal and domestic sector in Jordan are presented in the table below:

Table 14: Domestic Water Use Saving in Jordan: Summary of Potential

Cost Grouping	Policy Wedge	Quantity saved in Jordan (annual mcm, population 2020)	Cost (US$/$m^3$)
Minimal Cost Methods	Awareness Raising	20.5	0.15
Low Cost Methods	Gardening: (changing plant varieties)	54	0.25
	Accountability (technology, enforcement)		
Medium Cost Methods	Rainwater Roof catchment	12	0.45
	Rainwater Street catchment		
High Cost Methods	Toilet flushing (double flushing system installation and/or reuse of the grey water for toilet flushing)	56	0.60
	Network leakage reduction		
TOTAL		**142.5**	

The summary of Palestinian wedges in domestic and municipal sector is presented in the Table below:

Table 15: Potential Water Savings in Municipal and Domestic Sectors in Palestine

	Quantity saved in Palestine (annual mcm, population 2020)	Cost (US$/$m^3$)
Minimal Cost Methods (Public Awareness Raising)	14	0.15
Low Cost Methods (Rain water roof collection)	9	0.45 – 0.55
Medium Cost (Improved technologies for domestic use)	21	
High Cost Methods (Network Leakage decrease by 28 %)	14.5	0.60 – 0.70
TOTAL	**58.5**	

5.2 Water Savings in Agricultural Sector

5.2.1 Potential for Water Conservation in the Agricultural Sector in Israel

Though its share of national freshwater resources has declined steadily over the past two decades, including its use of reclaimed wastewater and brackish water, agriculture is still the largest water consuming sector in Israel. Agriculture accounts for nearly 40% of freshwater consumption in Israel and over 50% of total water consumption. In contrast, it contributes only roughly 1-2% to national Gross Domestic Product (GDP) and employment (CBS, 2009).

In general, the price of fresh water for agriculture covers the cost of pumping and delivery. As such, it is higher than the price of water to agriculture in most of the world. However, it is still below market rates in Israel, at less than half the price of desalinated water. As such, it can still be viewed as subsidized. Because of below market pricing of freshwater in agriculture there are opportunities for relatively low-cost water savings in this sector.

Agriculture produces numerous environmental impacts, both positive (e.g., preservation of open spaces) and negative (e.g., soil erosion, dispersion of pesticides into the soil and water). To the extent that they produce positive externalities, agriculture warrants government assistance, but this support need not be given via water subsidies. This is especially true of agriculture that does not provide such benefits, e.g., greenhouse agriculture, for which water use differs little than industrial uses.

Similarly, agriculture also provides some level of food security, and thus, it can be argued that it is providing a national service. However, such a rational is not valid for export crops or non-edible crops such as cotton. To the extent that it is valid, the question is whether the contribution to food security outweighs the depletion of water reserves and associated environmental damages.

Comparing the price for water by crop type, which differs by region, with a baseline of the cost of desalinated water (adjusted to account for delivery costs), it is possible to estimate the relative amount of water that could be saved.

Costs of price rises in the agricultural sector include the loss in profits to farmers, the loss of sunk costs in infrastructure, the effect of any long-term unemployment in the sector, and the loss of environmental services in terms of preservation of open space and provision of habitat.[16] Unemployment is generally not considered as a cost in most economic models, which assume full employment. However, if price rises force farmers to leave agriculture and these farmers do not find employment in other sectors, the price rises would have a social cost. Furthermore, it is

[16] In strictly environmental terms, loss of these environmental benefits would be partially offset by the avoided environmental damage from desalination. It should be noted too, that vegetables and flowers which are generally grown in greenhouses that involve high sunk capital costs, are generally less sensitive to price increases. These crops, however, also provide less environmental benefits in terms of preservation of open space and therefore are less justified in receiving water at low prices.

likely that any price increases to farmers would be accompanied by government compensation, at least for a period of several years. These costs would obviously reduce the economic benefits of water savings. On the other hand, much of agricultural work is done by foreign laborers. To the extent that declines in agricultural production reduce the number of foreign labors.

Table 16: Estimate of Price Increases on Agricultural Freshwater Consumption in Israel

Crop Type	Primary Market	Freshwater (mcm/y)	Primary Growing Location	Current Price (US$/m^3)	Profitability	Change in Demand (mcm/year)
Citrus	1	28	Golan, Hula, Jezreel Valley	0.18	Moderate	18
Other Orchard Crops	1-0	262	Golan, Galilee, Jordan Valley	0.18-0.35	Moderate	40
Animal Feed	0	46	Hula, Jordan Valley	0.18	Moderate	0
Nuts and Cotton	1	25	Hula, Jordan Valley	0.18	Moderate	15
Vegetables	1	139	Center, South	0.35	Moderate-High	50
Flowers	1	41	Center, South	0.35	Moderate-High	15
Livestock & Aquaculture	0	46	Broadly distributed	0.35	High	0
Total		587				138

In addition to changes in the price of water, changes in levels of international trade barriers, both tariff and non-tariff, can affect water demand in the agricultural sector. Currently trade barriers protecting local industry exist in the dairy industry, which is nearly completely protected from exports (with the exception of minor imports required by the World Trade Organization (WTO) and bilateral trade agreements), and to some degree in the fruit and vegetable sector, depending on the crop, the local price, and the growing season. Domestic banana production benefits from phyto-sanitary regulations which serve as non-tariff barriers. Most other agricultural production is not seen as likely to be affected by removal of trade barriers. [17]

Removal of trade protection such as quotas for dairy products would primarily affect the demand for powdered milk, not fresh dairy products. Removal of such barriers could make related production facilities up to half of current production redundant. The estimated water savings from such measures is 30 mcm per year, nearly two thirds of the freshwater use in this sector. Bananas are water-intensive crops, grown in Israel primarily in the Jordan River basin and, but for the trade barriers, would likely not be competitive vis-à-vis robust and high quality international supplies. Removal or relaxation of the phyto-sanitary restrictions would result in water savings of up to 15 mcm per year, or roughly three-fourths of the freshwater consumption dedicated to banana production.

In the case of both dairy and bananas, the effects on the market would likely be dramatic, and one can expect fierce political resistance to removal of current protections. If such barriers were to be removed, it is likely that farmers would be awarded compensation. The economic benefits of removal of such trade barriers would be largely contingent on the scale of compensation, and thus, no estimates are made herein.

Table 17: Effect of Removal of Trade Barriers on Agricultural Freshwater Consumption in Israel

Product Type	**Measure**	**Current Water Consumption (mcm/year)**	**Reduction in Water Demand (mcm/year)**
Milk powder	Removal of protection for milk powder	46	30
Bananas	Removal of phyto-sanitary regulations protecting bananas	20	15
Total		66	45

Sources: Israeli Water Authority, 2009; Ministry of Agriculture, 2009.

[17] Meat (primarily beef, lamb, and poultry) production would likely not be affected by international trade policies, for several reasons, including concerns over freshness, demand primarily for kosher meats, and the fact that imports for frozen meats already face little restrictions. Also, Israeli tastes have become accustomed to local varieties of fruits and vegetables, meaning that they may not be completely substitutable with foreign imports. This study focuses on dairy and bananas as the agricultural commodities most threatened by trade liberalization.

5.2.2 Potential for Water Conservation in the Agricultural Sector in Jordan

The options for the possible water savings from the agricultural sector are as following:

- Use of treated water for irrigation. Although there some negative implications that would require extra investment to compensate for it. Due to the fact that vegetables eaten raw can present health hazard if irrigated by treated water, it's considered that the savings of the freshwater sources will not exceed 80%.

- Renting the farmlands from farmers in summer period (Water User Associations should be consulted). Only the farmlands that plant vegetables should be considered. In winter season in Jordan Valley only supplementary irrigation is required, but in the summer period the agriculture in the Jordan Valley requires intensive irrigation, thus raising water consumption in agriculture dramatically. Renting the farms from farmers in the summer period will significantly decrease the water consumption.

- Optimization of irrigation. For six years, French cooperation, through its Regional Mission for Water and Agriculture (MREA) has developed in close collaboration with JVA the pilot phase of a project called IOJoV –"Irrigation optimization in the Jordan Valley". The project aims to optimize water distribution at both JVA distribution networks levels and at the farm level through the introduction of drip-irrigation and green-houses technology. Water savings reach up to40 %. The farmers that have made an agreement with JVA receive subsidies for equipment installation.

- Change of water tariffs in agriculture to cover not only pumping costs but operation and maintenance costs as well. It is considered as a high cost method due to the fact that the change of water tariffs in agriculture might result in the farmers abandoning the farms and seeking employment in other sectors and if not available, the price increase is likely to have a high social cost. Also, the price increases will require additional compensation or subsidies by the Jordanian government.

The table below presents the summary of possible water savings in irrigated agriculture in the Jordan Valley:

Table 18: Summary of Water Savings in Agricultural Sector in Jordan Valley

	Potential % saved	Quantity saved in Jordan Valley (annual mcm)	Cost (US$/m^3)
Use of treated water	80	74.75	0.55
Renting farmlands in summer period (vegetable crops)	80	11.3	0.55
Improved efficiency of irrigation	40	37.5	0.60 – 0.65
Change of water tariffs	50	46.7	0.55
TOTAL		**170.25**	

5.2.3 Potential for Water Conservation in the Agricultural Sector in Palestine

Currently, the agricultural sector uses potable water of drinking quality for irrigation. Municipal and domestic wastewater reuse in irrigation is currently non-existent. Also, the water tariffs in Palestine are not differentiated for the different uses. Therefore, the water tariff for agriculture is the same as the water tariff for domestic and municipal use, and therefore, it is assumed that it generally covers the expenses of abstraction and transmission.

Several policy wedges were examined for water savings in the agricultural sector in Palestine. All of the proposed wedges could be considered as high cost options.

1. Municipal wastewater reuse in agriculture: Currently, waste treatment facilities in Palestine are inadequate. The sewage network exists only in few places. Sewage collection in cesspits is primarily employed. Some of the municipal wastewater is transferred to Israel, however, the majority is not processed. Costs associated with increasing municipal wastewater reuse in agriculture include not only the establishment of the sewage treatment facilities, but also the cost of conveyance and the establishment of sewage network infrastructure.
2. Improved efficiency of irrigation: Adapting and introducing modern irrigation techniques will decrease losses in the irrigation transmission system including rehabilitation of springs will provide 10-12 mcm (MOBIC, 2001). The cost will include acquiring pipes for drip irrigation technique, estimated at US $0.60.
3. Rainwater collection and use for agriculture: At present, there are no storm water retention facilities in Palestine. Some farmers are using individual collection pits for rainwater collection. One of the options evaluated in this study includes the establishment of centralized facilities such as dams, the cost of which is considered to be very high. Another option, are the installation of individual rainwater storage facilities. The factor to be taken in consideration as with all proposed alternatives is that the Israeli authorities might not permit it.

Table 19: Summary of Savings in Agricultural Sector in Palestine

Methodology / Device Applied	**Quantity saved in Palestine (annual mcm, population 2020)**	**Cost (US$/m^3)**
High Cost Methods (Wastewater reuse)[18]	39	0.55 -0.60
High Cost Methods (Improved efficiency of irrigation by 40%)	11	0.60
TOTAL	**50**	

[18] ***Iyad Yaqoub, Wastewater Status in Palestine, WAP Rep.2004***

5.3 Reduced Water Losses from Reservoirs

Additionally, an innovative and but possibly controversial option was proposed in the Israeli analysis. Due to the region's high temperatures, a considerable amount of Israel's annual rainfall evaporates before it is able to be utilized. For instance, according to estimates, roughly 280 mcm evaporates annually from the Sea of Galilee alone.[19] This compares to 380 mcm that is pumped annually from the Sea into the national water system. There are also indications that temperatures have been rising and evaporation increasing in the region over the last 30 years, and that these changes may be indicative of future trends due to long term climate change.[20] Reducing water losses due to evaporation from exposed man-made surface water reservoirs represents another possible option for water conservation. There is no suggestion to cover natural water bodies.

In terms of fresh water, it is estimated that covering the reservoir at Beit Netufa could conserve up to 25 mcm per year. Other freshwater reservoirs could add additional supplies. The major opportunity for water savings from covering[21] reservoirs, however, is likely to be from covering treated sewage reservoirs. In 2009, Israel used 360 mcm of treated sewage. This amount is expected to increase to 480 mcm by 2020 and 560 mcm by 2030. Evaporation from these reservoirs is estimated at 12-15%.

In this analysis we assume that covering the reservoirs will reduce evaporation by 60-75%, that is, it will save 10% of the total amount of water used.

Table 20: Reduced Evaporation from Reservoirs

Water Source / Year	2010	2020	2030
Freshwater (mcm)	25	25	25
Treated Wastewater (mcm)	36	48	56
Total (mcm)	61	73	81
Cost (US$)	400,000	480,000	530,000

[19] Feitelson, Gazit, Fischhendler, 2005.
[20] Kafle and Bruins, 2009.
[21] http://www.mpccontainment.com/water-reservoir.shtml

5.4 Summary of Water Savings in Israel

A summation of the water conservation options identified in the Israeli analysis produces potential water savings of nearly 800 mcm per year. This is likely to be an over-estimate, as certain options overlap or partially crowd out others. In order to compensate for potential overlap between options, adjusted figures are given which are 15% lower than the unadjusted figures. From these adjusted figures, over 670 mcm of freshwater per year was identified as being available for conservation. Of this, over 500 mcm can be conserved at costs less than the marginal cost of water, i.e., the cost of desalination. An additional 150+ mcm of water per year can be conserved with current technology, but at costs that make it uncompetitive with desalination. Implementing the cost-effective measures would make unnecessary three large desalination plants, and/or alternatively, would free up water that could be returned to the natural flows of rivers. This amount represents nearly half of the natural flow of the Lower Jordan River.

The economic feasibility of the options shown was based on current prices. Changes in future prices of technologies, commodities, and externalities are likely to change the relative profitability of water saving options. By necessity this study had to limit its focus to options for which available data was available. Even with its limited focus, however, the study was able to identify numerous cost-effective options for water conservation at scales that would allow for significant stream restoration and/or reduction in the need for desalination. The figures for total water saved in the last three rows of the table have been reduced by 15% from the figures above to adjust for likely double-counting, as each option's water saving potential was evaluated in isolation.

Table 21: Summary of Policy Wedges Examined in Israel

	Policy Wedge	Water Conserved by 2020 (mcm/year)			Cost Effectiveness (US$/m³)	Feasibility 1-Low 5-High
		Low	Medium	High		
Supply	Reduced water losses from leakages	29	51	73	0.45	4-5
	Reduced water losses from reservoirs	61	73	81	0.007	4-5
	Rooftop rainwater collection	4	7	13	2.14	1-2
Demand	Awareness raising	76	101	126	0.10	4-5
	Change in plants used in gardens	23	46	68	0.61	4-5
	Price increases in agricultural sector	70	138	200	0.30	3
	Grey water use (irrigation)	36	76	118	1.32	1-2
	Grey water use (toilets)	13	27	55	2.21	1
	Removal of trade restrictions	30	45	60	High	1
Unadjusted	Total - net cost less than desalination	289	454	608		
	Total - net cost more than desalination	53	110	186		
	Total	**342**	**564**	**794**		
Adjusted	Total - net cost less than desalination	246	386	517		
	Total - net cost more than desalination	45	94	158		
	Total	**291**	**480**	**675**		

5.5 Summary of "Wedges" in Jordan

It is estimated that approximately 359 mcm of water can be saved in Jordan from water conservation, although the possibility exists of the overlap between certain options. In order to compensate for the possible overlap of the options the figures estimates were adjusted to 15% lower than the figures given. The adjusted total water savings is estimated at 305 mcm. All the identified policy wedges in Jordan are aligned with the national policies, which makes them highly politically feasible. In addition, all the possible savings are either below or on the level of the current cost of marginal water production.

Evaluation of the economic feasibility of the proposed savings is based on current prices, the profitability of the proposed alternatives of water savings is subject to change due to the future price changes for technologies, commodities, etc.

Table 22: Summary of Policy Wedges Examined by Jordan

Policy Wedge		Water Conserved by 2020 (mcm)			Cost effectiveness (cent/ m^3)	Long-term Feasibility Index(1 = low, 5 = high)
		Low	Medium	High		
Supply	Wastewater reclamation in agriculture	50	75	100	55	4
	Municipal rain catchment	7	10	13	51	4
	Reduction of water conveyance loss	17	21	25	51	3
	Farmland renting by JVA	8	12	16	55	3
	Accountability of supplied water	10	13	16	60	4-5
Demand	Public awareness	12	17	22	45-50	4-5
	Gardening reform	25	31	37	45-50	2-3
	Grey water for domestic use/double toilet flushing system	18	24	30	55-60	4-5
	Improved efficiency of irrigation	30	38	46	52	4-5
	Reform of agricultural water tariffs	40	47	54	55	4
	TOTAL	**217**	**288**	**359**		

5.3 Summary of "Wedges" in Palestine

It is estimated that around 108 mcm of water can be saved in Palestine from water conservation, although the possibility exists of the overlap between certain options. In order to compensate for the possible overlap of the options the figures estimates were adjusted to 15% lower than the figures given. The adjusted total water savings is estimated at 92 mcm.

The Israeli military orders, rules and regulations regarding water and water transfer, extraction, sale and distribution, control of water use, granting permits and all matters regarding water resources are serious impediments. These figures mentioned are in addition to Palestine receiving a fair share of shared water resources.

Table 23: Summary of Policy Wedges Examined by Palestine

	Annual mcm (average)	**Cost effectiveness (cent/ m^3)**	**Long-term Feasibility Index(1 = low, 5 = high)**
SUPPLY SIDE			
Wastewater reclamation for agriculture	39	55	4-5
Municipal rainwater catchments	9	52	4
Reduction of water conveyance loss	14.5	60	3--4
DEMAND SIDE			
Public awareness	14	45-50	4-5
Reduction of water for toilet flushing	21	55-60	4-5
Improved efficiency of irrigation	11	60	4-5
TOTAL	**108.5**		

6 Conclusion

A broad range of policy options, or wedges, exist to reduce water demand or augment supply. These options vary greatly in terms of cost per cubic meter of water conserved as well as in terms of political feasibility. Feasibility is a function of economic costs, likely opposition by negatively affected stakeholders and of the technological ease of implementation.

A simple summation of currently feasible water conservation options provided in this study produces potential water savings of nearly 1000 mcm per year. This amount is close to the historical natural flow of the Lower Jordan River and must be considered by policy makers at the national level prior to further advance of seawater desalination and /or the proposed Red Dead Conduit.

The economic feasibility of the options shown was based on current prices. Changes in future prices of technologies, commodities, and externalities are likely to change the relative profitability of water saving options. In particular as the cost of fossil fuels rise the feasibility of water conservation alternatives become even more attractive as the marginal cost of water will rise. It should also be noted that other options for conservation exist that have not been fully explored in this study, for instance, replacement of impervious surfaces with more pervious materials, the replacement of water-cooled air-conditioners with air-cooled systems, and many others. By necessity this study had to limit its focus to options for which available data was available. As such, it should be seen as an initial estimate, which can be the basis for future studies. Future studies may identify additional cost-effective methods for reducing water demand and/or augmenting supplies.

7 Next Steps

Having led the efforts to date for the river's rehabilitation, FoEME understands that a regional approach involving our respective governments that brings all sides to act together is a pre-requisite for gaining the political support for the flow of fresh water back to the river.

The next steps as identified by FoEME are as following:

- Develop and implement a Strategic Action Plan (SAP) in partnership with decision makers in Israel, Palestine and Jordan. The SAP will aim to advance support for the implementation of policy to address each "wedge" identified in this study.
- Help launch public awareness campaigns
- Work with regional and International "Champions" to promote recommendations of the Environmental Flow study and the Economic Analysis study
- Develop an international campaign to raise awareness on the state of the Lower Jordan River and the need for reform of regional water management.

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