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Alternatives in Jericho

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Report on Investment, Operation and Maintenance Costs of IWRM Technology Lines in the Jericho

Preface

The water sector in the West Bank and Gaza has remained undeveloped over the past three decades of occupation. Since 1967 West Bank water resources have been controlled and managed by the Israeli Military Authority through a number of Military Orders. These orders have barred Palestinians from participating in the planning and management of water resources and prevented them from developing local water resources in concert with growing water needs.

In addition, the lack of investments in improving infrastructure (physical water losses reach 50% in some areas), the scattered nature of the water supply and management utilities with the absence of adequate rules and regulations and absence of stakeholder participation has resulted in the deterioration of the entire water system in the OPT.

In reality, the advent of the peace process was not merely an opportunity for greater use, but rather a challenge to form new and responsive public institutions to govern water usage. It is for that the Palestinian Water Authority (PWA) was established in 1995 and was assigned the task of formulating and implementing a comprehensive Water Law and strategy, which would entail setting up adequate rules and regulations including the development of water master plans and regulating the water sector in the West Bank and Gaza. Due to the fact that Palestinians have not gained yet the full control over their water resources and the issue has been left to the final status negotiation, PWA faced with many constraints to implement the strategy and enforce the Water Law.

1. Introduction and Background

Water is one of the most important natural resources, access to safe water is vital for survival. However, despite significant investment in the water sector in the last decade, the outlook on access to safe water remains grim at the global level (World Bank, 2002. IDRC, 2005¹. UNESCO, 2009². UNWATER, 2008³) In order to overcome this problem, many attempts and studies mention the importance of a comprehensive approach to manage water resources and to enhance water supply

¹ IDRC: (International Development Research Center). (2005).Managing Water Demand: Policies, Practices, and Lessons. Published by International Water Association

² The United Nations World Water Development report 3. "Water in A changing World "Published by UNESCO.

³ United Nations Office to support the International Decade for Action "water for life 2005-2015 The reference the UN water Publication: the human right to water;current situation and future challenges.

services. One of the important components of the comprehensive Integrated Water Resources Management (IWRM) is to use socioeconomic indicators to formulate policies and practices (Sullivan, 2003 Alamarah, 2007), since the IWRM is not just about managing physical resources, but also to reform human systems to enable people to benefit from those resources. IWRM approach promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of the ecosystem (GWP, 2004). As demand increases, water resources are becoming increasingly scarce. The main driving forces behind that are population growth, economic development and changing trade policies. Water use has been growing at more than twice the rate of population increase during the century. By 2025, as much as two thirds of the world's population could be living in countries in water stress a majority of them in developing countries (SIWI, 2001). The fulfillment of poor people water related needs is fundamental to the elimination of poverty. Access to water and sanitation is a fundamental need for the poor, vital for their health and dignity and a key factor in improving economic productivity. The poor are often the ones who pay the highest price for accessing water for lower quality. (SIWI.2001)⁴.The Mediterranean, a water scarce area, it is estimated that 7% of the entire Mediterranean population (28 million persons, in 2007) lies below the poverty line of 500 m³/year per capita and another 29% (115 million person, in 2007) are below the threshold of 1000 m³/year per capita. (EUWI MED .2007).The ESCWA region⁵ accounts for about 4.5 % of the world's population, but only 0.62% of world's freshwater resources. Of the ten most water scarce countries in the world, eight ESCWA nations top of the list (Palestine one of them).

The per capita water availability in nine of thirteen countries falls below 500 cubic meters per year. The Palestinian Territories are among the most water-deprived countries in the world (Kawash, 2007. SUSMAQ⁶, 2005)⁷. This is mainly due to the

⁴ SIWI : (The Stockholm International Water Institute)

⁵ ESCWA countries are: Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Saudi Arabia, Syria, United Arab Emirates, Yemen

⁶ SUSMAQ :Sustainable Management of Aquifers in Palestine :three years project Funded by DFID , Implemented by Palestinian Water Authority in cooperation with New Castle University Between 2003-2005

arid climate conditions and the fluctuating political, social, and economic conditions which have resulted in weak institutional performance indicators. The actual available water is significantly lower than 80 m³⁸ per person per year for all purposes,⁹ due to the lack of accessibility of both ground water and infrastructure needed to fully utilize the available resources (West Bank Water Department, 2007). The available water per capita differs considerably among West Bank governorates¹⁰, which ranges from 29 to 150 liters per capita per day (L/capita/day). Most of the water available per capita is below the average value stated by Howard and Bartram the 100 L/capita/day (Howard and Bartram.2003)¹¹. This can be attributed to a lack of accessibility to water resources, poor water supply management, and the increasing poverty in the region.

The unique historical water situation in West Bank has resulted in suppressed water demand and water supplies are generally constrained due to technical, political, and institutional limitations. Approximately 30% of Palestinian communities in West Bank, approximately 700,000 people, 25% of which are under 16 years old, are not served by any water network and approximately 15 % of the population served less than one day a week. (National Water Council Report, 2007) .Thus the current water demands cannot be used to predict future demand,¹² (PWA, 2005)¹³ . A recent study carried out by the Palestinian Water Authority in cooperation with the German Technical Assistance Unit (GTZ) indicated that the gap between supply and demand will increase dramatically in the coming years (PWA, 2007)¹⁴; therefore, the Palestinian Authority (PA) should develop new water resources and formulate new policies and management options to fill the gap.

⁷Speech of Fadle Kawash (the Ex-Director Of The Palestinian Water Authority and chief of Negotiation team) in opening session of the General Meeting of Arab Water Council ,May 2007.Cairo.

⁸ This amount which is allocated by Israelis however the average renewable water per capita is 500m³

⁹ The amount the available for Palestinians for all purposes

¹⁰ Administratively West Bank divided to 11 governorates.

¹¹ Howard and Bartram argue that 7.5 l/c/d can be calculated as the basic minimum water requirement to meet direct human consumptive needs of which 21 l/c/d for food preparation and 50 l/c/d for hygiene and suggest 100 l/c/d as optimum access all requirement can be met.(domestic and health hygiene)

¹² Due to the Pressurized Water Consumption-.

¹³ Due to the limited predefined water quota ,The Palestinians have a limited water quota defined by Israelis , which means they use the available amount not the real need

¹⁴ Back ground Document submitted to the National Water Council .October 17th ,2007

The roles and responsibilities in the water sector in the West Bank are scattered and fragmented due to the lack of national coordination and the multiplicity of providers: municipalities, water utilities, private vendors. For the last 30 years of occupation, this continued situation of mixed roles and responsibilities in the water sector has led to inefficient management and uncoordinated investment and policies. There is an urgent need to restructure the water sector in order to regulate, monitor, and control the managerial, technical and financial performance of the national water suppliers¹⁵. Socioeconomic development in Palestine is to a large extent dependent on an adequate water supply. However, the current prices in most utilities do not reflect their real values since they are not based on economic and social analysis¹⁶. This makes it difficult to estimate real values and to set a reasonable water tariff structure.

Water resources must be managed in terms of both quality and quantity in an economically effective manner. A tariff policy has to be adopted in order to ensure both the efficient use and conservation of water while achieving cost recovery at all levels in the water sector. In line with the national water policy¹⁷, this tariff should take into consideration the high social and economic value of water, the socioeconomic insecurity of beneficiaries and the flexibility to assure that the poor can afford to pay for it¹⁸.

The coverage and quality of water services are generally correlated with income and wealth. The poor adopt strategies, such as purchasing water from trucks and hauling water from standpipes or domestic faucets in neighboring communities, to compensate for the absence or inadequacy of the piped water supply. Such strategies are normally extremely expensive in terms of money and time. In contrast, piped water normally is priced well below the marginal cost of provision. Due to the uncertain political and socioeconomic conditions in Palestine, the water management

¹⁵ Several local and international agencies attempt to formulate policy documents and reform plans, however the political willingness to do that still so low.

¹⁶ Most of water municipalities and the basis for water pricing and tariff are to cover the cost of the entire municipality not the waterborne cost.

¹⁷ The Palestinian Water Authority in the process to formulate the national water policy; however the main constrain are the political conditions.

¹⁸ Poor people pay between 10-16.5 % of the income however the recent increasing of unemployment expected to make this percentage higher than the research data.

policies and practices are not based on scientific approach or legal basis. There is also large scale mismanagement caused by the rapid changes of structure within the institutions of water sector. ¹⁹This study was done as part of the Integrated Water Resources Management approach to develop a financially sustainable water sector that maintains affordability and can upgrade the performance of water utilities.

2. Socio-Economic Conditions in the West Bank

2.1 Economy

The occupied territories are subject to exceptional political and economic conditions, having been under military rule for years. In situation characterized by legal restrictions, strikes and curfews, the local economy is by necessity constrained. The integration into the Israeli economy and infrastructure which has taken place during the years of occupation has profoundly changed the labor markets of the occupied territories.

More than seven years of Intifada and closures have plunged the Palestinian economy into deep crises, causing dramatic declines in living standards. Poverty has increased since last year, the overall poverty rate reached 70% in May 2007 as compared 68 % in July 2005. Poverty levels hit 71% in the West Bank 35% in Jerusalem and 79% in the Gaza Strip. Those Results show the same dramatic and deteriorating socio-economic situation as the last reports from the World Bank and PCBS. Indeed, PCBS estimated the poverty rate for the second quarter 2006 at 66.8% of households if income data were used, i.e., about 70.3% of population (PCBS, 2006). Moreover, the World Bank forecasts in its scenario 2 related to the Suspension of Clearance Revenue -Transfers, Trade and Labour Restrictions, that this situation will result in a dramatic contraction in 2006 of real GDP per capita (minus 21%). Under this scenario, unemployment jumps to 35% in 2006, with poverty levels reaching 62% (World Bank, 2006). The situation could be even worse in its scenario 4- Suspension of Clearance Revenue Transfers, Trade and Labour Restrictions, and Reduced Aid Flows- where real GDP per capita declines by 27% in 2006. Under this scenario, unemployment hits 40% and poverty 67% in 2006.¹ Extreme poverty also keeps increasing, affecting 38% of the overall population. The rates of extreme poverty are 33% in the West Bank, 54% in the Gaza Strip and 17% in Jerusalem. These figures are in line with the last set of 2005 PCBS data related to deep poverty according to

¹⁹ Social and political powers are the main drivers of institutional arrangement not the needs or the sustainability.

household monthly income which recorded 34,5% in the West Bank and 51,6% in the Gaza Strip (PCBS, 2006) .

Beyond the impacts of the protracted economic downturn since restrictions were imposed after the Second Intifadah, the Palestinian economy faces a more hazardous prospect- a fundamental change in its composition, with GDP increasingly driven by government spending and donor aid, leaving little resources for investment thus further reducing the productive base for a self-sustaining economy. Contributing to the crisis is an expanding labor force and a shrinking private sector, placing further pressure on the public sector to become the primary alternative for jobs.

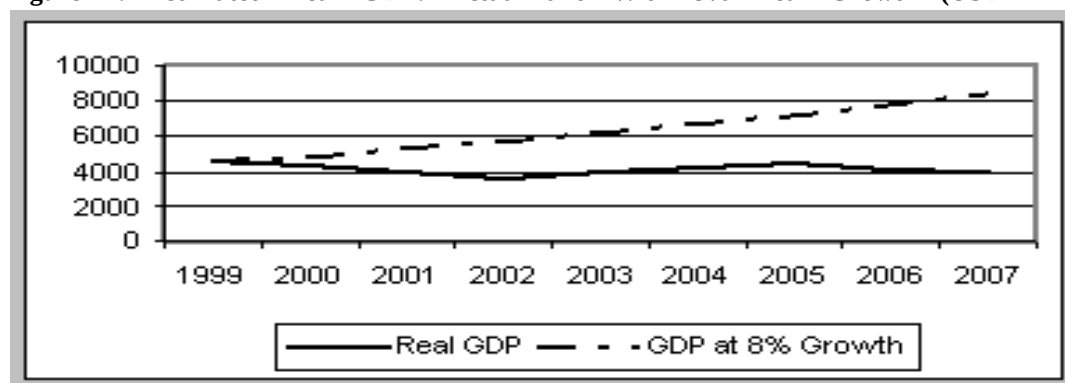
During the fiscal crisis in 2006 and 2007, the Palestinian economy relied on borrowing, remittances and increased aid outside the standard PA channels to sustain both public and private consumption. Investment, however, fell sharply. According to the Palestinian Central Bureau of Statistics (PCBS), household consumption dropped by only 0.6% between 2005 and 2006. However, investment fell to precariously low levels. Public investment in the last two years has nearly ceased as almost all government funds have been used to pay salaries and cover operating costs. The IMF estimates that private investments fell by over 15% between 2005 and 2006 and there is no evidence that it significantly increased in 2007. Gross capital formation by the private sector remains less than 16% in 2007.

The formation of the Caretaker Government in mid-2007, and the resumption of aid have reversed the impacts of the aid boycott in 2006 and 2007, but only partially. Real GDP was negative in the first half of 2007 but began to recover in the West bank during the second half. Because of the situation in Gaza, real GDP growth in 2007 is estimated to be about 30%, which given the rapidly growing population indicates falling per capita income⁴. Overall per capital income is estimated to be nearly 40% less than its peak in 1999. The contributing effects of the closures and movement restrictions cannot be overestimated. Between 1995 and 2000, the Palestinian economy was growing at an average rate of 6% per year. If that trend had continued after 2000, when restrictions intensified, real GDP may have been more than double its current value to reach over \$8 billion.

Following the Oslo accords in the early nineties, it was expected that the Palestinian economy would enter a period of sustained and rapid growth. While performance was not as strong as hoped, there was steady growth and by 1999 real GDP had grown to \$4,512 million. However, since the Intifada in 2000, when Israel instituted a strict closure regime, the Palestinian Economy has been on a downward trend (Figure 1). GDP fell to \$3,557 million at the height of the violence and Israeli incursions in 2002 and then recovered slightly in 2004 and 2005. But, with the continuing growth in settlements, continuing closures, and the cut off in direct aid after the election of a Hamas government, GDP fell again in 2006.

Real GDP in 2007 is expected to be about \$3,901 million, some 14 percent lower than its peak in 1999. Because of the rapid population growth during the same period, per capita GDP is off nearly 40% from its peak. The contributing effects of the closures and movement restrictions cannot be overestimated. Between, 1995 and 2000, the Palestinian economy was growing at an average rate of 8% per year. Had that trend continued through 2007 in the absence of restrictions, real GDP may have been more than double its current value (Figure 1).

Figure 2: Estimated Real GDP: Actual and With 8% Real Growth (USD million)



Source: PCBS and World Bank staff calculations

A combination of borrowing, remittances and increased aid that flowed around the PA has propped up GDP in the past two years and has allowed both public and private consumption to remain strong. A recent Palestinian Central Bureau of Statistics (PCBS) survey estimates that despite the economic crisis, household consumption dropped by only 0.6% between 2005 and 2006. But while consumption may have remained robust, investment has fallen to precariously low levels resulting in a hollowing out of the Palestinian productive sectors. Public investment has nearly ceased and in the last two years almost all government funds have been used to pay salaries and cover operating costs. Private investment is also low. The IMF estimates that it fell by over 15% between 2005 and 2006 and there is no evidence that it has significantly increased in 2007. A recent World Bank Investment Climate Assessment, which found that less than a quarter of private sector firms made any investments in 2005/2006 and that the equipment in manufacturing enterprises was on average over 12 years old. The lack of investment in public infrastructure and private enterprises is hollowing out the Palestinian productive base, leading to increased aid dependency and pointing to bleak future prospects unless the trend is reversed.

Despite large inflows of aid, the shrinking economy has led to increasing poverty. Unemployment in WB & G stands at nearly 22 percent up from only 10 percent before the beginning of the Intifadah in 2000. Unemployment is highest in Gaza at 29 percent of the active work force. Under the current closure regime and the restrictions on imports and exports for commercial activity, this is likely to become much higher as the layoffs in the industrial sector become permanent. The unemployment rate in the West Bank is approximately 19 percent. The percentage of Gazans who live in Deep Poverty has been steadily increasing, rising from 21.6% in 1998 to nearly 35% in 2006. With the continued economic decline in 2007 and the implementation of even more strict closures on Gaza, the current Deep Poverty rate is certainly higher.

2.2 Water Resources Availability and Supply –Demand Status

2.2.1 Water Resources Availability

The sources of the water in the West Bank are those renewable fresh waters of the Ground water aquifer which are estimated to be 650 mill m³ /year, in addition to the surface runoff in the Wadis, estimated to be 70 mill.m³/year. (PWA, 2005)²⁰.

The Gaza Coastal Aquifer is essentially the sole sources for water in the Gaza Governorates, a shallow aquifer that underlies the entire Gaza Governorates and extends northward into Israel. The natural renewable recharge is in the order of 45 mill.m³/year (PWA, 2005).

The Jordan River system has a natural capacity to deliver an average annual flow of 1320 mill.m³/year (PWA, 2006). The riparian of the Jordan River are Lebanon, Syria, Palestine and “Israel” and Jordan Palestine’s annual share from the Jordan River Basin has been estimated to be 20% of the total annual flow. As a result of water diversion of the upper Jordan River tributaries by the Israelis there is no fresh water down stream of Lake Tiberias, and the negligible quantity that reaches the Palestinian Riparian in the West Bank is of a deteriorated quality.

2.2.2 Water Uses and Consumption

Palestinian total use from the groundwater resources in the West Bank has been estimated to be 121 mill.m³/year. About 86 mill.m³/year. 71% is used to irrigate 90,000 donums. The remaining 34 mill.m³/yr are used for domestic and industrial consumption (industry’s share about 3%) with more than 40% of unaccounted (water loses) for water (PWA, 2006)²¹.

In Gaza, Palestinians total use of water is about 125 mill.m³/yr. is used to irrigate 120,000 donums. The remaining 45 millm³/yr are used for domestic and industrial consumption (industry’s share about 3% with more than 50% unaccounted for water. The water crises in Gaza are not limited to the deficit in quantity. However, the water quality is deteriorating and subject to continuous increase in salinity due to over-abstraction and to the percolation of sewage in the area.

At present, Israel is currently controlling 85% of the water from the Palestinian groundwater aquifers, and Palestinians are denied from their rights to the water of the

²⁰ Palestinian water authority Presentation in several workshops

²¹ PWA presentation submitted to the workshop “water in the Jordan river basin” Madrid 7-8 September 2008

Jordan River and Gaza Wadis. This policy has led to a severe water crisis in Palestine in general and the Gaza Governorates in particular.

2.2.3 Water Demand

The Unique historical water situation in the West Bank and Gaza Governorates has resulted in suppressed water demands. Water Supplies are generally constrained due to technical, institutional and political limitations. In addition to that, approximately 30% of Palestinian Communities are not served while 66% of the served communities suffer from water shortage especially in summer. Thus the current water demands cannot be used for predicting future demands.

Future demand projections should take into account the aforementioned facts in addition to normal assumptions used in predicting demands, like population growth and socio-economic development requirements.

Several studies²² conducted recently have indicated that the gap between supply and demand will increase dramatically in the coming few years, thus making the Palestinian's water right issue both a necessity seek feasible alternatives and options in order to fill this gap.

a. Domestic Water Demand

The target rates for domestics water consumption in order to bridge the gap between supply and demand falls within a range of 100 l/c/d and 150 l/c/d. These rates will be hopefully met after 10 and 15 years respectively with a target to and to use other resources and by reducing the loss rate to 25% over a 20 year period.

The historic water consumption in the West bank and Gaza has been artificially constrained by non- market forces as a result, historical consumption figures cannot be used to forecast future demand (NWC.2006)²³.

b. Agricultural Water Demand

Agriculture is considered one of the major economic sectors in Palestine. Its production contributes more than 30% to national income (MoA, 2006). Accordingly, there will be much emphasis regarding the development of irrigated agriculture in

²² GTZ .Middle East Regional Study On Water Supply and Demand Development -1997

And PWA Several studies and the study done by Flemish government (2007)

²³ Report submitted to the first National water council on march 9th 2006

Palestine. The potential area for irrigation is estimated to be 500,000 dunums. The projection of potential agricultural water demand is estimated to be 200 mill m³ over the coming 20 years. Treated wastewater is enlisted to be a support resource to irrigated agriculture (NWC, 2006).

c. Commercial and Industrial Water Demand

Due to lack of detailed economic industrial development plans for Palestine, it is not possible to base estimates of future commercial and industrial demand on economic projections. As a result, projected industrial and commercial water demands have been calculated as assumed percentage of the total water consumption in Palestine. These future demands are estimated to be 9% of the total consumption over a 20 years period (NWC, 2006).

d. Future Water Deficit

The numbers and data indicate that Palestinian facing harsh and tragic water conditions. The available water volume is decreasing year after year. While the demand is continuously due to the population increase, the expansion of inhabited areas and the industrial development. It is thus necessary to seek addition water resources and introduce methods that provide water.

Figure 3: The domestic consumption based on 60m³/c/year (basic human needs index)

	Population Million (Pop) 2007	Water consum- ption Mm ³ (WC)	POP 2010	WC	POP 2020	WC	POP 203 0	WC
Domestic								
WB	2.35	140.70	2.5	150.26	3.11	187.06	3.88	232.88
GAZA	1.41	84.9	1.56	93.7	2.16	129.8	2.99	179.9
SUB TOTAL	3.76	225.7	4.06	243.9	5.27	316.92	6.88	412.79
Agriculture								
WB		197		210		262		326
GAZA		119		131		182		252

Urban Needs								
WB		20		25		30		40
GAZA		10		12.5		15		20
Agriculture at household level (Rural)³								
WB		25.3		26.8		33.2		41.8
GAZA		11.2		11.8		14.6		18.4
Ecological Needs								
WB		12		12		12		12
GAZA		5		5		5		5
	3.76	625.2		678.08		870.72		1127.99

1. Urban needs based on PWA estimation
2. Rural areas (households gardens and livestock)

3. Case study

3.1 General Background

Jericho city (the town of moon, the city of palms or Antony s gift to Cleopatra) which is one of the oldest cities of the world, ten thousand years before the Christ) is located in the southern part of the Jordan Rift Valley which is extending From Africa in the south to Turkey in the North joining the crossroads of the east-west corridor and north-south corridor. The excavations have proven that the primitive man turned to be a settled one and moved from a hunter to a farmer.

It is 35 km east of Jerusalem and about 14 km northwest of the Dead Sea and 8 km west of the Jordan River and extends over 37,481 dunums. The city has been and will continue to be developed as a regional center for trade, tourism, and agriculture as well as environmental management particularly due to its unique historical, religious and cultural characteristics. Today Jericho City is the only international gateway for Palestinians residing in the West Bank to the outside world.

Due to its suitable climate, relatively abundant water resources and high land fertility the City is well known for its agricultural activities with an estimated 40% of its total

land area being used for such purposes giving the City an advantage when compared to other candidates for agri-business plans in the near future.

A large sector of the residents in the Jericho relies on tourism as an essential source of income, as Jericho enjoys great touristic constituents. The large number of historical, ancient, religions and natural sites and the medicinal tourist areas as well as its wonderful weather, its fantastic nature, its quality services and the colorful recreation means made Jericho focus of attraction as far as internal and external investors are concerned. The town attracted the largest local and international tourism companies to establish five star hotels as well as other touristic utilities. In 1996, investors found Jericho a suitable place to invest in. The size of new investments in tourism sector since 1997 up till 2000 exceeded 180 million US dollars. New hotels were founded to cope with the ever increasing numbers of tourists coming to Jericho and one of the unique salt lakes, the Dead Sea, in the World. Furthermore, it has a rich diversity in terms of flora and fauna and combines both northern and southern type of diversity. It also includes the caves where the oldest evidence of the written bible was found.

3.2 Hydrology and Climate

In general, Jericho belongs to the tropical zone. The climate is characterized by a long hot and dry summer, and short warm with little rainy winter. Temperature average of the air is ranging between 13.2 and 30° c in January, and August respectively. The mean maximum temperature ranges from 19.1 (January) to 37.6 c° (August), while the mean minimum temperature is ranging between 7.4 c° and 22.4 c° for the same months. Figure 4 presents the minimum, maximum and average monthly temperatures in Jericho area.

The mean annual of relative humidity reaches about 52 %, The minimum value of relative humidity is 38% which occurs in May and June during the Khamaseen weather, while the maximum relative humidity of 70% is usually registered in January and December.

Rainfall in Jericho area usually begins in October and continues through May. About 60% of the annual rainfall precipitated in that period between December and February, while 28% of annual rainfall occurs in November and March. Rain in the rest of the year is rare. The annual average of rainfall reaches 166 mm, while the maximum monthly rainfall recorded in February of about 112 mm.

Due to high temperatures, intensive sunshine and low humidity in the summer months, evaporation has a high magnitude. The potential evapotranspiration (PET) amounts range between more than 194 mm in July to 52 mm in January (Figure 4)

Figure 4: Long term monthly averages of climate parameters of Jericho.

Element	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Max. Temp (c°)	19.1	20.9	24.3	29.3	33.7	36.7	37.8	37.6	36.1	32.3	26.4	20.4
Mean Min. Temp (c°)	7.4	8.3	10.5	14.2	17.6	20.4	22.1	22.4	21.2	17.9	12.9	9.0
Absolute Max. Temp (c°)	25.0	6.27	33.8	41.4	46.4	45.0	44.0	45.6	43.4	40.6	34.8	28.8
Absolute Min. Temp (c°)	0.2	-0.4	2.8	2.4	10.4	15.4	18.0	19.0	13.2	11.4	4.2	2.1
Mean Temp (c°)	13.2	14.6	17.4	21.7	25.6	28.5	29.9	30.0	28.6	25.1	19.6	14.7
Mean Wind Speed (Km/h)	8.9	10.4	13.1	16.2	15.8	15.3	16.0	14.8	12.5	9.4	7.9	7.6
Pressure (mbar)	1048	1046	1044	1041	1040	1037	1034	1035	1039	1042	1046	1048
Mean Sunshine (hr/d)	5.5	5.9	7.7	9.3	9.4	11.8	11.7	11.6	10.5	8.7	6.5	5.6
Mean RH (%)	70	65	57	45	38	38	40	44	47	51	60	70
Total Rainfall (mm) *	36	31	25	10	2	0	0	0	0	7	22	33
Total Evaporation (mm) *	78	76	128	189	261	289	298	267	227	135	94	59
Total PET (mm) *	52	56	85	121	163	181	194	188	166	140	91	58
Max Monthly Rainfall (mm)	62	112	41	20	22	7	0	0	7	71	81	104

3.3 Population and Socio- Economic Conditions

According to the Palestinian Central Bureau of Statistics (PCBS), the population of Jericho City today is estimated to be 19,696. Known as the city with the lowest population density, Jericho is inhabited by 69 persons/km² (JICA, 2006) which implies a potential for future expansion.

3.3.1 Employment

most of the population in Jericho City relies upon agriculture and the service sector as their main source of livelihood. Many of the residents in the Jericho Governorate also rely on tourism as an important source of income. It has a 9% average unemployment rate.

Based on the results of the household survey more than half of the sampled households rely on the private sector as their main income source as in Around 40% of the respondents earn between 1000 and 2000 NIS, that is \$US 2/capita/day. The breadwinners in these households are prevalently males, around 95%, at an average age of 50 years old and have a secondary education or less

3.3.2 Water

Supplied from Ein al Sultan spring almost all of the households in Jericho City are connected to a water network. The results from the household survey give a general overview of the water services from a household perspective. More than 85% of the respondents complain of seasonal water cutoffs mainly during the summer during the night.

This problem is further complicated by the lack of storage facilities in a considerable number of households as 11.5% of the responding households do not have any storage facilities and those who do can store an average of 2 m³ or two small plastic roof tanks common to the area. Despite the seasonal cutoffs, which when compared to other areas in the West Bank are very minor, 80% of the respondents believe that the water supply is sufficient enough to fulfill their needs. However, residents in some neighborhoods complained more than others such as those in Ein al Sultan and Al Jami where 50% said that the water is not enough.

Households pay an average 173 NIS/cycle in the summer and 116 NIS/cycle; meaning that households are paying an average of 7% of their income for water supply.

In order to grasp a clear understanding of water use trends the households were asked if they own certain devices or facilities that maybe related to water consumption, see Table 12. Of the most interesting results is that 67% of the respondents own at least one wet cooling system used extensively in the summer regardless of their high water

consumption rates or their negative health impacts. Of the households surveyed 2.6% own swimming pools with an average volume of 40 m³, changing the water 1.17 times/year. Related to water practices about 64% irrigate their home gardens with an average area of 500 m² (half a dunum), 75% of which rely on the domestic network for their supply. The produce is used for personnel consumption. About 84% do not reuse water for irrigating their home gardens while 63% are willing to reuse treated wastewater for irrigating their gardens. An average 72% do not use water saving devices in their homes such as pressurized taps.

3.3.3 Economic Activity

a. Commerce

Situated on one of the main commercial routes and being the main urban center in the Governorate gave Jericho a significant commercial role throughout history. However, the difficult circumstances that Palestinians experience under occupation have very much paralyzed any significant economic activities. Following the Oslo Agreement a number of small workshops and businesses were established in the City including sewing and food factories in addition to a water bottling company, cement storage facilities imported from Jordan and a steel factory. Commercial activities today in the City are limited to small privately owned businesses. But what distinguishes Jericho is the variety of agricultural products cultivated in the area housing the central fruit and vegetable market. Today, commercial facilities in Jericho extend over 336 dunums although the lack of industrial zones far away from residential areas is a challenge as result of the complicated geo-political context since most of the proposed industrial areas are to the north and are all classified as Area C under Israeli control. Challenges to the sector also include the lack of financial resources and infrastructure.

Future plans envision the City to be a trilateral free market area for Jordan- Israel- Palestine as it is the eastern gate of Palestine. A planned Agro-industrial Park will put its priority on business dealing with high value added fresh fruits and vegetables, and food processing industry. Export promotion of priority industries will be the important mission of the Agro-industrial Park development (JICA, 2009).

b. Tourism

Jericho, the oldest and lowest city in the world, is considered as the main resort in the West Bank due to its unique weather and beautiful settings in addition to its numerous recreational parks, touristic and historical sites. It contains around 80 religious, touristic and ancient ruined sites, including Hisham Palace, Old Jericho (Tel Sultan), and Mount of Temptation.

In 2008, the city hosted some 500,000 tourists, an increase of over 100,000 from 2007. According to the Palestinian Ministry of Tourism, the number of visitors has risen dramatically over the last year due to patches and updates that were completed for the most important attraction locations. The number of local visitors and residents in the city increased from about 80 thousand visitors during the month of February, 2009 (32 thousand overnights) to more than 150 thousand visitors during the same period of this year (55 thousand overnights), which means an increase of 90.3%.

There are 6 hotels in the City with a total of 335 rooms. According to PCBS the room occupancy rate in 2008 was 28% with around 700 guests per month and a 2.2 night stay per guest.

A phenomenon that is unique to Jericho is known as internal tourism. Jerusalemites are very frequent visitors to Jericho, “temporary residents”, that tend to spend the weekends for every month in the City especially during the winter and are well known to be large water consumers since many of them are said to own swimming pools. The results of the household survey show that almost 9% of the sample are temporary residents that spend an average of 6 days per month.

Also known as the only international gateway more than one million Palestinian was reported to have passed through Jericho while entering or departing the West Bank last year. A 32% increase in the number of entries and departures through the Jericho between 2006 and 2009 (Figure 5).

Figure 5: No. of entries and departures through King Hussein Bridge

Year	No. of enteries and departures
2006	706,005
2007	865,461
2008	942,300
2009	1,035,500

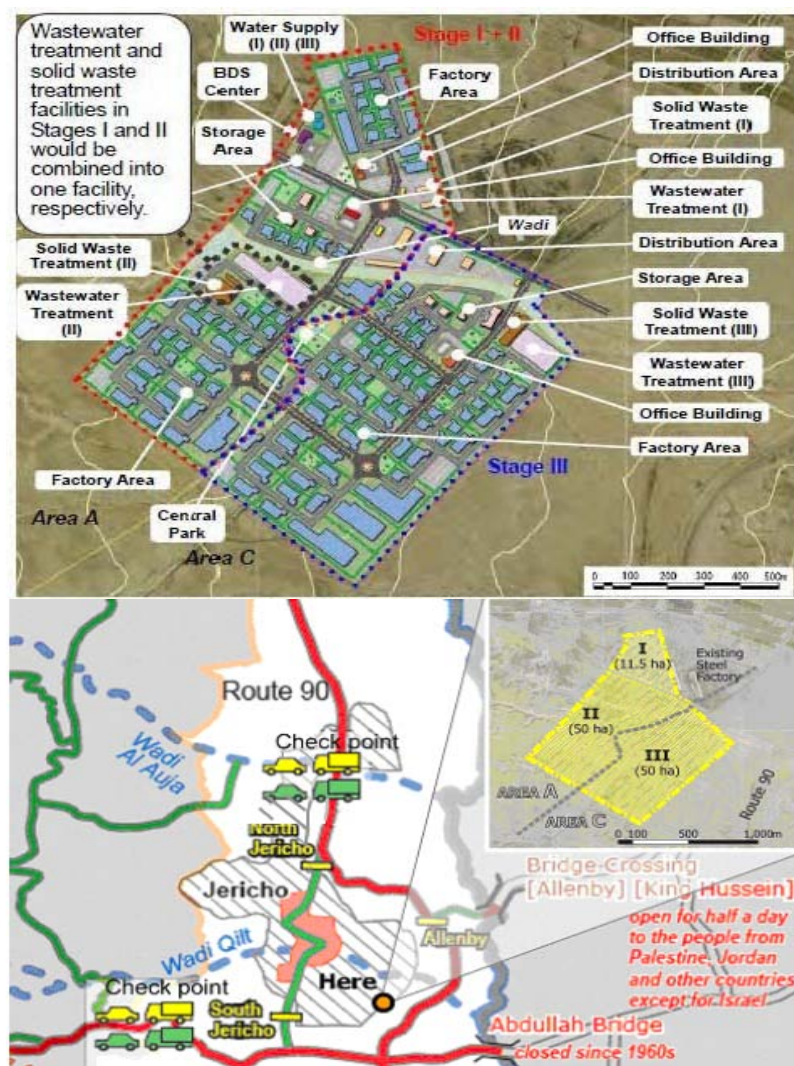
However, there remains a great potential for an increase in touristic activity. The city will be developed as a major tourism center, attracting more international tourists, as well as local visitors. Resort tourism developments in the Dead Sea area will be proposed to stimulate tourism in the longer term. The area around the Dead Sea bordering with Jordan and Israel would be proposed for a border free eco tourism zone utilizing existing natural resources and geographical features (JICA, 2006).

c. Industry

Industrial activities in Jericho City are also very limited. One of the main water consuming industries is the Sultan Water Bottling Factory in addition to the Iron Factory, Kef Al Wad Brick Factory, the Market Brick Factory and Ar Rowad Meat Factory.

Since the Jericho governorate is the largest in the area of all Palestinian governorates in the West Bank, and due to the abundance of suitable lands it's nominated for the establishment of an industrial zone (Agro Industrial Park) the center of which is expected to be the City due to its strategic location and proximity to borders.

The Agro Industrial Park is expected to be constructed over three phases and will occupy 1115 dunums and will include nearly 123 food processing factories in addition to other businesses and logistic support businesses as shown in Figure 6 & 7.



Figures 6&7: Agro Industrial Park

d. Agriculture

Agriculture plays a significant role in the economical lives of the people in Jericho. The essential combination of a warm climate and abundance of water gives the area a perfect agricultural environment. Most of the planted area depends on irrigation rather than rainfall. The irrigation is organized in small to medium land slots around the major irrigation network lines that are fed by Ein Al Sultan spring. Furthermore, some private farms possess their own wells, so they are independent from public supply and can sell some of their irrigation loads to other farmers. Irrigation in the area is mostly drip irrigation (82%). Surface irrigation represents only 1.4% and sprinkler 2%, however 14.6% are using mixed methods. In future plans the City is expected to be a vital agribusiness and export terminal and has a large potential for agricultural expansion under efficient water management schemes.

In the agricultural survey 32.1% of the respondents were land owners, 34% tenants, 32.1% farmers and 1.9% both owners and tenants all being permanent residents of Jericho City, as depicted in (Figure 8).

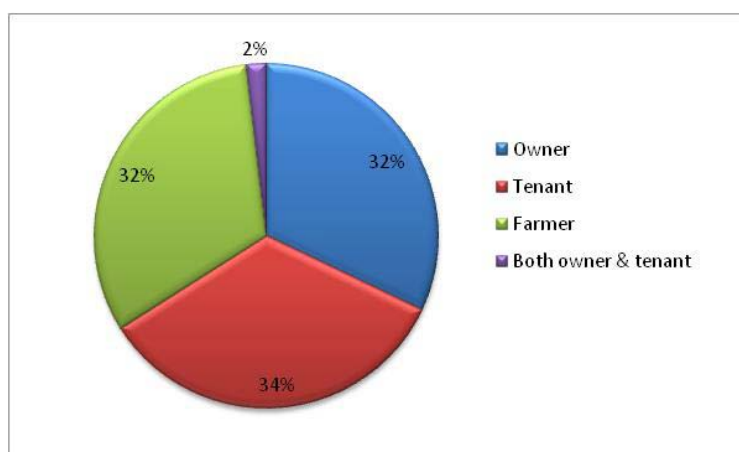


Figure 8: Distribution of respondents according to land ownership

In the socio-economic context of these farmers 61.5% of the respondents depend on agriculture as their main income source. Around 73.5% of the respondents earn between 1000 and 3000 NIS, that is \$US 2 /capita/day managing households of 8 members.

On the farm level the results show that an average of 3.6 people work in the farms of the respondents. About 98% of the farmers use the irrigation network of which 66% use hydrometers and 32% use water meters while the remaining respondents use groundwater wells. The respondents receive an average of 2 days of supply per week. Forty nine out of the 54 respondents use drip systems for irrigation. About 70% of the sampled say that the water is sufficient only for irrigating a percentage of their land

(82%) on a seasonal basis, 97% in the winter and 59% in the summer. Only 34% use storage facilities, mostly agricultural pools with an average capacity of 765 m³. Distributed among months the water is mostly used during the period between April and August as in Figure 9.

In terms of prices 56% of basateen share owners do not know how the fees are determined while 72% of muftalah share owners do not know how the fees are determined.

Some of the most interesting results from the survey were the perspectives of the surveyed farmers in terms of water management as 78.7 % believe that the Municipality has the technical capacity to maintain the irrigation network while 74.5 % believe that the Municipality has the managerial capacity to maintain the irrigation network. In terms of cropping patterns and irrigation methods 69.7% are willing to change crops according to a national strategy and 12.1% are willing to change irrigation methods to decrease losses while 12.1% are willing to do both. An encouraging 71.2% are willing to reuse treated wastewater for agricultural purposes but for specific crops, 21.2% are not and 7.7% do not know a lot about this option.

Some of the main problems mentioned by the surveyed farmers include the insufficient water supply (especially during the summer season), the weak pressure of water supply and the expensive water fees from source (price per m³ & annual taxes). Mainly anticipated to be caused by the lack of timely distribution of water shares on a weekly basis, the lack of compliance between supply and demand throughout the seasons, the increase of water demand due to urban expansion and the mismanagement of the water and lack of follow up.

The farmers mainly suggested the introduction of better management and follow up plans (including water distribution) and new water sources as the best ways to solving these problems.

3.4 Water resources

3.4.1 Conventional Water Resources (Surface and Groundwater)

Water resources in the study area are mainly limited to groundwater that is being exploited through wells and springs. However, the only surface water resource is the Jordan River but Palestinians have no access to its water as of yet. At the same time, flood flows of two main valleys of Wadi Qilt and Wadi Nuwei'meh which are crossing the area are not used. Thus, groundwater forms the main water resource in the area through wells and springs. The main aquifer systems in the area are:

The Shallow aquifer (Alluvium and Lisan Formation) of Plio-Pleistocene ages:

Geologically, the area is mostly covered by Lisan Formation rocks that related to Pleistocene age. Lisan formation in the area is mainly composed of thin laminated marls, and gypsum beds (Table 1). Structurally, the marls are very simple, having some slight north-south trending folds and towards the Jordan river, the center of the basin a slight depositional dip which may have been accentuated by subsidence. Marginally the lithology is gravels and poorly sorted pebble beds, occasionally calcareous with little or no evaporites, sometimes siliceous adjacent to present of former outcrops of Chert, and limestone adjacent to older rocks. In addition, Alluvium deposits occur alongside the Jordan River tributaries. These deposits are mainly unconsolidated, laminated marls, and mud with some siliceous sand.

Alluvium and Lisan formation are considered the main aquifer system in the area where it is tapped by many agricultural wells drilled in the area. Hydrogeological properties of this aquifer differ from one area to another regarding the lithological composition and the thickness of these sediments (Table 15). Recharge of Pleistocene system is mainly originated from the lateral flow from the Mountain Aquifer Systems that is replenished in the mountain area some 10 to 30 km to the west; and the infiltration of storm water from flooded valleys crossing the aquifer.

The depth of the groundwater level of this aquifer varies from one area to another ranging from 20 m to 80 m below ground level. The seasonal / annual groundwater level fluctuation is a function of recharge - discharge relation. In general, groundwater moves in this system towards the Jordan River and the Dead Sea to the east.

3.4.2 Non-Conventional Resources (Runoff, Treated Effluent ...)

a. Wastewater

Wastewater quantity and characteristics is currently not known due to the lack of data especially concerning Jericho. Usually the calculated wastewater generated is based on 80% of the water consumption. However the case in Jericho may be different due to the large amounts of water that are used in irrigation purposes for home gardens and yards. Wastewater composition is mainly domestic and usually concentrated due to low water consumption rates.

Jericho has no wastewater collection system instead cesspits are used. When they are full, if ever due to leakage, they are emptied by sewage tankers and the contents are disposed of in a nearby sewage dump or simply into wadis surrounding the area. A cesspit with an average volume of 25 m³ is usually emptied once every 5 to 6 months. Each tank load costs 50 NIS. Currently, four sewage tankers are in use in the city alone. The dumpsite is located about 1.5 km east of the nearest residential area. This was the farthest point that could be reached due to the Israeli restriction on land use in the area.

Obviously, no treatment prior to disposal occurs. One private treatment plant exists belonging to Jericho's Intercontinental Hotel Casino. Before the current Intifada the Municipality discharged all wastewater coming from public facilities and other municipal centers into the small-scale plant. About 250 m³ were dumped weekly. However, this is not the present situation.

b. Storm Water Runoff

The two major wadis in the study area are those of Al-Qilt and Nuiemeh as shown in (Figure 10) with average total annual flow of 1.47 Mcm and 0.945 Mcm respectively.

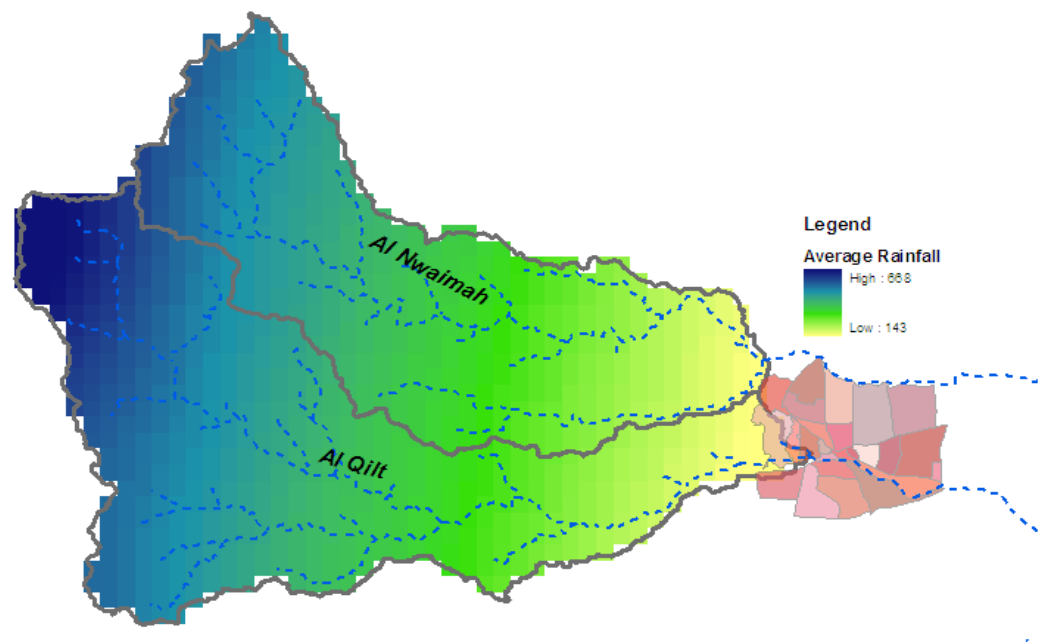


Figure 10: Surface catchment areas and runoff

3.5 Supply –Demand

3.5.1 Water Demand Projection scenarios

Water situation has been intensified considerably due to the increased demand of various users especially tourists and holiday-makers. Yet, Jericho is the food basket of the West Bank, therefore, agriculture is the main sector that will likely remain in the city to maintain food provision to the rest of the Palestinian Areas. Moreover, according to the argumentation laid out at the Bethlehem Investors' Conference in May 2008, the Middle East Quartet does its best to encourage private investment in Palestine, and a large industrial Estate has been planned in the Jericho area. Under this project, the Municipality of Jericho could become an area with highly concentrated economic activity.

In the light of this situation and rapid increase in population and industrial development, it is likely that Jericho will be faced with several challenges that may affect its unique status. Accordingly, the purpose of developing this water master plan for Jericho city is to manage the existing water resources as well as looking for additional water sources in order to meet the growing domestic, commercial and agricultural needs. Consequently, the master plan will be developed to provide guidance and directions for managing the supply and demand of the Jericho city. It includes different types of actions, starting from development of new water sources which aims to increase the supply, demand management actions to rationalize the

demand and infrastructural actions which aims to improve its efficiency and decrease the losses from the system.

Figure 11: Water distribution for the domestic network under Do Nothing Scenario

		2010	2020	2030	2040	2050
Population (Inhabitant)		19671	25676	33515	43747	57101
Supply Requirement (including loss, reuse and other demand Management)	Domestic Demand (1000 m ³ /yr)	1795	2343	3058	3992	5211
	Domestic Demand (l/c/d)	250	250	250	250	250
	Public Demand (1000 m ³ /yr)	425	555	725	946	1235
	Commercial Demand (1000 m ³ /yr)	138	180	235	307	401
	Aqbat Jaber Camp (1000 m ³ /yr)	46.5				
	Agricultural Demand (1000 m ³ /yr)	164	198	232	265	299
	Agro-Industrial Zone (1000 m ³ /yr)	0	0	0	0	0
	Sum (Mm ³ /yr)	2.57	3.32	4.30	5.56	7.19
Delivered Supply at demand sites	Domestic Demand (1000 m ³ /yr)	1470	1556	1580	1607	1639
	Domestic Demand (l/c/d)	205	166	129	101	79
	Public Demand (1000 m ³ /yr)	355	377	382	389	397
	Commercial Demand (1000 m ³ /yr)	115	123	124	127	129
	Aqbat Jaber Camp (1000 m ³ /yr)	46.5				
	Agricultural Demand (1000 m ³ /yr)	138	136	124	111	97
	Agro-Industrial Zone (1000 m ³ /yr)	0	0	0	0	0
	Sum (Mm ³ /yr)	2.12	2.24	2.26	2.28	2.31
Un-met demand (Mm³/yr)		0.44	1.08	2.04	3.28	4.88

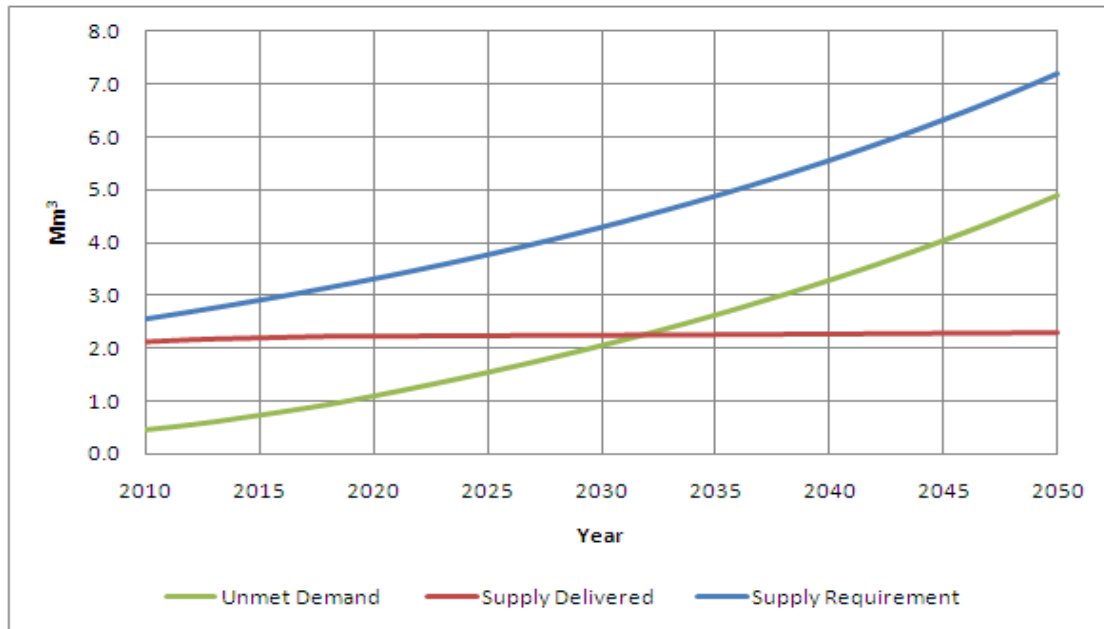


Figure 12: Supply-demand quantities for the domestic network under Do-Nothing Scenario

As can be noticed that the gap between the supply and demand for the domestic sector under the do nothing scenario is very high. Total domestic demand will exceed 7 Mm³ by the year 2050 while the supply will remain constant around 2 Mm³/year. Such situation would mean that the entire spring discharge should be allocated to domestic and agriculture would be abandoned completely and probably can rely on alternative sources. Even the total spring discharge will not be sufficient to cover this deficit and new resources must be developed from 2015 onward if the situation continues as is today.

3.5.2 Agricultural Demand

The demands, the available supply and the network losses for the five lines on the agricultural network as well as other related information are summarized in Figure 13 and Figure 14

Figure 13: Water distribution for the agricultural network under Do Nothing Scenario

		2010	2020	2030	2040	2050
Supply Requirement (including loss, reuse and other demand Management)	Line A (1000 m ³ /yr)	644	619	593	567	542
	Line B (1000 m ³ /yr)	609	596	583	571	558
	Line C (1000 m ³ /yr)	756	747	739	730	721
	Line CD (1000 m ³ /yr)	31	30	29	28	27
	Line D (1000 m ³ /yr)	360	356	351	347	343
	Sum(Mm³/yr)	2.40	2.35	2.30	2.24	2.19
Supply Delivered at Demands sites	Line A (1000 m ³ /yr)	578	572	565	555	540
	Line B (1000 m ³ /yr)	556	553	550	546	541
	Line C (1000 m ³ /yr)	756	747	739	730	721
	Line CD (1000 m ³ /yr)	29	28	28	27	26
	Line D (1000 m ³ /yr)	351	349	347	344	341
	Total supply (Mm³/yr)	2.27	2.25	2.23	2.20	2.17
Un-met demand (Mm³/yr)		0.13	0.10	0.07	0.04	0.02

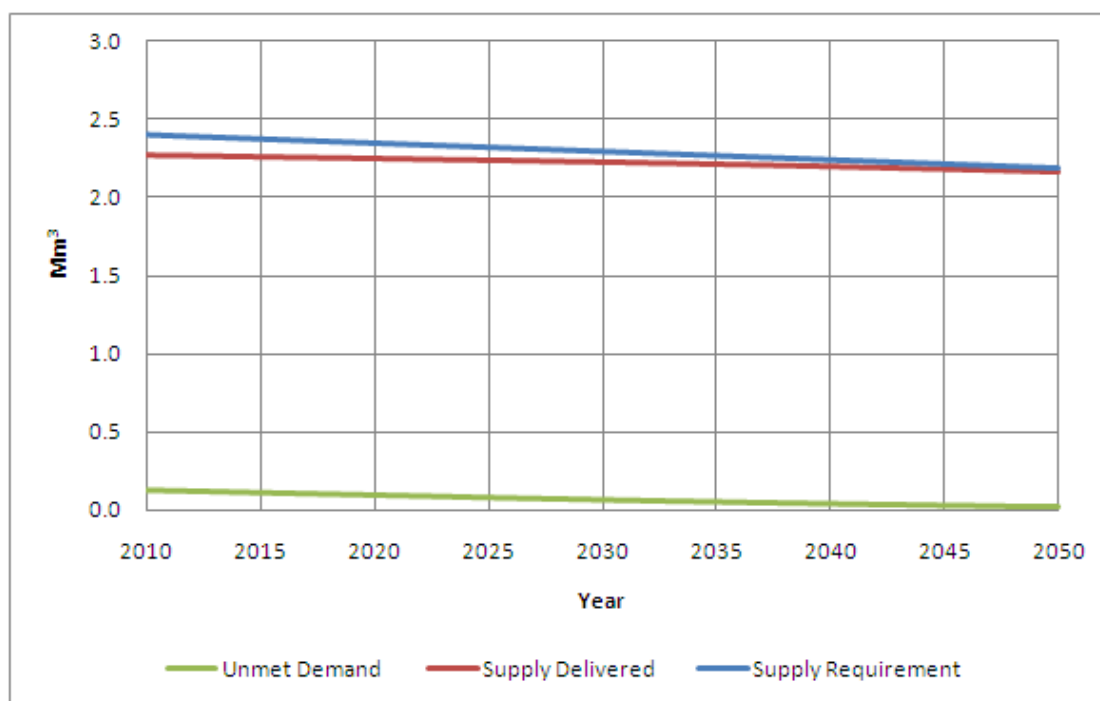


Figure 14: Supply-demand quantities for agricultural network under Do-Nothing Scenario

As expected, agriculture will be declining since domestic water use will increase and more urbanization will take place.

Ein As-Sultan Camp: the demand and the supply delivered to Ein As Sultan Camp is considered constant for the entire master plan period. (Supply=Demand= 0.144 Mm³/yr). The total demand/supply on Ein As-Sultan Spring for all demand sites (domestic, agriculture, commercial, public and for the two camps) is shown in Figure 15, 16 and 17.

Figure 15: Supply/Demand for Ein As-Sultan spring under Do Nothing Scenario

	2010	2020	2030	2040	2050
Supply Requirement (including loss, reuse and other demand Management) (Mm³/yr)	5.12	5.82	6.74	7.95	9.53
Supply Delivered at Demands sites (Mm³/yr)	4.53	4.63	4.63	4.62	4.62
Supply Delivered at Source (Mm³/yr)	5.67	5.67	5.67	5.67	5.67
Un-met demand (Mm³/yr)	0.59	1.19	2.11	3.33	4.91

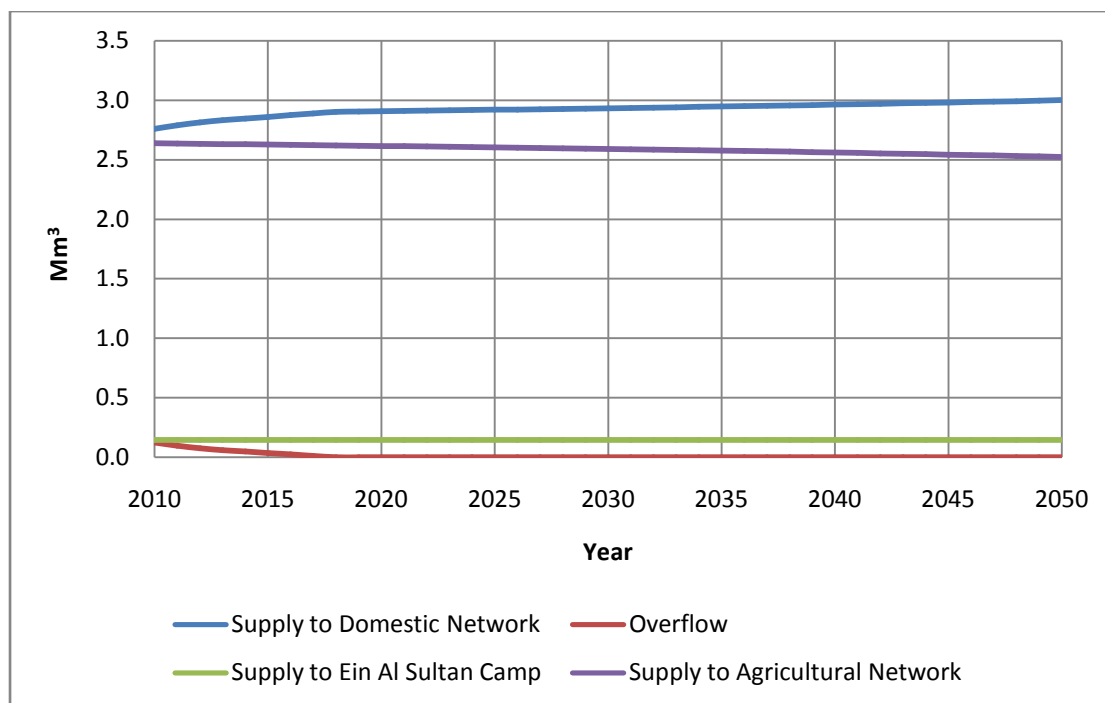


Figure 16: spring utilization under Do Nothing Scenario

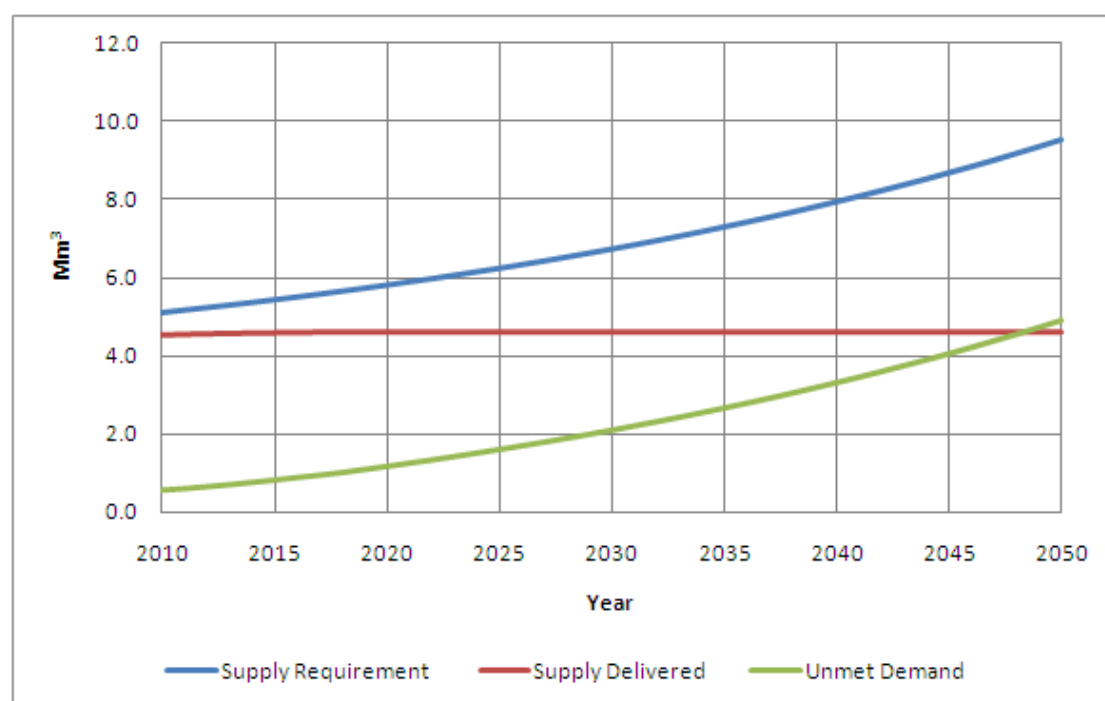


Figure 17: Supply-demand for Ein As-Sultan spring under Do Nothing Scenario

Agricultural Demand (east of Jericho city): the demand and the supply delivered to around 6500 donums under do nothing scenario is shown in Figure 18.

Figure 18: Supply-demand for irrigable lands east of Jericho city under Do Nothing Scenario

	2010	2020	2030	2040	2050
Demand (Mm³/yr)	3.62	4.08	4.54	5.00	5.46
Supply Delivered (Mm³/yr)	2.86	1.61	0.90	0.51	0.29
Un-met demand (Mm³/yr)	0.75	2.47	3.63	4.49	5.18
Irrigated areas (Donums)	3451	1940	1090	613	344

3.6 IWRM Applications

Activity
Execute laws and rules
Finding and development of alternative/ additional water resources
Installing a wastewater network system
Installing wastewater treatment plant
Conducting small-scale rainwater harvesting techniques
Installing brackish water desalination projects
Exploiting surface water sources
Improving utilization of Groundwater Supply
Founding Sanitary Landfill Sites. (In avoidance of soil and groundwater contamination)
Distribution of responsibilities amongst organizations and bodies working in the sector.
Raising public awareness
Establishing a just water system for the allocation and distribution of the available supply according to water laws
Establishing a higher committee or commission to take control over water services in the Valley Area.
Capacity building for technical staff.
Rehabilitation and maintenance of water network system.
The introduction of advanced technology in the sector
Changing cultivation and irrigation trends to reduce agricultural consumption
Establishing a credible tariff system.
Potentially, encouraging the substitution of water based cooling systems (wet conditioners) with gas based ones (dry conditioners).

3.6.1 Cost of the application

First: Demand Management Actions:

Several actions are proposed in order to rationalize the demand level; the main actions are to replace the wet cooling system by dry cooling system as well as improve infrastructure and management. Other actions are proposed such as modifying the used tariff system, institutional reform and conducting public awareness activities that include:

- Community meetings (lectures in schools, meeting with local social organizations).
- Launching a water conservation campaign.
- Distributing of brochures and conservation instructions attached to the monthly bills.

a. Replace the wet cooling system by dry cooling system, as described earlier, an amount of 0.29126 Mm³/yr (15.2 l/c/d) is annually used for wet cooling system. The assumption made here that, by the year 2020, all wet cooling system will be replaced to dry cooling system. As a result, the domestic demand will be reduced to 76 m³/capita/year by the year 2020.

b. Infrastructural actions: it is assumed during the development of the master plan that the network losses will remain at the current rate of 23.7%. As a result, the municipality of Jericho should maintain the network in order to minimize the losses or at least prevent any further deterioration.

It is assumed that these actions will contribute to decrease the demand by nearly 30% by the year 2050.

Second: Supply Management Actions:

There are many actions related to supply management, where the supply will be increased. These actions and their details are summarized in the following points:

a. Samed Well: is already drilled since 1970s. It is assumed that the well will be rehabilitated (new pump, casing and electrical board) and then use the abstracted water for agricultural use for the irrigable lands within the agricultural network. The well is expected to deliver 30 m³/hr starting from the year 2012. Consequently, 30 m³/hr will be deducted from the agricultural quota (Ein AS Sultan) and delivered for the domestic network, Figure19.

Figure 19: Details of Well Samed action

Supply	30 m³/hr
Starting Year	2012
Supply from As Sultan Spring after Well Rehabilitation	44.6% from Spring Ein As Sultan Discharge (283 m ³ /hr)
Losses	15%
Expected Cost (€)	35,000

b. Jericho New Well: a new groundwater well of capacity 50 m³/hr has been approved to be drilled within the area of Jericho municipality. This well is assumed to be drilled and equipped in the year 2013 where in year 2014 the well will be operated. Similar to well Samed, this well will supply the agricultural network and the same amount of Ein As-Sultan spring discharge will be diverted to domestic network as shown in Figure 20.

Figure 20: Details of Jericho new Well action

Supply	50 m³/hr
Starting Year	2013
Supply from As Sultan Spring after Well Rehabilitation	33.6% from Spring Ein As Sultan Discharge (213 m ³ /hr)
Losses	15%
Expected Cost (€)	100,000

c. Ed Dyuke At Tihta Spring: In 2010, Jericho Municipality purchased 27,900 m³/month from Ein Ed Dyuke At Tihta spring. This quantity will be supplied in bulk quantities of 5000 cubic meter each shot every five days cycle. Accordingly, the current water supply system of the Municipality can't handle this quantity. Therefore, the municipality is planning to construct a storage tank close to the Ein Eddyuke spring and pipe line to transfer water to the domestic network in Jericho city.

d. Jericho Wastewater Treatment Plant: it is assumed that in year 2015, the proposed Jericho wastewater treatment plant financed by JICA will be operated. It is assumed that, the treated wastewater will be mixed with brackish water abstracted from the agricultural wells located outside Jericho city (to the east) and then used for irrigation.

e. Storm Water Harvesting: it is calculated that, on average, nearly 2.5 Mm³/year of surface runoff is generated in the two watersheds within Jericho city (Al Qilt and An Nueimeh watersheds). It is assumed that in year 2018, a storage earth pools will be constructed on the two wadis with storage capacity of around 1 Million m³. Moreover, it is expected that 0.5 M m³ will be collected by the year 2022 through additional storage capacity that will be developed on the two valleys.

The target areas that will be irrigated are located within the city area (originally irrigated from the agricultural network). As results the supplied water from Ein As sultan Spring to Agricultural network will be reduced in by the same amount of collected water from the storm water. Figure 21 summarizes the quantity that can potentially be collected.

Figure 21: Details of earth pools action

	Starting Year	Size (m ³)	Cost (€)
Al Qilt	2018	1,000,000	??
An Nueimeh	2022	500,000	??

f. Constructing Mixing Tank: mixing tank is proposed to be built downstream of Jericho city in year 2015. The aim of this tank is to mix the treated wastewater with a specific amount of brackish water abstracted from the agricultural wells in the same area and then used for irrigation. The salinity of the treated waste water is assumed to be 100mg/l while the salinity of brackish water is assumed to be 2000 mg/l. as a result; the total brackish water to be mixed with the treated wastewater in order to reach an accepted level for irrigation (i.e. 1000 mg/l) will reach up to 2 Mm³/year. The details of this action are shown in Figure 22.

Figure 22: Details of Mixing Tank action

Starting Year	2015	
Inflow	Treated Wastewater	Brackish water
	According to domestic water use	Up to 2Mm ³ /yr
Storage	5000 m ³	
Expected Cost (€)	35,000 € (including the cost of distribution pipes)	

g. Constructing brackish water desalination plants: it is assumed that brackish water treatment plants will be built for the brackish water wells to treat the abstracted water before use for agricultural purposes. This action is intended to increase the supply of the agricultural water up to additional 2 Mm³/yr in the year 2050.

Finally, there are other actions that are potentially relevant to this plan such as the proposed potential water that might come from the Red Sea Dead Sea Conveyance and also the possibility that Jericho might obtain some additional water from nearby sources and springs such as Nuiemeh and Feshkha. However, such options were not included in the action list due to the fact that it was not clear of when and how they can be implemented or even how feasible some of them are. They will remain for future investigations

3.7 Expected Results

The un-met demand for all demands sites in Jericho city is reduced as a consequence of the proposed master actions. The expected outcome of the proposed actions is evaluated by the WEAP model. The sections below show the expected water utilization compared with the “Do Nothing Scenario” for the demand sites in both agricultural and domestic network. A new demand is added to the scheme described under the do nothing scenario. According to the discussion with municipality as well as the feasibility study of the Agro-Industrial zone, JICA 2007, The Agro-Industrial zone is expected to be constructed over three phases. The first phase is assumed to be built by the year 2015 where municipality of Jericho will supply the site by 100,000 m³/yr. It is also assumed that the Agro-industrial zone will develop its own water sources by year 2030 and then supply from Ein As Sultan spring will be terminated.

Domestic and Industrial Demand: the demands, the delivered supply at the demand sites, the network losses and the supply at source for the domestic network as well as other related information are summarized in Figure 23 and Figure 24.

Figure 23: Water distribution for the domestic network under Master Plan Scenario

		2010	2020	2030	2040	2050
Population (Inhabitant)		19671	25676	33515	43747	57101
Supply Requirement (including loss, reuse and other demand)	Domestic Demand (1000 m ³ /yr)	1782	1775	1912	2031	2115
	Domestic Demand (l/c/d)	248	189	156	127	101
	Public Demand (1000 m ³ /yr)	420	391	459	534	614
	Commercial Demand (1000 m ³ /yr)	136	128	151	178	206
	Aqbat Jaber Camp (1000 m ³ /yr)	46.5				

	Agricultural Demand (1000 m ³ /yr)	162	168	197	225	254
	Agro-Industrial Zone (1000 m ³ /yr)	0	100	0	0	0
	Sum (Mm ³ /yr)	2.55	2.61	2.77	3.01	3.23
Delivered Supply	Domestic Demand (1000 m ³ /yr)	1468	1775	1912	2031	2115
	Domestic Demand (l/c/d)	204	189	156	127	101
	Public Demand (1000 m ³ /yr)	352	391	459	534	614
	Commercial Demand (1000 m ³ /yr)	114	128	151	178	191
	Aqbat Jaber Camp (1000 m ³ /yr)	46.5				
	Agricultural Demand (1000 m ³ /yr)	137	168	197	255	224
	Agro-Industrial Zone (1000 m ³ /yr)	0	100	0	0	0
	Sum (Mm ³ /yr)	2.11	2.61	2.76	3.01	3.19
Un-met demand (Mm ³ /yr)		0.43	0.00	0.00	0.00	0.02

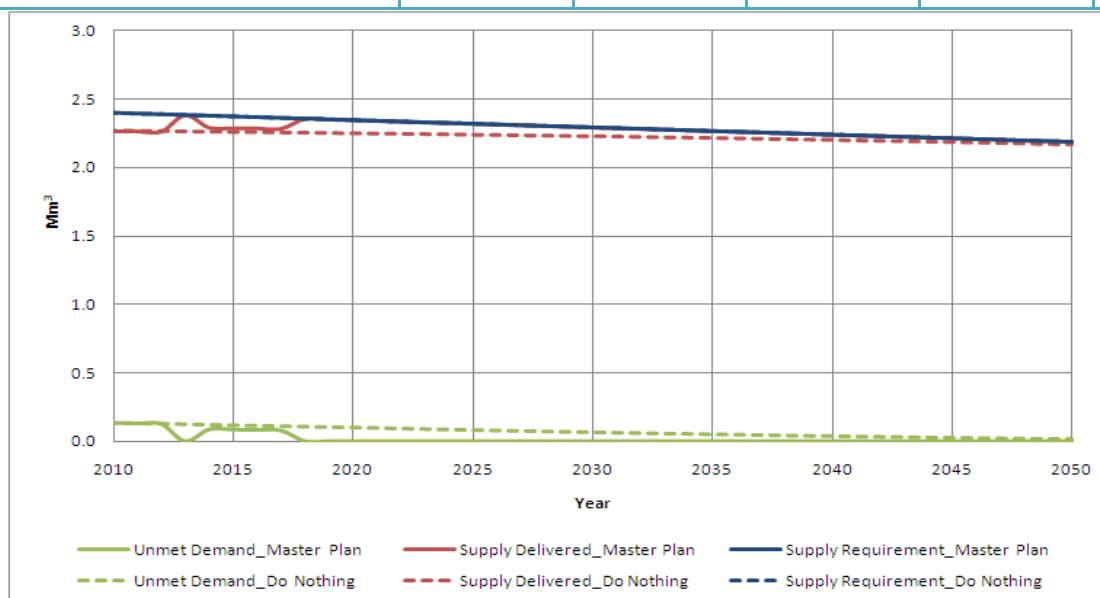


Figure 24: Supply-demand for agricultural network

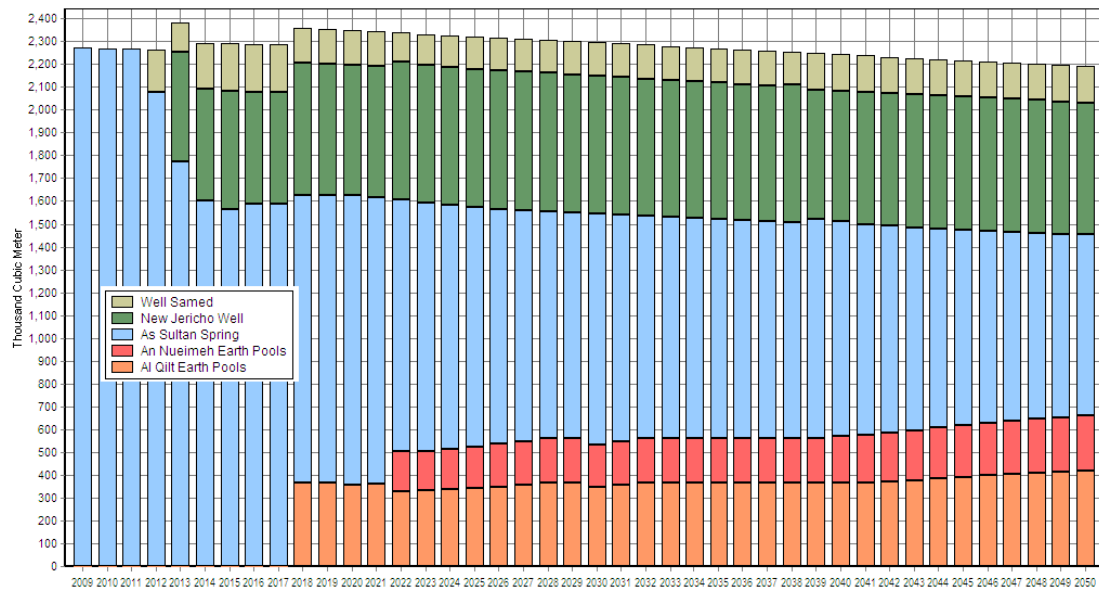


Figure 25: Supply by source for the agricultural network

The total demand/supply on Ein As Sultan Spring for all demands sites (domestic, agriculture, commercial, public and for the two camps) is shown in Figure 25.

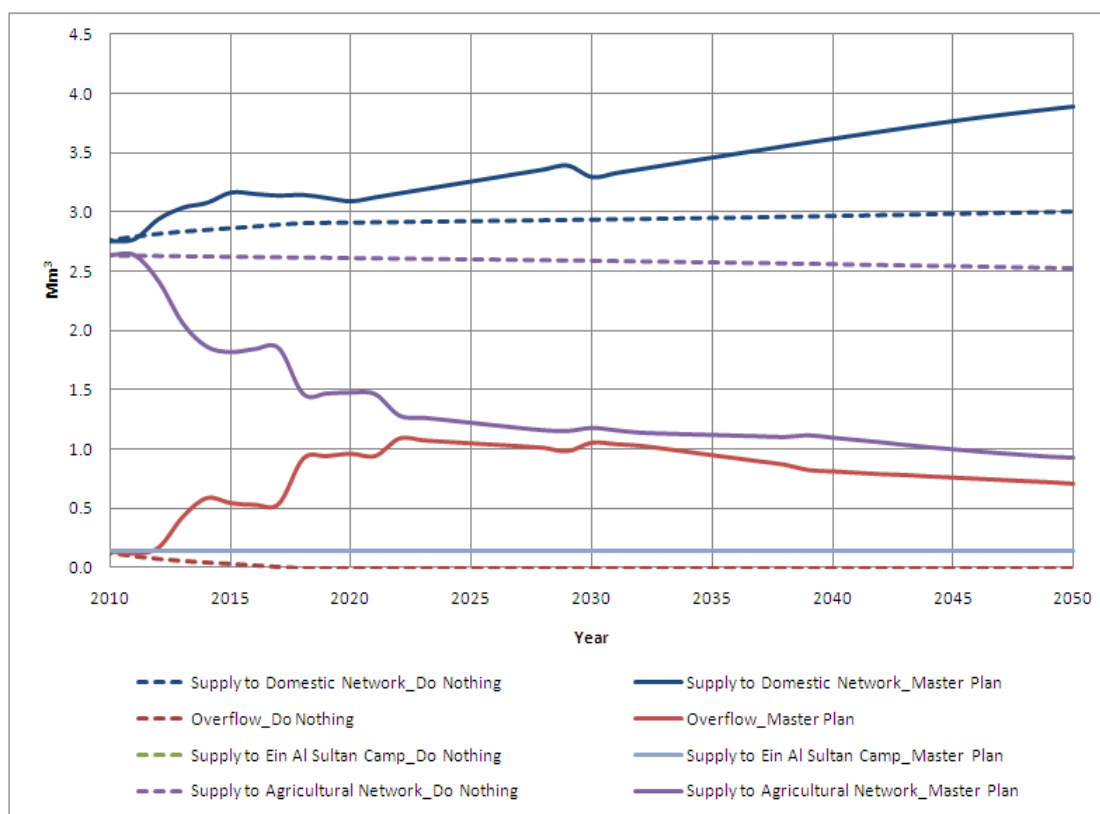


Figure 26: Spring Utilization under Master Plan Scenario

Agricultural Demand (east of Jericho city): the demand and the supply delivered to around 6500 donums under Master plan scenario is shown in Figure 27 and Figure 28.

Figure 27: Supply-Demand for Irrigable Lands East of Jericho City under Master Plan Scenario

	2010	2020	2030	2040	2050
Demand (Mm³/yr)	3.62	4.08	4.54	5.00	5.46
Supply Delivered (Mm³/yr)	2.89	3.63	4.54	5.00	5.46
Un-met demand (Mm³/yr)	0.73	0.45	0.00	0.00	0.00
Irrigated areas (Donums)	3479	4371	5469	6026	6583

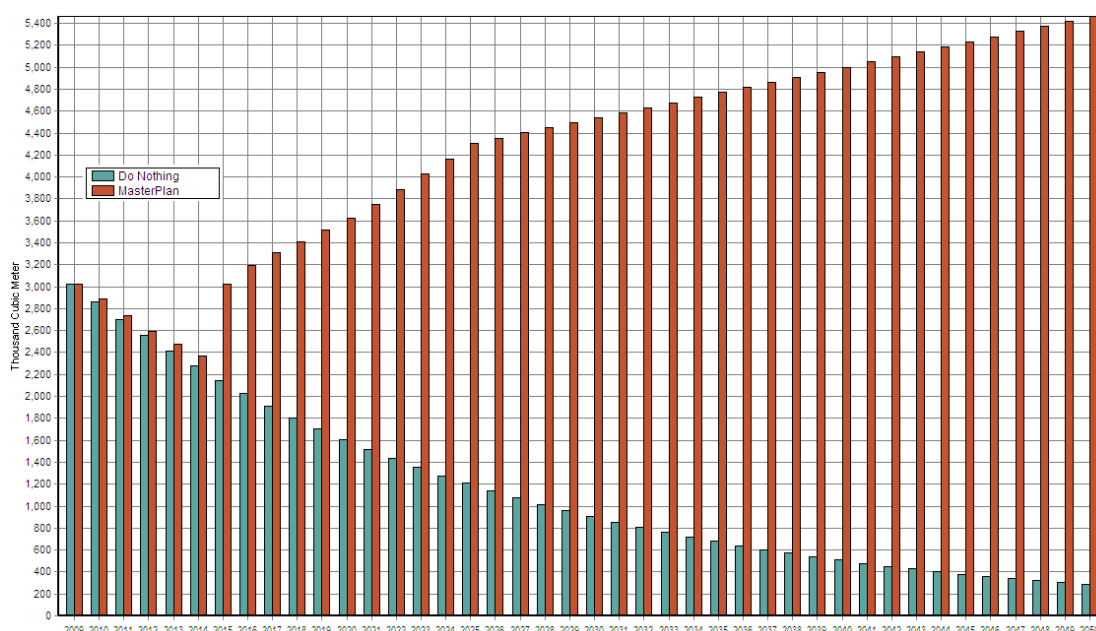


Figure 28: Supply Delivered to Irrigable lands East of Jericho city

To improve the performance of both networks, some solutions to the problems defined earlier are presented in Figures 29 and 30

Figure 29: Problems and proposed solutions for improving the domestic network performance

PROBLEM	SOLUTION
B1. There are so many pumps in the system, and there is a real problem in the performance of the main pumps at Ein As Sultan pumping station which are currently working out of their working range, which means high operation and maintenance costs and shorter life-time for the pumps	S1. Re-installation and arrangement of pumps in Ein As Sultan pumping station based on the performance curve for each pump, so as to reduce operation and maintenance costs and to maintain the efficiency and sustainability of pumps
B2. Northern tank (500 m³) is very old and suffers from problems of leakage and cracks and the lack of protection for the tank area and the difficulty of access to it	S2. Restoration and rehabilitation of the tank from inside and outside as well as the rehabilitation of the existing fence around the tank, and to facilitate access to it, so as to facilitate periodic maintenance works
B3. The current mode of operation of water tanks in Jericho city do not achieve the desired goal, the main goal of the tank is to	S3. Jericho Municipality can use their water reservoirs to operate and regulate the supply in the system by dividing the city into 3 to 4

store and distribute water to people in emergency and peak times, but tanks in Jericho is part of the network and distributes water to the network constantly and most of the time may be empty	pressure zones and using the reservoirs to supply water on rotational basis to each zone every certain time.
B4. The Southern water tank (500 m³ elevated tank) is fed through the public domestic water network, This means no water reach the tank because of the low pressure, as a result that most of the time the tank is empty	S4. Construct a bypass water line either from the spring (Ein As Sultan) or from the main reservoir to the southern tank to ensure enough water quantity and pressure
B5. Water meters used in the system are very old and are velocity water meter, which are two indicators of bad performance of the water metering in the system, this will of course increase the UfW in the system	S5. Using volumetric water meters to reduce UfW and to improve performance
B6. Jericho Municipality doesn't have a detailed model for the current water network (house connections, future extension and large consumer points). This is actually important, as the consequences will be lack of comprehensive control over the system and bad hydraulic performance of the system	S6. Implementation of a complete survey for the current water network to prepare a complete scheme includes the main network, house connections, points of large consumers and the future extension to facilitate the addition of new water lines and detect problems in the network
B7. Weakness in dealing with computer software related to water hydraulics like EPANET and WaterCAD, to be able to deal with the water network through computer	S7. Training those in charge of water system maintenance and administration on a number of programs such as WaterCAD and EPANET

Figure 30: Problems and proposed solutions for improving the Agricultural network performance

PROBLEM	SOLUTION
1. Direct Bumping to the irrigation water network which is more than 33 km long, no storage tanks. which means high operation costs and less performance	S1. Construction of a tank to store water for agriculture which is then distributed to farmers by gravity or by pumping, if necessary, to some high places
B2. Pollution problems for the water coming from the spring through the open channel to the pumping station	S2. Proper pre-treatment
B3. Negative pressure in some locations in the irrigation network especially in Line C and Line D where they taking water from line CD, note that CD is the main line with 315mm diameter and C is 315mm, D is 225mm	S3. Constructing one main pipe for Line C and another one for Line D to increase pressure in both lines C and D
B4. Most of the installed water meters are not working due to a variety of technical issues and implementation faults (the current water meters aren't working because they were installed without filters)	S4. Constructing a new water manholes with suitable size for the installation of meters according to the manufacturer's instructions to ensure their good performance
B5. The private ownership of Ein As Sultan water shares which cause the lines over loaded simply because the owner can sell his hours on line X to new owner in line Y putting more pressure on line Y	S5. Restrict the sale of hours and transfer from one line to another before making sure the possibility of transport by referring to the hydraulic design of network using EPANET
B6. Weakness in dealing with computer software related to water hydraulics like EPANET and WaterCAD, to be able to deal with the water network through computer	S6. Training those in charge of water system maintenance and administration on a number of programs such as WaterCAD and EPANET

As a result of master plan, the domestic demands (all demands on domestic network) will be reduced by 1.5 Mm³ in year 2050 (i.e. the domestic demand will reach to 7.7 Mm³ compared with Do Nothing Scenario, the demand is 9.2 Mm³). Regarding the

supply, it will be constant ($\sim 2.9 \text{ Mm}^3$) under do nothing scenario, by implementing the master plan actions, the supply at source will increase to reach around 5.1 Mm^3 in year 2050. In addition to decreasing the demand requirements and increasing the supply delivered, part of the water needs will be met by management actions (water reuse, changing wet cooling system to dry cooling system, using water saving devices, etc), consequently, the unmet demand will be very low (less than $0.05 \text{ Mm}^3/\text{year}$ during the coming 30 years and increase to $0.32 \text{ Mm}^3/\text{year}$ by year 2050).

Concerning the agricultural sector, there are minor changes on the supply quantities to the irrigable lands within the city area. The only change is the source of the supply and the water quality as well.

In relation to the irrigable lands to the east of Jericho city, a major change in the supply quantity and quality will occur by the year 2050. Total water supply from groundwater (Brackish and Fresh) and from the treatment plant will reach to 5.2 Mm^3 which is equivalent to 94% of the agricultural demand.

Figure 31, shows the summary of the proposed actions within the master plan. It is divided into three phases. The first phase is the short term phase (2010-2014) while the intermediate and long term phases are 2015-2024 and 2025-2050 respectively.

Figure 31: Summarized Master Plan Actions

	Action	Objective	Target	Starting Year	Number of Units	Estimated cost(€)²⁴
Short Term Phase (2010-2014)	Rehabilitation of Samed groundwater Well	Increase the rate of groundwater abstraction	Increase the supply to Domestic demands by changing the water sharing of Ein As Sultan Spring	2012	1	35,000
	Drilling new groundwater well (New Jericho well)	Increase the rate of groundwater abstraction	Increase the supply to Domestic demands by changing the water sharing of Ein As Sultan Spring	2013	1	150,000
	Purchasing water from Ein Ad Duke At Tihta spring	Increase the supply to the Domestic demand	Increase the supply to Domestic demands	2013	-	275,000 (including storage tank and 3200 m pipe line)

²⁴ Expected cost is very rough estimates , actual cost is related to the actual design and needs more investigation

	Construction of gray wastewater treatment Plants	Increase the rate of water reuse for the domestic demands	Increase the rate of water recycle, consequently, water needs from the source will be decrease	2012	10	25,000
	Demand Management actions (changing cooling systems, modifying tariff system, institutional reform)	Decrease the domestic demands	Decrease the domestic demands	2011	-	10,000
	Network Maintenance	Improve the domestic and agricultural networks, building reservoirs, installing pumps, improve the distribution regimes, training technicians, etc	Decrease the networks losses and improving the water distributions among users	2011	-	1,000,000
	Construction of Jericho waste water treatment plant (including collection network)	Collection and treatment of generated wastewater in the domestic demands	Increase the supply to agricultural demand in the east of Jericho city	2015	1	35,000,000
mid Term	Construction of mixing tank	To be used for mixing brackish groundwater with treated waste	Increase the supply to agricultural demand in the east of Jericho city	2015	1	30,000

		water				
	Construction of gray wastewater treatment Plants	Increase the rate of water reuse for the domestic demands	Increase the rate of water recycle, consequently, water needs from the source will be decrease	-	250	875,000
	Demand Management actions (changing cooling systems, modifying tariff system, institutional reform)	Decrease the domestic demands	Decrease the domestic demands	-	-	40,000
	Storm water Harvesting	To utilize the storm water in wadis	Increase the supply for agricultural demand inside the city	2015	250	3,750,000
	Constriction of Brackish water treatment plants	To utilize the brackish groundwater	Increase the supply for agricultural demand outside the city	2015	4	1,200,000
	Network Maintenance	Improve the domestic and agricultural networks, building reservoirs, installing pumps, improve the distribution regimes, training technicians, etc	Decrease the networks losses and improving the water distributions among users		-	3,000,000

	Construction of gray wastewater treatment Plants	Increase the rate of water reuse for the domestic demands	Increase the rate of water recycle, consequently, water needs from the source will be decrease	-	650	2,600,000
Long Term Phase (2015-2024)	Demand Management actions (changing cooling systems, modifying tariff system, institutional reform)	Decrease the domestic demands	Decrease the domestic demands	-	-	80,000
	Network Maintenance	Improve the domestic and agricultural networks, building reservoirs, installing pumps, improve the distribution regimes, training technicians, etc	Decrease the networks losses and improving the water distributions among users		-	6,000,000
	Storm water Harvesting	To utilize the storm water in wadis	Increase the supply for agricultural demand inside the city	-	350	7,000,000
	Constriction of Brackish water treatment plants	To utilize the brackish groundwater	Increase the supply for agricultural demand outside the city	2015	6	1,800,000

3.8 The cost of options to meet the demand

Despite the fact of uncertain socioeconomic and political conditions, the Palestinians have to put a huge efforts to see the optimal way to enhance the availability of people at the affordable level, In order to achieve this difficult goal, the shortest way is to trade off a several options, eventually the options focusing on the economy of conventional and unconventional water resources.

First: Conventional water resources

3.8.1 Developing Current Ground Water options

Because groundwater is one of the main water resources found in Palestine this management option is a very important one. From the point of view of hydrologic uncertainty, the availability of groundwater resources is reasonably well known and dependable. Production can be sustained up to the total renewable capacities of the aquifers. Groundwater supply development includes:

- Artificial Groundwater Recharge (AGR) and Recovery
- Rehabilitation of springs.
- Rehabilitation of old wells and drilling of new wells.

3.8.1.a Artificial recharge of groundwater²⁵

Artificial groundwater recharge (AGR) projects have been developed throughout the world to meet a number of water resources management purposes. Some of these management purposes are: (1) conservation, including water level control. (2) treatment of sewage effluent for reuse or water quality management, (3) conjunctive management of surface water and groundwater supplies, (4) seawater barriers in coastal aquifers, (5) flood control, (6) control of subsidence, (7) waste disposal, and (8) increased well production. Water sources for recharge can be flood water, treated sewage water, or water pumped from production wells.(SUSMAQ,2005)²⁶,(PHG,2003)²⁷

²⁵ This option can be used to benefit from treated waste water or unused runoff

²⁶ Sustainable Aquifers Management “ A project funded by DFID to help Palestinian Water Authority” implemented between 2000-2004

²⁷ Palestinian Hydrology Group(2003) .”The Palestinian water demand –unpublished report”

3.8.1.b Rehabilitation of springs

Water from springs is used mostly for irrigation in the Jordan Valley area. Since most of the springs in the West Bank have not been developed, their water flows by force of gravity through open channels. The greater part of this water is lost either by seepage in the same area or by leakage and evaporation during conveyance through open channels. Consequently, it is essential to set policy and embark on a nationwide survey to determine the condition of the main springs, the rehabilitation and maintenance needed for each and for the related conveyance and storing facilities, in order to minimize the losses and to optimize the utilization of the spring flow, the average cost between 100-500 thousand, the cost of cubic meter is 0.05 -0.10 \$/m³.

3.8.1.c Rehabilitation of old wells and drilling of new wells

The general condition of groundwater wells is unsatisfactory. Their capacity has been reduced by aging, deteriorated casing, partial clogging and large quantities of accumulated sedimentation in their beds. The overall efficiency of the well pumping equipment is very low, ranging from 45%-60%. This efficiency can be raised to 75% if the current pumping equipment is replaced by a newer, more efficient one. Raising the efficiency will lead to energy savings, to a considerable increase in produced quantities and thus to a reduction in the production cost. As a first step, a comprehensive survey should be conducted to determine the condition of the wells, the pumping equipment, and the possibility of using electricity for the wells that are driven by diesel engines in order to set a plan for either their rehabilitation or their replacement. Plans have also been set for drilling new wells according to the distribution of demand and the aquifers' safe yields. The average cost of drilling new well varies from 600-700 thousand US\$ the average cost of cubic meter is 0.30-.35\$/m³

3.8.2 Demand management policy

In the West Bank and Gaza a comprehensive rehabilitation program is required to reduce the high distribution system losses and to improve water use efficiency, the following Figure shows the proposed water demand management measures the quantities which could be saved and the unit water costs.

Figure 32: the amount and cost per unit of saved water by Demand management (West Bank and Gaza)

Demand Management measures	Unit cost US\$/M³
Rehabilitation domestic wells	0.7
Rehabilitation of domestic water supply systems	6.0
Replacement of water meter	8.0
Rehabilitation of springs	1.5
Rehabilitation of springs conveyance systems	30
Rehabilitation of irrigation water wells	0.7
Rehabilitation of irrigation conveyance systems	30

This table based on actual projects cost done by PHG during 2005-2007

3.8.3 Surface water

The Palestinians lacking the experience of using surface water at large scale (dams), however several projects were implemented at micro level (small retention walls , large pools), although this projects are small scale but the contribution into water budget can reach 5-10 million cubic meter. The Jordanian experience of surface water shows the average price reaches to 0.1 \$ per cubic meter, the potential of surface water between 40-60 million cubic meters additional to the Jordan River.

The only major surface water source in the region is the Jordan River. However, the Palestinian share of the Jordan River is yet to be defined in the final status negotiations.

Costs for surface water exploitation would be highly variable, depending on the specific water resource and the types and capacities of the storage and conveyance systems involved.

3.8.3.a Earth Dams on large dams

Earth dams are above-grade structures built on intermittent streams or wadi channels in semi-arid regions, and designed to capture and retain storm runoff for the purpose of artificial recharge, as well as direct water supply for domestic use, cattle or irrigation. There are many wadis in the West Bank where dams can be built like Wadi Quilt, Wadi Fara, and Wadi Zimar.

Given the size and sophisticated design of dams, plus their requirements for detailed site characterization and catchment hydrology studies, capital costs for such structures are high. However, as the designs are often passive or include only minimal pumping and mechanical equipment, annual and recurring costs are minimal. Capital costs are very much dependent on the dam configuration and the physiography of the local site, as well on the availability of local materials and work force. The Jordanian experience showed the price of water in the dams is around 0.2 \$/ m³. While the investment cost 3.7 \$/m³, the cost for large dams 7\$/m³

Second: Non Conventional Water Resources

3.8.4 Waste Water treatment and reuse

The combination of severe water shortage, contamination of water resources, densely populated urban areas and highly intensive irrigated agriculture, makes it essential that put wastewater treatment and reuse high on its list of national priorities. Effluents are the most readily available and cheapest source of additional water and provide a partial solution to the water scarcity problem.

Many examples of the potential benefits of wastewater reuse in different countries will be present in this document. Naturally, they are most obvious for the arid areas but the general increasing pressures on water resources all over the world should also make wastewater reuse attractive in other areas. This examination has been carried out in the frame of the MEDAWARE project (<http://147.102.83.100/projects/meda/meda.htm>) funded by the Euro-Mediterranean partnership and more specifically by its Regional Program for Local Water Management whose main objectives are the development of the appropriate tools for the effective control and monitoring of the operation of the wastewater treatment plants and the development of relevant guidelines to ensure the safe operation of the wastewater treatment plants and also the safe reuse of the effluent.

The use of wastewater for irrigation is a way of disposing urban sewage water with several advantages. Recycled water can be cost-effective means of supplying nutrients for

agricultural irrigation and of possibly avoiding the need for nitrogen removal at wastewater works in sensitive areas. Furthermore, sewage water is an alternative water source in arid and semi-arid areas where water is scarce. Besides these advantages, wastewater can contain heavy metals, organic compounds and a wide spectrum of enteric pathogens which have a negative impact on the environment and human health.

3.8.4.a Cost effective cases of reuse in Agriculture

Water reuse has recorded indisputable progress in recent years in the Mediterranean. Some concrete recent noteworthy examples can be pointed out in some Mediterranean countries, both nationally and locally. These examples show the considerable benefits of wastewater reuse. These benefits are both financial (savings in very costly heavy infrastructures), economic and social (wastewater reclamation and reuse processes, if they are well managed, may for example allow agricultural incomes to be improved and give better access to water for the least well-off) and environmental (reducing pressure on, and even restoring, ecosystems and resources).

In Cyprus the wastewater generated by the main cities, about 25 million m³/yr, is planned to be collected and used for irrigation after tertiary treatment. Because of the high transportation cost, it is anticipated that most of the recycled water, about 55 to 60%, will be used for amenity purposes used as hotel gardens, parks, golf courses, etc. A net of about 10 million m³ is conservatively estimated to be available for agricultural irrigation. This will reportedly allow irrigated agriculture to be expanded by 8-10% while conserving an equivalent amount of water for other sectors (Papadopoulos, 1995).

An interesting case in Cyprus is the Larnaca wastewater reuse system. Since the plant has been in operation (year 2000), the effluent is being used for irrigation of 150 hectares of agricultural land at Dromolaxia Village where corn and alfalfa are cultivated. The treated water is also used by the hotels, International Airport and Larnaca Municipality for the irrigation of gardens, parks and fields during the summer season. For that purpose, the effluent is being discharged through pumping stations. The total cost of the project is 50 million €, out of this, 9,3 million € is the cost of the tertiary treatment plant with the reuse network and pumping station. The cost for the production of tertiary treated water is around 0,5 €/m³ (Hidalgo *et al*, 2004).

Another remarkable case in Cyprus is the reuse system in Cavo Greco area. Since the plant has been in operation, the effluent is being used for irrigation of agricultural land in Paralimni where potatoes are mostly cultivated. The treated water is also used by the hotels and the Municipalities for the irrigation of gardens and parks during the summer season. The total cost of the plant has been 14,4 million €, out of this 5,9 million €, is the

cost of the tertiary treatment plant with the reuse network and pumping station. The cost for the production of tertiary treated water is around 0,50 €/m³ (35 cents for secondary treatment and 15 cents for tertiary treatment). The Sewerage Board of Paralimni and Ayia Napa sells this water at the price of 0,25 €/m³ for the hotels and 0,10 €/m³ for agriculture (Hidalgo *et al*, 2004).

Few projects have in fact been carried out up to now in France, mainly because of problems relating to the cost of tertiary treatments. The projects implemented cover more than 3.000 hectares of land, and quite a wide variety of applications: market gardening crops, orchard fruit, cereals, tree plantations and forests, grasslands, gardens and golf courses. The Clermont-Ferrand recycling scheme for irrigation of over 700 hectares of maize is today considered to be one of the largest projects in Europe. The recent development of new treatment processes, such as membrane bioreactors (ultrafiltration, microfiltration), to obtain very high quality purified water, disinfected and with no suspended solids, could change the approach to the problem and could open the door to recycling for domestic purposes (cleaning, toilet flushing, etc.). The reuse of industrial wastewater after purification to supply cooling water, wash water or even process water after sophisticated complementary treatment is widely developed in France (Kamizoulis *et al.*, 2003).

In Israel about 92% of the wastewater is collected by municipal sewers. Subsequently, 72% is used for irrigation (42%) or groundwater recharge (30%). Cost-benefit analysis indicates that recycled wastewater is a very low cost source of water in this country. As a result, treated wastewater within the overall water supply, particularly for irrigation, has risen to 24,4% of the allocations. The water crisis in Israel and the relatively low cost of treated wastewater, rather than pure environmental considerations, are the main driving forces behind the high percentage of reuse (Angelakis *et al.*, 2003). Dan Region project in Israel seems to be the largest and most remarkable one with 120 million m³/yr capacity. An average agricultural area of 16.000 ha is irrigated with this reclaimed water. The price of the water is 0,36 €/m³.

Two interesting examples, where plants intend to use their effluent in irrigating ornamental trees, reeds and bamboos, are founded in Lebanon in the regions of Hasbaya and Yanta. The plants of Hasbaya cover a built up area of about 2.000 m². Even though two municipal wastewater treatment plants were designed for this town, only one was completed and became operational by the year 2002. The construction of the other plant was completed but has not been put into operation. The actual total cost of construction for both plants was set at about 250.000 €. The plants are located at the lowest part of the Hasbaya area adjacent to two existing open channels in order to reduce pumping needs. Two plants are located also in Yanta village. Their capacities are 240 m³/day and 120

m³/day, respectively. The quality of the effluent from the smaller plant is quite acceptable and there are plans for using this effluent in irrigation. The total cost of the 2 plants was 91.000 €. It was also necessary to construct a wastewater collection network for the whole village at a cost of 245.000 € (Ayoub and El Fadel, 2004).

Most Moroccan towns are equipped with sewerage networks, frequently collecting also industrial effluent. However, out of the 60 largest towns only 7 have a municipal wastewater treatment plant, but both their design and operation are considered insufficient. As a consequence, most of the wastewater produced by the inland towns is used to irrigate crops after insufficient or even no treatment. Anyway, some cases of reuse can be pointed out in this country. One of them is the Ben Slimane reuse system (80 km South West of Rabat). The reclaimed water is used in irrigation of an average of 100 hectares of golf courses by sprinkling. In this case, the total cost of the project reached the amount of 8 million € while the exploitation cost are 78.000 €/year. The cost of the clean water produced is 0,12 € and the selling price of the purified water is 0,17 € (Mountadar and Assobhei, 2004).

Palestine has some guidelines applied to the reuse of treated wastewater from housing, municipalities, industry and commercial enterprises in the Gaza-Strip. The main objective is to reuse all treated wastewater to improve the water balance and the ground water quality as well as protecting soil and the public health. The Al-Beirah wastewater reuse system, developed in 2000, is an example of water reclamation and reuse in Palestine. The final effluent is discharged through Wadi Al-Ein, by 5 km pipeline, to be reused for irrigation in Dir-Dabwan land where large uncultivated areas exist. The construction cost of the wastewater reuse system is about 7 million €. The total cost for treating one cubic meter is 0,32 €. The results of the three-year operation of the plant have indicated that use of treated wastewater for food crops (pilot scale) irrigation is safe and acceptable. No adverse impacts in terms of soil or groundwater quality degradation were observed. Conventional farming practices were shown to be adequate and the marketability of the produce did not appear to pose any problems, and no project-related health problems were detected through medical examinations (Salem *et al.*, 2004).

Figure 33: Costs of waste water treatment and conveyance and distribution against tariff of waste water sale in Jordan and Tunisia

Tariff /cost	Jordan		Tunisia	
	JD/M ³ *	\$/M ³	TD/M ³ *	\$/M ³
	0.0-0.049	0.0-0.08		0.02-0.1
	0.014-.08			

Tariff				
CONVEYANCE & DISTRIBUTION COSTS**				
Operational cost		0.028-0.084	0.04-0.12	0.125-
0.21 0.09-0.08				
Total cost incl. Depreciation		0.07-0.147	0.1-0.21	0.175-
0.35 0.13-0.25				

Treatment cost				
Operational cost		0.014-0.238	0.02-0.34	0.042-
0.24 0.03-0.17				
Total cost incl. Depreciation		0.035-0.665	0.05-0.95	0.56-
1.30 0.04-0.93				
Total cost of treatment				
and Conveyance			0.10-0.81	0.15-1.16
0.231-1.65 0.17-1.18				
conveyance and distribution cost		18.1-66.7	21.2-75.8	
As % of the total cost				

1US\$=.70JD = 1.4TD

Source: Abu Madi, M.(2004) .Incentive systems for waste water treatment and reuse in irrigated agriculture in the MENA region .UNESCO-IHE –Netherlands

3.8.4.b Future Capital Investment on Sewage Treatment Facilities

Within the coming 10 years, the PNA plans to invest about 32 million US\$ (PRDP.2007) through the technical and financial assistance of some donor agencies involved in water and sanitation sector in urban areas, like USAID/USA and KfW/Germany. This money will be allocated for large urban municipal wastewater treatment facilities including collection, treatment, disposal and municipal staff training. Since the beginning of the peace process, the international community mainly the German and USAID committed 230 million US\$ for sewage treatment projects in Palestinian cities. Since these huge funds are going to be invested on the Palestinian communities, proper strategic concepts in treatment consideration and planning in order to avoid technical and managerial problems encountered in the urban sanitation projects is needed.

In addition to the proper strategic planning for wastewater treatment, the management of wastewater sector would be improved tremendously if the PWA and ministries involved in water and environmental sector in Palestine would enforce standards for design of wastewater treatment and set the criteria and regulations for the improvements of technical and managerial skills of professionals working in the field.

3.8.4.c Rural Wastewater Management

In Palestine, many non-governmental organizations (NGOs) provide technical and financial services to small Palestinian communities through the small national and international funds. These NGOs assist rural areas in identifying and implementing the cost-effective solutions to their problems. Some of the mismanagement in wastewater sector can be found in the following textbox.

Shortcoming of the wastewater management

Lots of money was wasted in the past in unsustainable treatment plants built during the period of the Israeli occupation. Most of the erected treatment plants were WSPs which were constructed to serve the Israeli environmental policy during the period of the Israeli occupation without real strategic plans for wastewater management. Because of the complicated political situation in the West Bank, experience gained from recently implemented urban sewage projects, indicated that about 10 years of planning is needed (Al-bireh case). Newly constructed and/or under design wastewater treatment plants adopted activated sludge systems in urban areas. Activated sludge systems are able to reduce organic and nitrogen levels in municipal sewage. However, in such systems, the investment and operational cost is high. It is questionable whether sufficient financial

resources can be made available for such technology, which aims to remove organic matters and to enhance biological nitrification and denitrification in order to strip nitrogen from the water and convert it into atmospheric N₂ gas. In addition to the treatment efficiency and reliability, several other aspects should be considered i.e. sludge disposal, land requirement, environmental impact, capital and operational cost, sustainability and process simplicity.

Figure 34: Total Waste Water Generated in different governorate in WB

GOVERNORATE	POULATION 2005	TOTAL WASTE WATER GENERATION MCM/Y	VOLUME OF WASTE WATER		
			NETWORKS	CESPITS	OPENSACE
NABLUS	326.873	2.299	1.236	1.057	0
RAMALLAH	280.805	0.374	0.104	0.252	0.014
JERICHO	43.620	3.182	0	3.182	0
JERUSALEM	149.150	5.208	0.954	4.248	0
BETHLEHM	174.654	2.160	0.990	2.154	0
JENIN	254.218	0.902	0.126	0.168	0.044
TUBAS	46.664	1.291	0.004	1.134	0.151
TULKERM	167.873	5.611	2.508	3.102	0
QALQILYA	94.214	3.355	1.542	1.806	0
SALFIT	62.125	4.358	0.660	3.690	0

Source: ARIJ (Applied research center-Jeusalem):Status of the Environment In the occupied Palestinian territory (2007)

3.8.4.d Small Scale Wastewater Treatment Plants in Rural Areas

Strategic planning and appropriate policy for wastewater management in rural areas is not existence despite the high number of population in these areas which lack adequate sanitation. About 73% of the households in the West Bank have cesspit sanitation and almost 3% lack any sanitation facilities (Abu Madi et al., 2000) mainly in rural areas. Several small scale wastewater treatment plants have been constructed in the unsewerd rural areas of the West Bank. In addition, some applied research studies of biological treatment systems for small rural communities were recently installed and studied (Mustafa, 1996; PHG, 1999; Zimmo et al., 2002). Most of the rural sanitation facilities installed recently entail trickling filters and natural treatment systems preceded by septic tanks. Small rural sewage treatment plants showed good removal rates of organic matter and suspended solids but poor in nitrogen removal (Mustafa, 1996).

Municipal wastewater is more than twice as strong as gray wastewater. PARC have constructed about 300 households treatment plants and six collective treatment plants receiving 0.5 to 20 m³/d of gray wastewater. BOD and COD removal efficiencies of 76-88% were achieved. The household gray wastewater treatment plants consist of septic Tank followed by upflow gravel filter. The collective gray wastewater treatment plants consist of anaerobic pond, gravel filter, sand filter and the polishing pond. Each system connected approximately 20 houses with about 180 inhabitants.

Figure 35: The cost of reuse all available waste water in OPT

Area	Total waste water Mm³	UNIT COST c/m³	Total cost \$
West Bank	36.010	0.15-1.16	5.4-41.7
Gaza	29.949	0.15-1.16	4.5-34.74
Total	65.959	0.15-1.16	9.9-76.5

This cost doesn't include the investment cost

In the West Bank and Gaza Strip an estimated 50-70% of urban waste water is collected within residential areas, only few waste water treatment plants exist in the WBG, their performance is inadequate, the amount of collected waste water about 73(7 Mm³ from small communities) Mm³ and this amount projected to be 135 Mm³ by 2020, the average unit cost for treatment and reuse about 0.65 US\$/m³

3.8.5 Desalination (Sea water and Brackish water)

This review presents the world situation concerning the production, processes, technologies and costs of desalination. Experience accumulated worldwide and in Israel enables the forecasting of developmental trends, namely, a continuation of cost reduction, when Israel will enter the era of large-scale desalination. To date, desalination in Israel has served local demand, mainly in Eilat and in the Negev Desert. However, during the next decade activation of this technology will be necessary for covering water deficits on a national scale (Dreizin, 1998).

3.8.5.a Desalination in Israel and in the World

Installations in Israel

By early 2000, 13,600 desalination units were operating worldwide, with an output of 25.9 million cubic meters (MCM) per day (approximately 8 billion cubic meters annually). Eleven percent of these installations were erected within the past two years. Of these units, 38% are located in the Persian Gulf and 17% in the US (Wangnick, 2000). Plants installed in Israel over the last 30 years have a capacity of approximately 100,000 CM/day. However, production actually amounts to 60,000 CM/day, since some of the plants, mainly those based on evaporation technology, are not in operation.

Processes

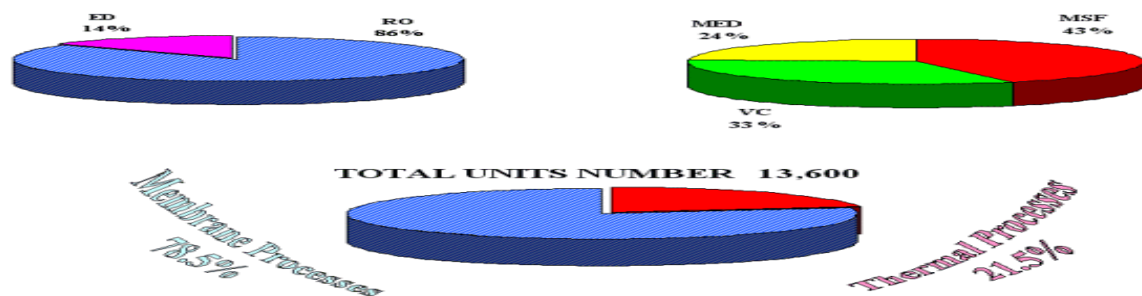
The two most widely applied processes are Multi-Stage Flash (MSF) evaporation and Reverse Osmosis (RO), each of which produces approximately 43% of the total global output. Although RO has the same output, it is employed in 68% of the installations, with only 9% of the installations using the MSF process. The reason for this similar output in both methods is that the average MSF unit produces 8,800 CM/day, while the average RO unit produces 1,200 CM/day.

From these figures it can be seen that those installations operating with the RO and the MSF methods produce 86% of the desalinated water in the world. In addition, electro-dialysis (ED) plants produce 6%, vapor compression (VC) plants produce approximately 4% and multi effect distillation (MED) produces 4% of the desalinated water in the world.

Most MSF installations operate in the Persian Gulf, whereas RO plants are common in other parts of the world. Mediterranean countries, including Spain, Malta and Cyprus, as well as Israel, have reverted to the RO method during the past two decades. All desalination plants in Israel operate using the RO method (Figure 36).

Developments

Improvements have been achieved in all technologies, by improved materials, improving pre-treatment of raw water and improving computerized management of operations. Progress in the RO method has been much greater than in the other technologies, since this technology is suitable for all types of water sources as well as due to the intensive competition between companies in this field.



LEGEND:

ED - Electro Dialysis

RO - Reverse Osmosis

MSF - Multi Stage Flash

MED - Multi Effect Distillation

VC - Vapor Compression

Figure 36: Distribution of Desalination Installations in the World according to the Number of Units

Costs and Cost Reduction

Massive reductions in costs have occurred during the past decade in all three main cost areas: capital, energy, operation and maintenance. This is due mainly to:

- Technological developments
- Increasing size of plants
- Lower interest rate and energy costs
- Changes in managing enterprise performance
- Intense competition between equipment suppliers worldwide

Thus, for example, the cost of one cubic meter desalinated seawater dropped from one dollar in the early 90s to between 70-80 cents (Glueckstern, 2006).²⁸

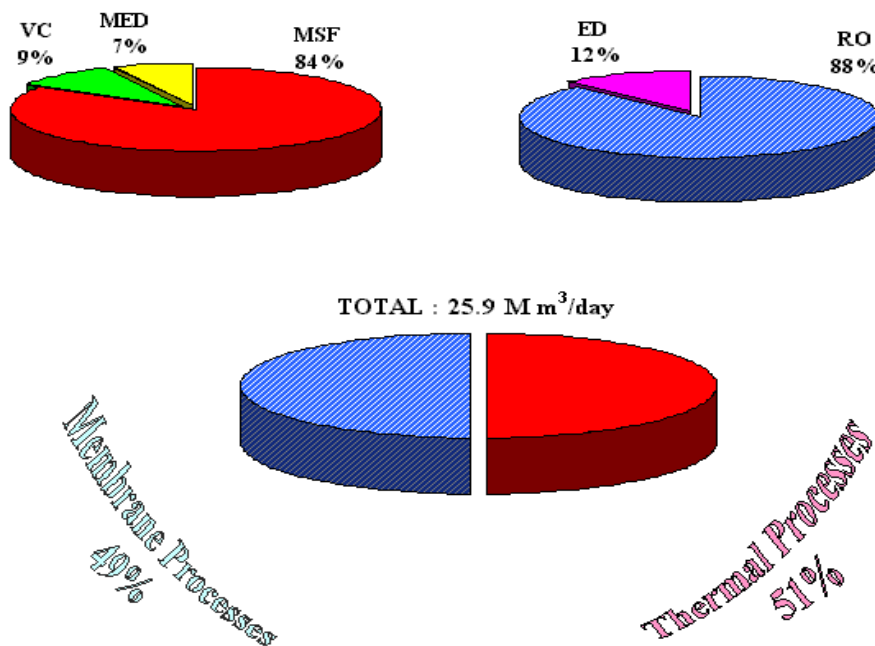
The investment in a typical plant with a capacity of 20,000 CM/day, such as the plant established at the beginning of the decade in the Canary Isles, was approximately \$20 million. The cost of the desalinated water was approximately one dollar, distributed as follows:

²⁸ Glueckstern : Review of dead sea hydropower project; a paper presented in wshared knowledge Tiesta (June,2006)

- Capital cost according to 8% for 20 years 30 cents/CM
- Energy costs (5.5 kWh/CM) according to 8 cents 44 cents/CM
- Operation and maintenance 24 cents/CM
- Total 98 cents/CM

For comparison purposes, the capital cost of a plant of similar capacity in Eilat (Glueckstern, 2006), Israel, which began operations in 1997, and which will produce 20,000 cubic meters per day by 2003, is also \$20 million. However, the cost of water is 25% lower, as indicated below:

- Capital cost according to 6.5% for 20 years 27 cents/CM
- Energy costs (4 kWh/CM) according to 6 cents 24 cents/CM
- Operation and maintenance 21 cents/CM
- Total 72 cents/CM
-



LEGEND:

ED - Electro Dialysis
 RO - Reverse Osmosis
 MSF - Multi Stage Flash
 MED - Multi Effect Distillation
 VC - Vapor Compression

Figure 37: Capacity of Desalination Installations in the World According to Types of Processes

The lower water cost is mainly due to the energy component: the Eilat plant uses 30% less electricity, and the cost of electricity is also lower. Lower operating costs are mainly due to the lower cost of achieve even larger cost reductions.

Larger plants will Tenders for Build-Own-Operate (BOO) or Build-Own-Operate Transfer (BOOT) plants have recently been published as well as a tender for a large plant with a capacity of 76,000 CM/day (25-27 million cubic meters per year), to be erected in Tampa, Florida (Leitner, 1998). This approach leads to water cost reductions. Of the five international concerns bidding for the Tampa plant, the three bids proposing the establishment of RO plants were the lowest cost bids. The other two bids proposed the establishment of a Vapor Compression plant and a Multiple Effect plant together with a power plant. These were more expensive proposals.

Investments per cubic meter per year according to these proposals vary between \$2.5 (the lowest) and \$7.5 (the highest). The cost of water produced by the BOO method for 30 years, varies between 61 cents/CM and \$1.55/CM. The higher price refers to the proposal of a combined water desalination plant and power station. The average cost of water from the proposed RO units will be 70 cents/CM, i.e. less than half the most expensive

3.8.5.b Development During the Past Decade

The decrease in desalinated water costs discussed above have been achieved as a result of a combination of technological development and changes in macro-economic parameters such as the prices of fuel and capital, and the transition to larger units that enjoy the "advantages of size". The most extensive progress took place in the RO process, mainly in the area of performance and salt rejection, durability and lower membrane costs per output unit.

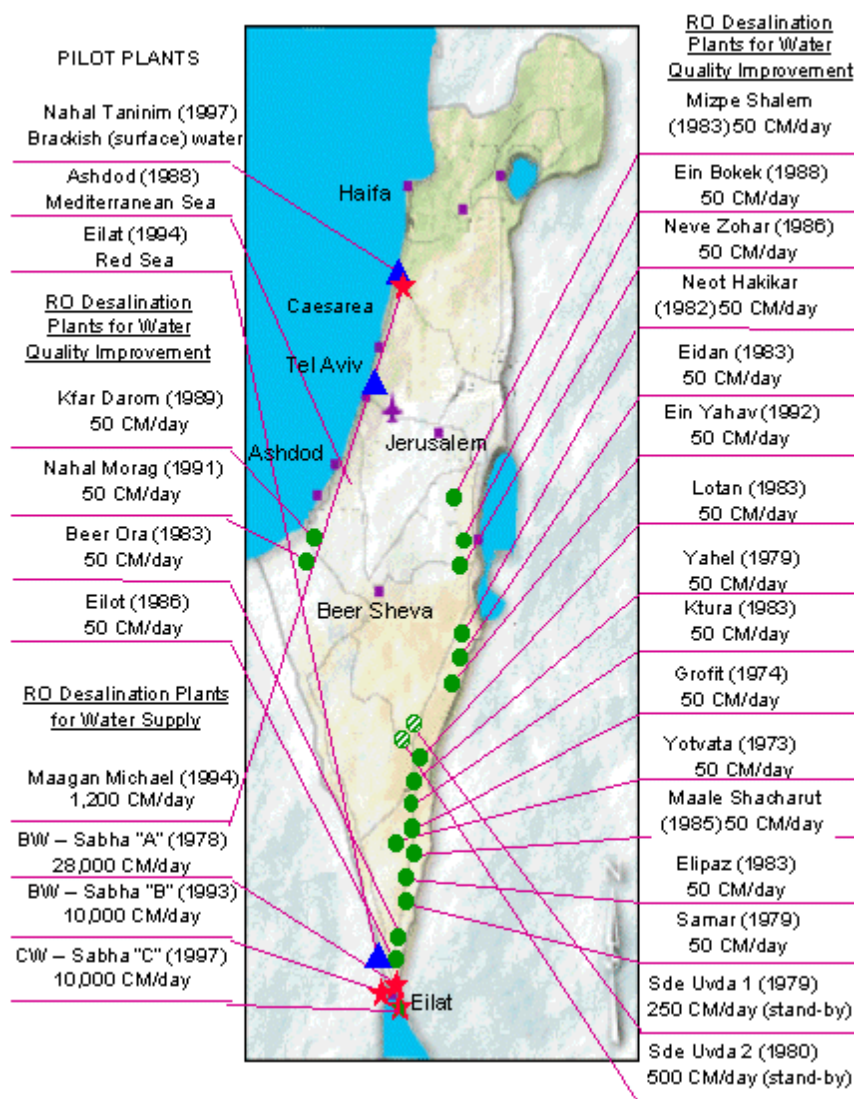


Figure 38: Distribution of Mekorot's Desalination Sites - Active and Reserve Installations

Thus, for example, salt rejection has risen from 98.5% ten years ago to 99.7% today, whereas the output per single unit within a series of membranes installed in a single pressure vessel has risen from 60 cubic meters per day in 1991 to 84 CM/day in 1998. The increasing demand and the competition have led to a reduction of approximately 50% in cost per unit output. Furthermore, in 1998 the membrane manufacturers extended the guaranteed membrane life span from two-three years to six and even ten.

The effect of membrane price and life span on costs is presented in Fig. 5. It can be seen that the cost of replacing membranes has declined from a range of 10-16 cents/CM to between five and eight cents and has decreased further in 1998 to between 2.5-3.5 cents/CM.

Another component that affected desalination cost reductions is the significant decrease in unit energy costs, resulting from improvements in pump and turbine technology for recovery of energy from the reject brine. This factor, combined with the trend of building larger installations, enabled a reduction in energy requirements in 1998 from 5.5-6.0 kWh/CM to 4.0-4.5 kWh/CM (Fig. 6). This development, together with the lower cost of electricity resulting from the decrease in fuel prices, has led to a 30%-40% reduction in desalination energy costs.

3.8.5.c Future Prospects

A forecast for the next ten years is presented herewith. This forecast is based on an analysis of the last decade's developments in plant size, improvements and cost reductions of membranes, energy costs and overall costs per cubic meter. It will take into account recent international tenders and the preliminary design by Mekorot (Israel's National Water Company) concerning large desalination plants along Israel's coast, as well as current R&D programs in Israel and abroad, which should bear fruit within the next few years (Glueckstern, 2000).

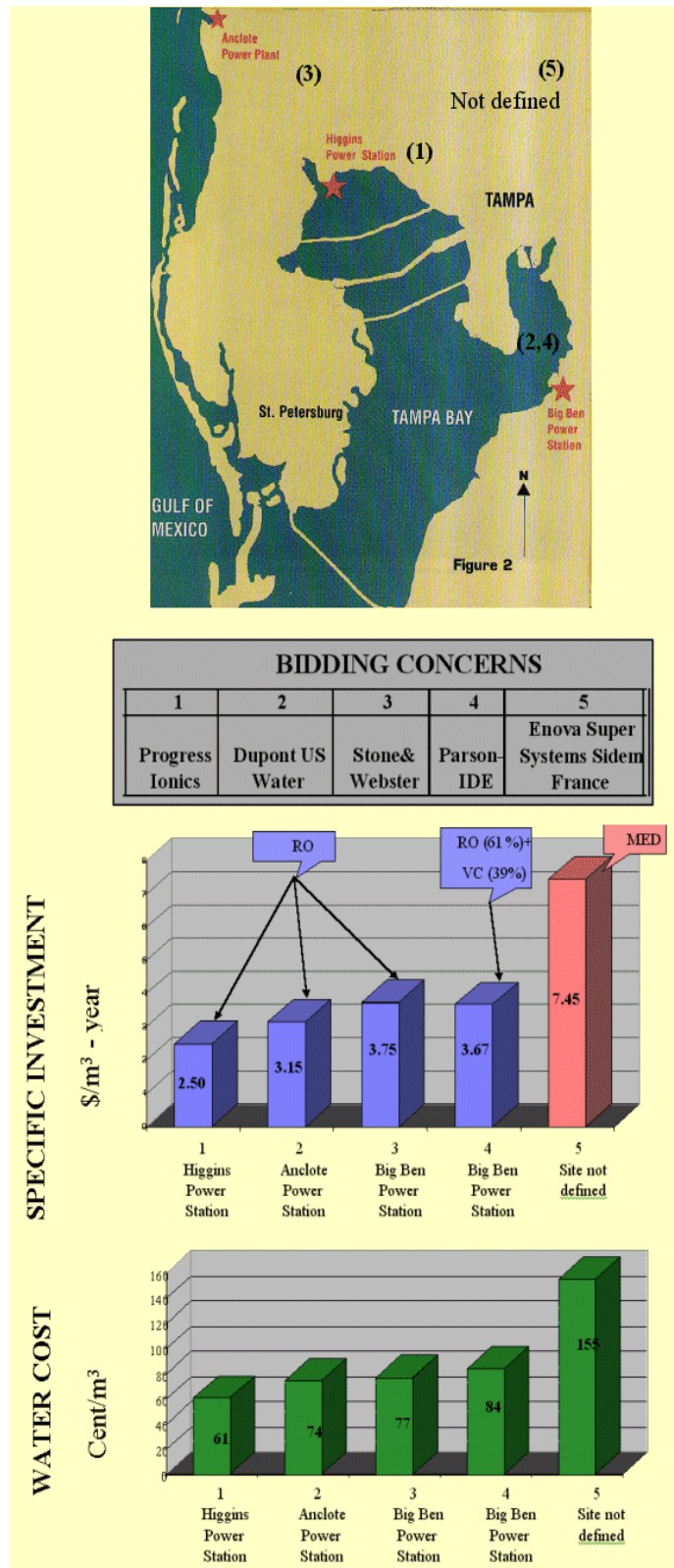


Figure 39: Comparison between the Specific Investment and Water Costs in the Various Proposals of the Tampa Tender

Unit Size

Today larger desalination units can be built mainly due to the availability of high-pressure pumps and large turbines for energy recovery. Reasonable estimates indicate that the country will need plants with a capacity of 150,000-300,000 CM desalinated water per day (50-100 million CM/year). Planning for such a scope must take into consideration 10-20 units, each unit yielding 15,000-30,000 CM desalinated water per day.

Membranes

The increase in output per unit membrane will be achieved mainly by improvements in the treatment of raw water, by the implementation of a new pre-treatment method for feed-water using membrane processes such as Micro-Filtration (MF) or Ultra-Filtration (UF).

Energy

A reduction in energy consumption from 4-4.5 kWh/CM to 3.5-3.8 kWh/CM will be achieved using larger and more efficient pumps as well as improved pre-treatment in order to minimize fouling, which obligates use of higher pressure. Energy costs will decrease if the units are linked to an extra-high voltage network instead of the high voltage network and with on-site power production, since this electricity is cheaper than network electricity, except during off-peak hours.

Investments

Large installations which will use the cooling water and existing infrastructure of power stations (Glueckstern & Priel, 1998b), will reduce the investment per unit (by 2005) from \$3-\$3.5 per CM/year to \$2.3-\$2.8 per CM/year. Another factor in capital cost is the life span of the desalination plants. It can be assumed that the life span of the plants will increase due to the use of improved building materials, lower interest rates, use of more mature technologies and prolonged plant life span. The risk factor in project financing will thus decrease and the capital cost component will decrease considerably.

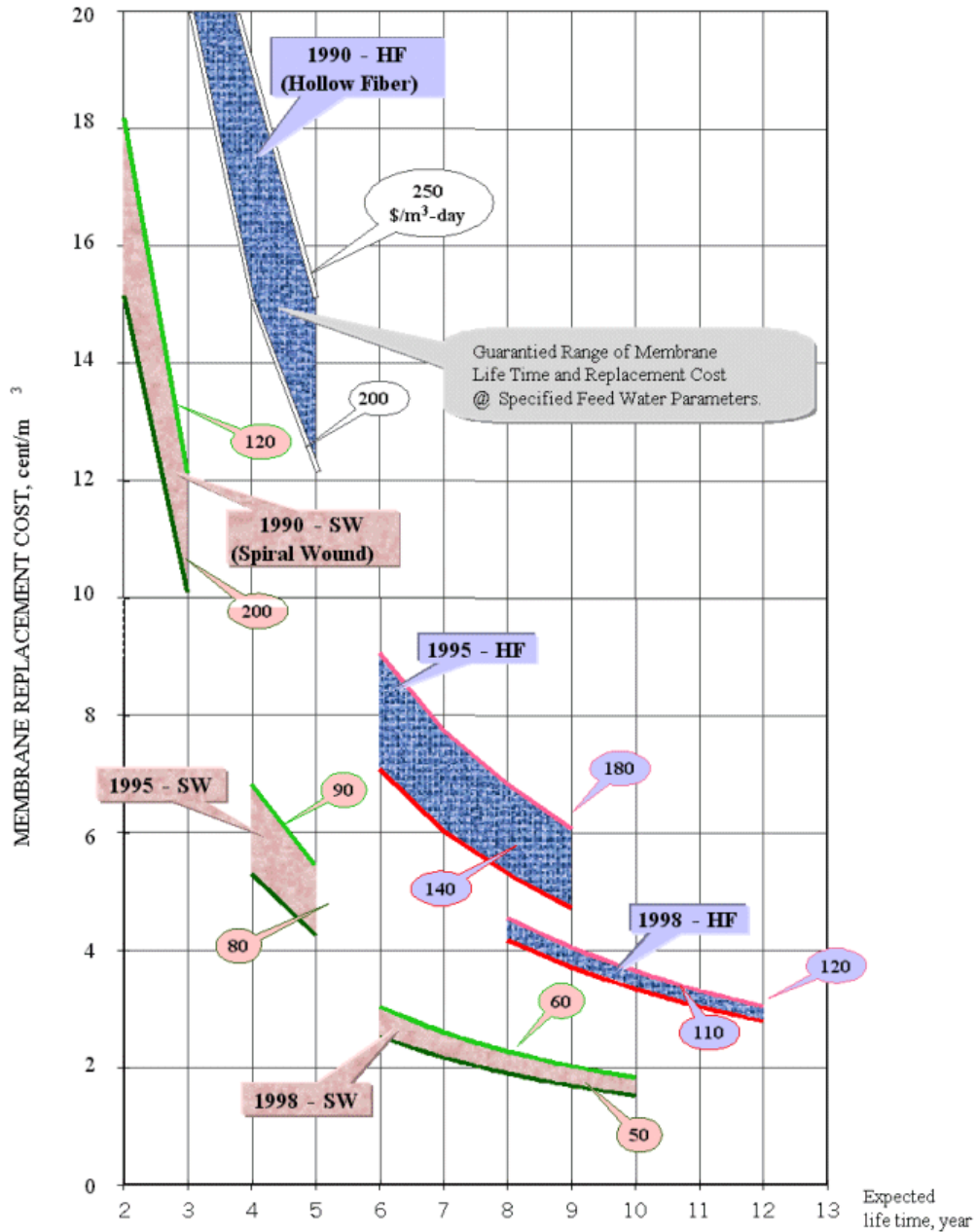


Figure 38: Membrane Replacement Cost Vs. Unit Capacity Cost and Membrane Life Span

Operation and Maintenance

Reduction of this cost factor will result mainly from a reduction in manpower in the large plants. A smaller saving will ensue from the decrease in the cost of membrane replacement and of the chemicals needed for pre-treatment.

Total Costs Per Cubic Meter

All these savings in cost should lower the cost of desalinated water by the year 2005 by approximately 30%, from a range of 67-84 cents per cubic meter to 48-56 cents.

Long Range Possibilities

The general concern over global ecology has led to the examination of renewable energy sources in various parts of the world, especially in the fields of solar and nuclear energy. In Israel and Jordan, the most likely source is the exploitation of the altitude difference of approximately 400 meters between the Mediterranean or Red Sea and the Dead Sea, known as the "Dead Sea Hydro Project" (Glueckstern, 1995). The evaporation capacity at the Dead Sea enables the establishment of a desalination plant at the end of a canal beginning either at the Mediterranean or at the Red Sea. Exploitation of this potential will enable the desalination of 800 to 1,000 million cubic meters of water a year, which will be supplied to Jordan, the Palestinian Authority, as well as to Israel (to the eastern Negev). Due to the huge investments on the one hand and the excessive (compared to demand in the next decade) quantities of water on the other hand, this possibility will be considered in the more distant future, especially in view of concern for the disappearance of the Dead Sea.

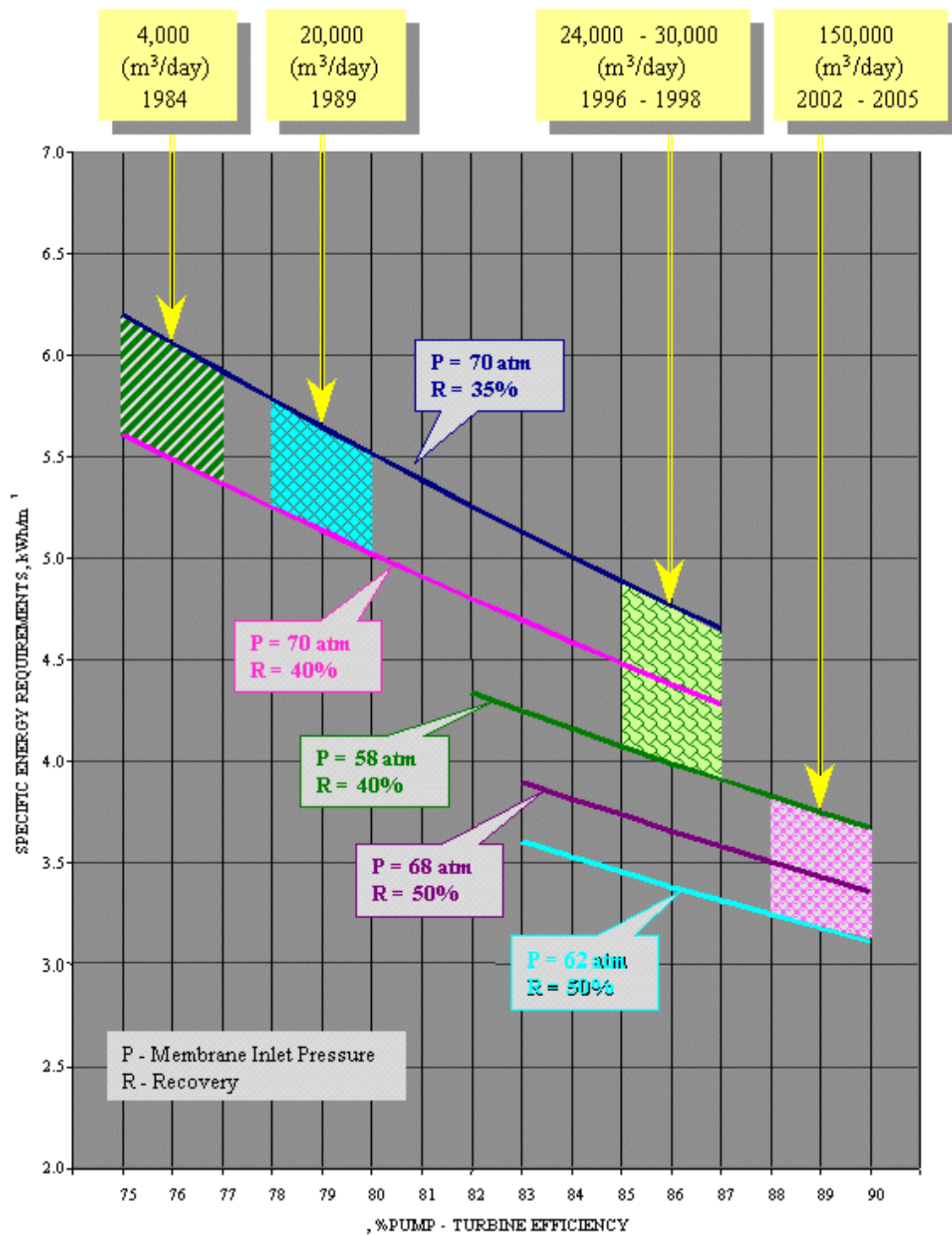


Figure 40: Relation between Specific Energy Consumption in Reverse Osmosis Plants for Seawater Vs. Pump-Turbine Efficiency, Process Pressure and Recovery Factor

Trends in Israel

Concomitantly to embarking on a massive seawater desalination program, Israel should exploit lower cost brackish water sources. Tens of millions of cubic meters of brackish water are found in various areas such as the Dead Sea region, Mishor Rotem, the Carmel coast, the Sea of Galilee region and the Western Negev. This water can be desalinated at a cost of 20-50 cents per cubic meter. The lower price refers to large desalination plants and low pumping costs, whereas the higher cost will result from deeper wells with higher drilling and pumping costs. Other marginal brackish water sources, such as polluted river water, agricultural drainage water, fishpond effluents and eventually wastewater will also be considered (Glueckstern & Priel, 2000, 2000b). Desalination of these sources may complement a substantial part of the required capacity at a lower cost and will be friendlier to the environment.

The accelerated progress in desalination technologies has substantially lowered water costs. This factor, together with increased demand and the trend to establish bigger plants, will lead to a reduction in water costs in the coming years.

Israel has recently jointed an international research network, with wide-ranging collaboration between research institutions and industry, intended to advance research in various aspects of desalination. These projects are likely to accelerate progress in the treatment of polluted brackish waters other than seawater, such as drainage from agricultural and urban waste sources.

A goal of desalinated seawater at 50 cents per cubic meter is not a "Mission Impossible", if the planning, preparation and management are carried out properly.

3.8.5.d Summary of several experience

SEA WATER DESALINATION COST c/m³

COST	BENEFIT
• CONTRACT PRICE =57	IMPROVING W.QUALITY= 11
• ADDITIONAL COST= 9	SAVING IN PUMPING= 3
• ENVIRON.DAMAGE=10	INCREASING OF W.SUPPLY=1
TOTAL = 76	61

$$\text{NET BENEFIT} = 15\text{C/M}^3$$

The cost of desalinization of one M³ in existing plant is today around 0.68 U.S Dollar. The cost of transferring the water to the National Carrier cost additional price of about 0.08 U.S Dollar (8 cent). The average cost of 50 mm³ plant will be about 150 million dollar

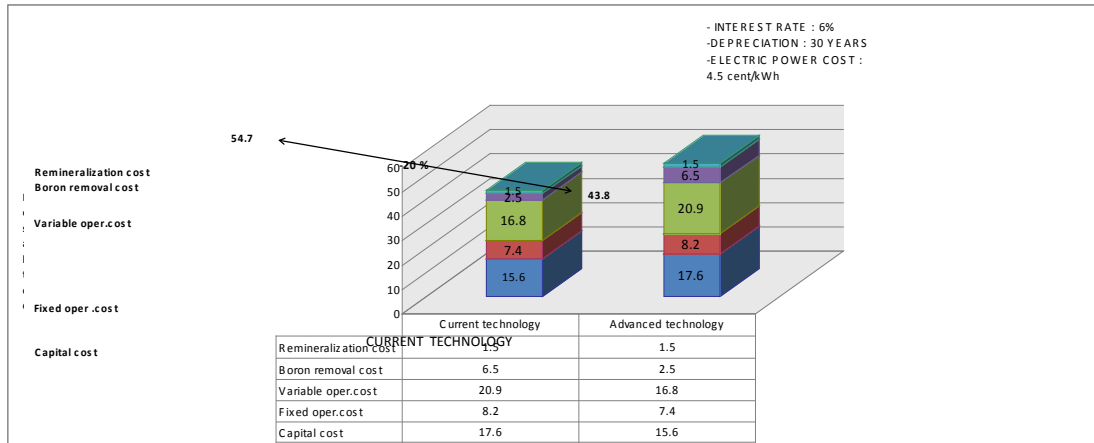


Figure 41: cost of different components of desalination

Figure 42: The use of desalination from sea and brackish water at national level

Area	Cost c/M ³	Total desalinated water Mm ³	Total Cost m ³ \$/y
West Bank*	0.3	28	8.4
Gaza			
Sea water	0.6	100	60
Brackish water	0.3	50	15
Total			75

The cost does not include the investment cost

In west Bank only brackish water available

3.8.6 Red-Dead Sea Canal

At the Johannesburg Environmental Summit in 2002, the Jordanian Minister of Water suggested the Red-Dead Sea Canal project with the following objectives:

- to protect the Dead Sea from disappearing;
- to desalinate some 850 Mcm/yr of seawater;
- to generate 550 megawatts/year of electricity, and
- to develop new tourism and industrial zones.

The decline of the Dead Sea level to 417 mbsl and the shrinking of the surface area of the Dead Sea to 500 km² are serious problems that need to be addressed. Most importantly is the fact that this project would provide an inflow into the Dead Sea after the ‘un-natural’ reduction of its historic flow.

The total cost of this project is estimated to be five billion US dollars, with one billion given as a grant and the remaining amount as a loan. The project would probably take nearly 20 years to fully implement. The project is a new source of water and energy, provided that all of its phases will be completed.

- 800 MW peak load –use of access sea water capacity not used for desalination
- 800 million cubic meter water production
- Net Present Value (NPV)= value of produced electricity+ cost saving of desalination –investment – O & M COST

The economic data of this project as following:

Desalinated water cost 0.53\$/m³

3.8.7 Water from Jordan River

3.8.7.a Cost of water from the Tiberius

The pumping prices change during the year and between the years as a function of the total amount. As you know there are differences in the electrical price during the day hours and between seasons. Therefore, if we have to pump during the expensive hours, then the cost is high and vice versa. The average price in 2007 was around 0.05 \$/m³.

The pumping is to Zalmon Reservoir that is the highest point. From this point, it is going southward by gravity (sometimes we operate some station along the line but it is rare).

3.8.7.b West Ghore Canal

Despite the fact that the canal size and capacity highly depends on the volume of water released from Jordan Valley, in order to optimize the usage of canal can be used as a national carrier for:

1. Jordan valley water about 150-200 mm³
2. desalinated brackish water
3. treated waste water
4. water harvested in the dams
5. Jordan valley springs

The estimated cost of water will be (0.05 \$/m³) the estimation based on the integration of the five sources of water mentioned above and the Jordanian experience .

Figure 43: Investment costs \$/ m³ / year per option

Water Resource	Investment Unit Cost \$ m ³
Ground water (existing resources):	
• Artificial recharge	3.0
• Rehabilitation of springs	0.7
• Rehabilitation of wells	0.8
Mountain aquifer(new wells	
Deep wells &	0.9
Shallow wells	0.7
Rain water Harvesting	50
Desalination	
• Sea water	3.5

	8
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4. Conclusion and recommendations

Based on socioeconomic context and the political situation the following conclusions and actions were presented:

Despite the fact that Jericho area relatively depends on good water resources and has potentiality to have additional water resources , however efficient institutional arrangement and legal reform is a pre condition to implement additional water resources projects . The lack of good governance and weakness of legal frame are the main

1. The investment to develop additional water resources should be divided into three phases immediate, short and long term options.
2. The rehabilitation and good governance of current water resources need an immediate plan which will secure 20% of current water demand
3. Integrated spring conveyance system for the major spring is very important to create efficient management
4. Water harvesting and artificial recharge are feasible at current situation
5. Waste water treatment and reuse option will face several social and economical constrains
6. Each option needs a sensitivity analysis
7. Agricultural policy should be reformulated and more focus on cash crops should be done

constrains to develop the current water resources .Also, many actions should be taken to harmonize the regional plan for water resources development with national plan .

The following are the main recommendations:

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