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Water Soft Path Analysis – Jordan Case

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1. Introduction

In water management today, there are two primary ways of meeting water-related needs, or two “paths”. One path can be called the “hard” path which relies almost exclusively on centralized infrastructure and decision making: building dams and reservoirs, pipelines and treatment plants, and establishing water departments and agencies. It delivers water, mostly of potable quality, and takes away wastewater. The second path or the “soft” path may rely on centralized infrastructure, but complements it with extensive investment in decentralized facilities, efficient technologies, and human capital. It delivers diverse water services matched to the users’ needs and works with water users at local and community scales. –

The purpose of this chapter is to present the “Soft Path Analysis” as an approach that improves the overall productivity of water use, rather than the business as usual approach with the endless search of new sources of water supplies.

The water soft path is modelled on the highly successful approach to energy known as the soft energy path. The “soft path” planning approach for fresh water differs fundamentally from supply focused planning. It starts by changing the conception of water demand. Instead of viewing water as an end product, the soft path views water as the means to accomplish certain tasks. The role of water management changes from building and maintaining water supply infrastructure to providing water related services, such as new forms of sanitation, drought-resistant landscapes, urban redesign for conservation and rain-fed ways to grow crops (Brandes et. al, 2005)

What calls for new approaches are also the inadequacies by which water planners and policymakers are addressing the new challenges that are further complicating the traditional approaches to solving the water problems. Issues such as regional and international water conflicts, the dependence of many regions on unsustainable groundwater use, the growing threat of anthropogenic climate change, and our declining capacity to monitor critical aspects of the global water balance are all currently inadequately addressed by water planners and policymakers. If these challenges are to be met within ecological, financial, and social constraints, new approaches are needed (Gliek, 2003).

1.1 Concept of soft paths

Soft paths can be defined briefly as approaches to natural resources management that rely on a multitude of distributed, relatively small-scale sources of supply coupled with ultra

efficient ways of meeting end-use demands (Brooks et al, 2004). Gleick (in Brooks ,2004) provides a more comprehensive definition:

What is required is a “soft path,” one that continues to rely on carefully planned and managed centralized infrastructure but complements it with small-scale decentralized facilities. The soft path for water strives to improve the productivity of water use rather than seek endless sources of new supply. It delivers water services and qualities matched to users’ needs, rather than just delivering quantities of water. It applies economic tools such as markets and pricing, but with the goal of encouraging efficient use, equitable distribution of the resource, and sustainable system operation over time. In addition includes local communities in decisions about water management, allocation, and use.

1.2 Twentieth century policy and planning

The predominant focus of water planners and managers has been identifying and meeting growing human demands for water. Their principal tools have been long-range demand projections and the construction of tens of thousands of large facilities for storing, moving, and treating water. The long construction times and high capital costs of water infrastructure require that planners try to make long-term forecasts and projections of demand. Yet these are fraught with uncertainty. Three basic futures are possible: (i) exponential growth in water demand as populations and economies grow, (ii) a slowing of demand growth until it reaches a steady state, and (iii) slowing and ultimately a reversal of demand (Figure 1).

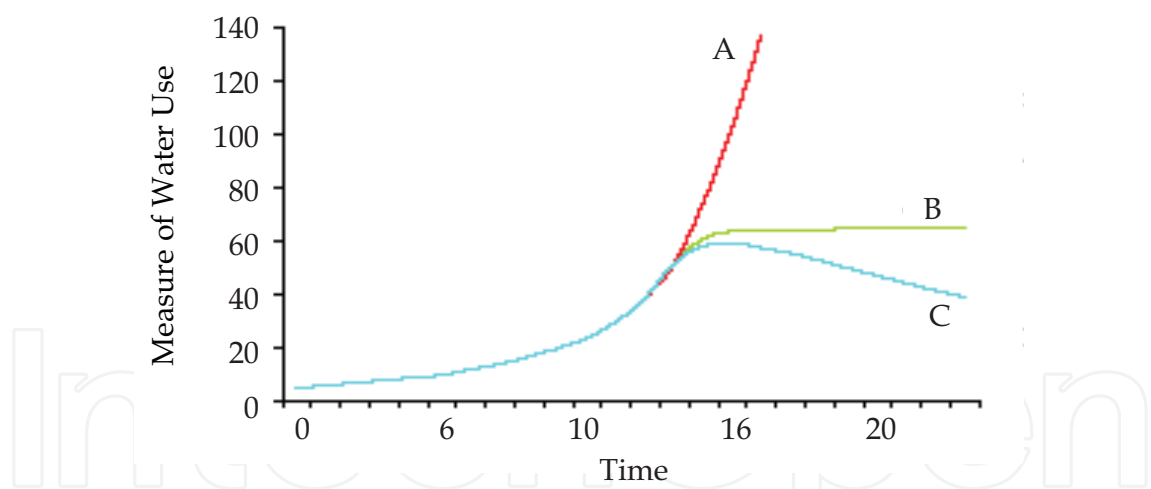


Fig. 1. Scenarios of future water use. (Gliek, 2003)

The three curves represent continued exponential growth in demand (A), a leveling off of demand to steady state (B), and declining demand (C).

Reviewing the last several decades of projections shows that in the developing world planners consistently assumed continued, and even accelerated, exponential growth in total water demand. Some projections were that water withdrawals would have to triple and even quadruple in coming years, requiring additional dams and diversions on previously untapped water resources in remote or pristine areas once declared off-limits to development (Gliek, 2003).

However, instead, total water withdrawals began to stabilize in the 1970s and 1980s, and construction activities began to slow. More recently, the economic costs of the traditional hard path have also risen to levels that society now seems unwilling or unable to bear.

Similarly, as large-infrastructure solutions have become less attractive, new ideas are being developed and tried and some old ideas are being revived, such as rainwater harvesting and integrated land and water management. These alternative approaches must be woven together to offer a comprehensive toolbox of possible solutions (Gliek, 2003).

1.3 Experiences with actual soft path analyses

Soft path analysis as a detailed and rigorous method was initially developed around energy alternatives. Soft path analysis as a methodology was initially developed in the 1970s in a search for alternatives to conventional energy policy by Lovins. Its normative base was clear from the start. The early work was done within Friends of the Earth USA, partly as a way to counter the then-growing drive to build nuclear power plants (Brooks, 2005).

By the end of the 1970s, articles on soft energy paths were appearing in professional journals, and several books had been published. By the middle of the 1980s, the methodology could be considered proven; some 35 soft energy path studies had been published for various nations or regions of the world. Canadians were among the leaders in seeing the potential for soft energy paths, and Friends of the Earth Canada provided the base for some of the developmental work and later for four iterations of soft energy path analysis on Canada, including a 12 volume report by Brooks, Robinson and Torrie in 1983, and a more popular book by Bott, Brooks and Robinson in 1983. Methodological guides were also made available (Brooks, 2004).

Though no nation or state whole heartedly accepted soft path conclusions as guiding principles, their impact was quite evident in policies that began to lean toward soft technologies and in results that showed more “new” energy coming from gains in energy efficiency than from all new sources of supply together (Brooks, 2005).

In comparing and contrasting energy and water we can notice water and energy exhibit many analogies, not just as physical substances, but also in the ways in which human beings have developed them as resources. The gradual shift from simple to combined to highly complex technologies, and from individual to local to highly centralized systems, has typified these two key resources for human development. However, the shift has proceeded much further for energy than it has for water. In many respects, water systems and water policies are not so far from the soft alternative today as energy policies and systems already were 25 years ago. Water supply is, for example, typically municipal or at most national in scope, and much of it is publicly owned; energy supply is commonly global in scope, and much of it is privately owned (Brooks, 2003). But looking at water or energy as a bundle of services, rather than as a commodity, many more options can be conceived to satisfy demands (Brooks, 2005).

1.4 Water soft path analyses

From the first, analysts agreed that the soft path methodology could be applied to other natural resources, but analytical models have only appeared for energy, and, more recently

and more partially, for water. Still today, it is fair to say that, to date, there has been no full water soft path study – at least not if by “full” we mean a semi-quantitative model of water scenarios based on soft path methods and relying on soft technologies.

The early proposals for and experiments with water soft path studies published prior to 2000 are described by Brooks (2003). Since that report, there have been further publications. By far the most important is another report from Peter Gleick and his colleagues at the Pacific Institute (Gleick et al., 2003). This report provides a review of urban water use in California, and of cost-effective methods to reduce consumption. This report is both more detailed and more rigorous than anything else to date. Happily, its conclusions are equally impressive: Without any change in water end-uses, economic structure or expected growth, at least one-third of all water use could be saved by the application of technologies that are cheaper than the costs of new supply. Should these technologies be adopted (at reasonable rates of implementation), projected economic and population growth in California could be accommodated without a single additional water supply project.

In Canada, The POLIS Project on Ecological Governance at the University of Victoria has created an Urban Water Demand Management group. Since 2003, this group has published a series of reports (Brandes, 2003; Maas, 2003; Brandes and Ferguson, 2004). The first report used information in the Statistics Canada Municipal (Water) Use Database (nicknamed MUD) to identify wide variation in both total and domestic per capita water use in Canadian municipalities. With some exceptions, it also identified an association of lower rates of use with the presence of water metres and with higher water prices. This report notes the opportunity to reduce water use in Canadian cities just by bringing the higher water consuming cities down to best practices elsewhere in Canada, and the latest report suggests the policies that would be effective at achieving this goal (Brooks et al, 2004).

1.5 Methodology of soft path studies

The concept for water soft paths is clearly attractive. Wolff and Gleick (2002) listed a number of characteristics of soft paths, but the key principles can be reduced to three:

- The first principle is to resolve supply-demand gaps in natural resources as much as possible from the demand side. Beyond the 50 litres per person-day commonly cited as the minimum for an adequate quality of life, there are many ways to satisfy human demands for water. The approach depends upon applying least-cost choices to every stage from water withdrawal to wastewater disposal and (ideally) reclamation plus emphasis on the need for the actual “services” desired, as opposed simply to providing quantities of water.
- The second principle is to match the quality of the resource supplied to the quality required by the end-use. It is almost as important to conserve the quality of a resource as to conserve its quantity. High-quality resources can be used for many purposes; low-quality resources for only a few. In contrast, we only need small quantities of high-quality resources but vast amounts of low-quality resources. Of course, those uses requiring high-quality resources are critically important, as with drinking (for water) and certain industrial processes (as for manufacturing semiconductors).
- The third principle is to turn typical planning practices around. Instead of starting from today and projecting forward, start from some future water-efficient time and work

backwards to find a feasible and desirable way (“a soft path”) between that future and the present. The main objective of planning is not to see where current directions will take us, but to see how we can achieve desired goals. This step is called “backcasting” (to make an obvious contrast with forecasting). It is at this stage that appropriate transition technologies must be identified to bridge the time between full implementation of soft technologies. Finally, at the end of the process politically and socially acceptable policies and programs must be defined to bring about the desired changes.

1.6 Differences between soft and hard paths

The soft path can be defined in terms of its differences from the hard path. The two paths differ in at least six ways according to Wolff, Gary and Peter H. Gleick (2002):

1. The soft path redirects government agencies, private companies, and individuals to work to meet the water-related needs of people and businesses, rather than merely to supply water. For example, people want to be clean or to clean their clothes or produce certain goods and services using convenient, cost-effective, and socially acceptable means. They do not fundamentally care how much water is used, and may not care whether water is used at all. Water utilities on the soft path work to identify and satisfy their customers’ demands for water-based services. Since they are not concerned with selling water per se, promoting water-use efficiency becomes an essential task rather than a way of responding to pressure from environmentalists. The hard path, in contrast, fosters organizations and solutions that make a profit or fulfill their public objectives by delivering water – and the more the better.
2. The soft path leads to water systems that supply water of various qualities, with higher quality water reserved for those uses that require higher quality. For example, storm runoff, gray water, and reclaimed wastewater are explicitly recognized as water supplies suited for landscape irrigation and other non potable uses. This is almost never the case in traditional water planning: all future water demand in urban areas is implicitly assumed to require potable water. This practice exaggerates the amount of water actually needed and inflates the overall cost of providing it. The soft path recognizes that single-pipe distribution networks and once-through consumptive-use appliances are no longer the only cost-effective and practical technologies. The hard path, in contrast, discounts new technology, and over-emphasizes the importance of economies of scale and the behavioral simplicity of one-pipe, one-quality-of-water, once-through patterns of use.
3. The soft path recognizes that investments in decentralized solutions can be just as cost-effective as investments in large, centralized options. For example, there is nothing inherently more reliable or cost-effective about providing irrigation water from centralized rather than decentralized rainwater capture and storage facilities, despite claims by hard-path advocates to the contrary. Decentralized investments are highly reliable when they include adequate investment in human capital, that is, in the people who use the facilities. And they can be cost-effective when the easiest opportunities for centralized rainwater capture and storage have been exhausted. In contrast, the hard path assumes that water users – even with extensive training and ongoing public education – are unable or unwilling to participate effectively in water-system management, operations, and maintenance.

4. The soft path requires water agency or company personnel to interact closely with water users and to effectively engage community groups in water management. Users need help determining how much water of various qualities they need, and to capture low-cost opportunities. In contrast, the hard path is governed by an engineering mentality that is accustomed to meeting generic needs.
5. The soft path recognizes that ecological health and the activities that depend on it (e.g., fishing, swimming, tourism, delivery of clean raw water to downstream users) are water-based services demanded, at least in part, by their customers, not just third parties. Water that is not abstracted, treated, and distributed is being used productively to meet these demands. Water is part of a natural infrastructure that stores and uses water in productive ways. The hard path, by ignoring this natural infrastructure, often reduces the amount and quality of water available for use. The hard path defines infrastructure as built structures, rather than separating it into built and natural components.
6. The soft path recognizes the complexity of water economics, including the power of economies of scope. The hard path looks at projects, revenues, and economies of scale. An economy of scope exists when a combined decision-making process would allow specific services to be delivered at lower cost than would result from separate decision-making processes. For example, water suppliers, flood control departments, and landuse authorities can often reduce the total cost of services to their customers by accounting for the interactions that none of the authorities can account for alone. This requires thinking about landuse patterns, flood control, and water demands in an integrated, not isolated, way.

1.7 Comparing different management approaches

When viewed on a spectrum, all three water management approaches – supply management, demand management, and the soft path – represent incremental steps toward sustainability. However, far from being a simple progression some key characteristics distinguish them. The most significant difference is the view of the limits of water available for human use and of the nature of the choices that should determine how we manage water. Figure 2 is an idealized sketch of the different paths that will result from following each of the three approaches.

Water demand management seeks primarily water efficiency, and is often focused on the implementation of cost-effective ways to achieve the same service with less water. Demand management options have been known for years, but with water prices kept artificially low, little incentive existed for widespread adoption (Brandes et al, 2005).

Though demand management has always been part of how water system operate, it is typically treated as a secondary or temporary measure needed until additional supplies are secured. Changing our water management paradigm requires that demand management become the primary focus. With rampant growth and the uncertainty of climate change, reducing the demand for water is our best “source” of “new” water (Brandes et al, 2005).

The soft path approach changes the conception of “water.” Instead of being viewed simply as an end product, water becomes the means to accomplish specific tasks, such as sanitation or agricultural production. Conventional demand management asks the question “How” –

How can we get more from each drop of water? Water soft paths also ask the question “Why” – Why should we use water to do this at all? (Brandes et al, 2005).

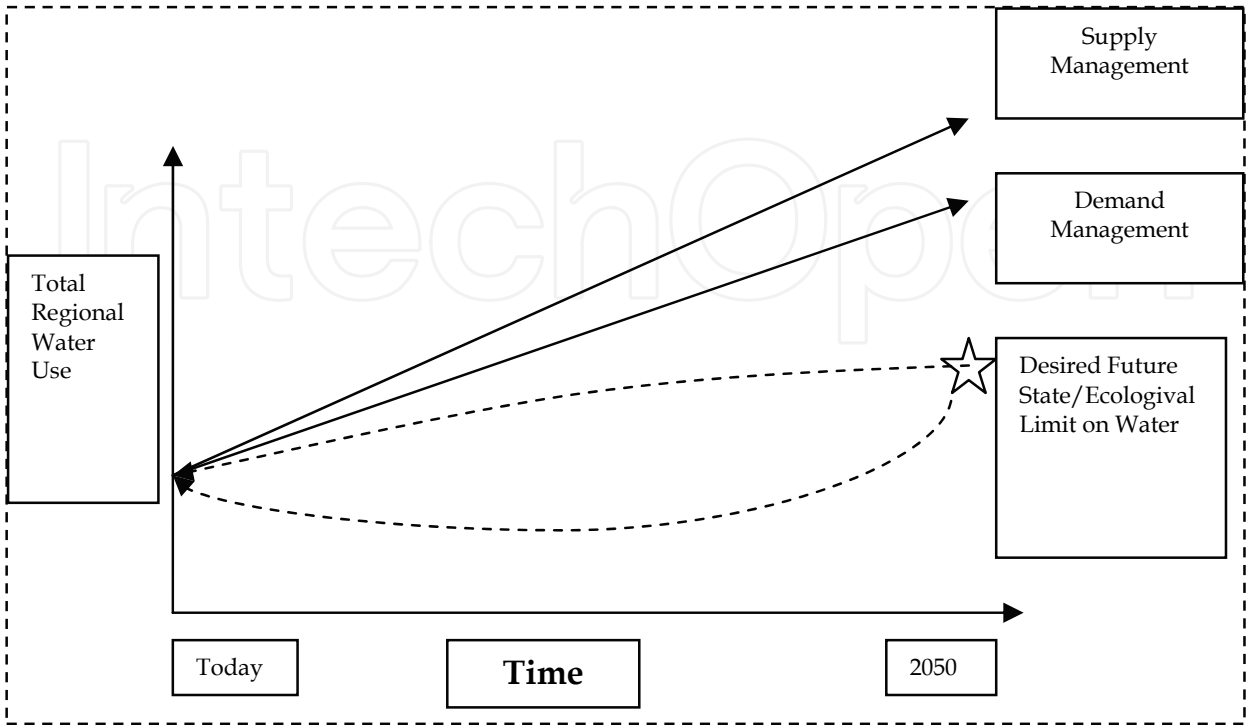


Fig. 2. Planning for the future with a soft path approach. (Brandes et al, 2005)

1.8 One continuing gap in soft path analyses

Probably the most legitimate criticism of energy soft path studies was that they neglected issues of equity. This led to many comments about the need to introduce environmental justice as an explicit element of policy, regardless of the nature of the policy. If that criticism was true of energy, it is even more so of water. The inequities in water and land distribution around the world are sizable and, as a result of misguided policies that promote centralization and privatization, they seem to be growing. As it is, poor people in urban areas commonly pay 10 times as much per litre for water of questionable quality as do richer people for water of good quality; and poor subsistence farmers sometimes (especially if they are women) get no water at all when commercial farms are adequately supplied (Webb et al , and Koppen et al in Brooks et al 2004). Though it is almost unquestionably true that water soft paths would improve the situation for poor people around the world, water soft paths by themselves are not sufficient. As emphasized by staff at the International Water Management Institute (IWMI) in Sri Lanka, water policies must be explicitly “pro-poor” and “pro-women”. Urban water systems in developing countries are notoriously leaky if one compares the difference between water put into the system and water that reaches registered consumers. Some of those leaks are true losses, but some (highly indeterminate) portion is “stolen” or redirected to illegal taps, which may serve hundreds of poor residents. Fixing the “leaks,” another common recommendation, should be undertaken only if coupled with additional, and possibly free, taps in low-income neighborhoods. In short, greater efficiency for water needs to be tempered with concern for equity, and this concern must be introduced explicitly in soft path analyses.

2. Where are we: Jordan water situation today

2.1 Introduction

Jordan is an arid to semi-arid country with land area of 92,000 sq km, located to the east of the Jordan River. Jordan's topographic features are variable. A mountainous range runs from the north to the south of the country. To the east of the mountain ranges, ground slopes gently to form the eastern deserts, to the west ground slopes steeply towards the Jordan Rift valley. The Jordan Rift valley extends from lake Tiberias in the north, at ground elevation of -220 m, to the Red Sea at Aqaba. At 120 km south of lake Tiberias lies the Dead Sea with water level at approximately -405 m. The southern Ghors and Wadi Araba, south of the Dead Sea, form the southern part of the Rift Valley. To the south of Wadi Araba region lies a 25 km coastline which stretches along the northern shores of the Red Sea. Due to the variable topographic features of Jordan, the distribution of rainfall varies considerably with location.

2.2 Climate

The climate in Jordan is characterized by a long, dry, hot summer, and a rainy winter. The temperature increases towards the south, with the exception of some southern highlands. Rainfall varies considerably with location, due mainly to the country's topography. Annual rainfall ranges between 50 mm in the eastern and southern desert regions to 650 mm in the northern highlands. Over 90% of the country receives less than 200 mm of rainfall per year, and 70% receives less than 100 millimeters per year. Figure 3 represents spatial variation of rainfall in Jordan.

Long term average annual rainfall for the country as a whole gives a total volume of 8352 million cubic meter (MCM). The minimum value of annual rainfall registered was 4802 MCM at the water year 1946/1947 and the maximum annual value registered was 17797 MCM at the water year 1966/1967. Approximately 92.48% of the rainfall evaporates back to the atmosphere, the rest flows in rivers and wadis as flood flows and recharges groundwater. Groundwater recharge amounts to approximately 5.16 % of the total rainfall volume, and surface water amounts to approximately 2.36% of total rainfall volume. (Ministry of Water and Irrigation records)

2.3 Water situation

Jordan is considered to be a highly water-stressed country, with only 153 cubic meter per capita per year available in 2006 compared to an average of 1,200 m³ per capita for the whole of the Middle East (FAO, 2007).

The availability of water is classified as very low on the Water Stress Index, which indicates the degree of water shortage or scarcity. Water Stress Index is the value of annual rainfall that charges surface and groundwater divided by the total population (m³/capita/year). Countries with less than 1,700 m³/capita/year are regarded as countries with "existing stress", while countries with less than 1,000 m³/capita/year are regarded as having "scarcity" and countries with less than 500 m³/capita/year are regarded as having "absolute scarcity". With 153 m³/capita/year Jordan falls into the category of "absolute scarcity" - a category comprising only 12 countries (UNEP 2002 in Fisher, 2005).

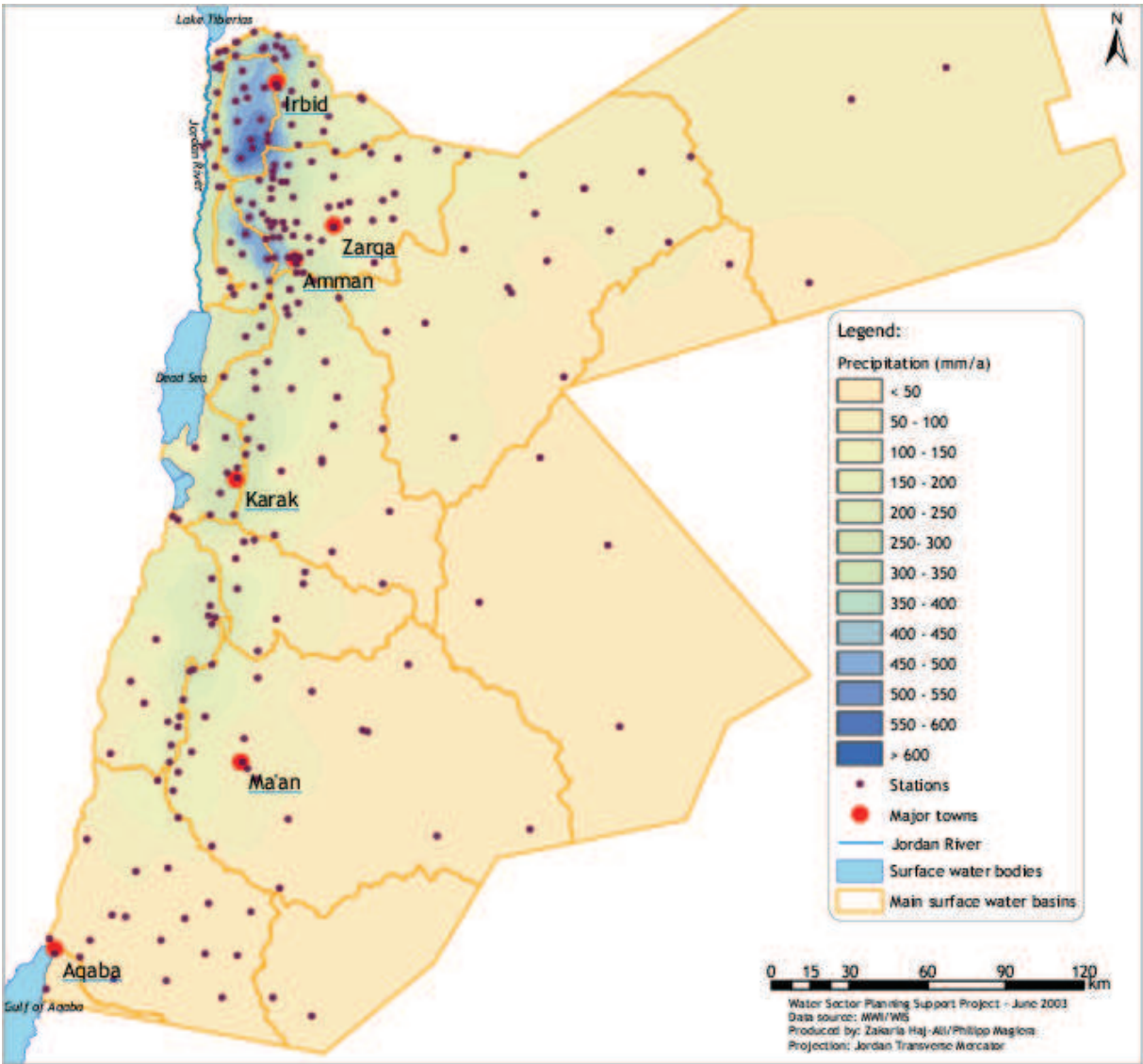


Fig. 3. Spatial distribution of rainfall in Jordan (National Water Master Plan, 2004)

The water challenge in Jordan stands as a major threat confronting human development and poverty alleviation. For this reason, the enhancement of water resource management is featured as a high priority in the National Agenda.

A description of how serious the water situation is in Jordan is presented in a paper written by Beaumont (2002) as follows:

Of all the countries in the Middle East it is Jordan which faces the greatest water problems (Salameh & Bannayan,; Beaumont in Beaumont, 2002). To meet its predicted urban water demand of 832 million cubic meters by 2025 would require 113% of its current irrigation use (1990s). In other words even if it reallocates all the irrigation water which was being used in the 1990s there would not be sufficient water to meet the expected demand. When figures on renewable water resources are examined the position becomes even more serious. It can be seen that Jordan has an internal renewable water resource base of 680 million cubic meters and a total natural water resource base of 880 million cubic meters. Yet in the 1990s withdrawals were 984 million cubic meters, which is well in excess of the total natural water

resource base. Although a limited amount of reuse of water was occurring in Jordan, the explanation of this fact is that large quantities of water were being withdrawn from groundwater reserves at a rate faster than that of natural recharge. Jordan is, therefore, a country which will soon experience serious water shortages. Indeed, it is the **only** country in the Middle East which faces such a serious situation.

Later, Beautmont (2002) suggests that the only long-term solution would be for Jordan to embark on a policy of desalinated water supply for at least some of its major urban centers. However, it could be carried out from Aqaba. The great problem, though, with Aqaba is that the desalinated water would have to be transported over distances of at least 250 km, and pumped 1000 metres in height to reach the urban centres of Amman and Zerqa. In summary, there are no easy solutions to the water problem for Jordan. In the short term the reallocation of at least some of the irrigation water will buy time, but in itself it will not solve the water scarcity issue.

The following sections describes the situation in more details.

2.4 Water resources

Water resources consist primarily of surface and ground water sources. In recent years wastewater has increasingly been used for irrigation.

2.4.1 Surface water resources

Surface water resources in Jordan vary considerably from year to year. The long-term average surface water flow is estimated at 706.91 MCM/year, comprising of 451.40MCM/year base flow, and 255.51 MCM/year flood flow. Of these only an estimated 473MCM/year is usable or can be economically developed.

Surface water resources are unevenly distributed among 15 basins. The largest source of external surface water is the Yarmouk river, at the border with Syria. The Yarmouk river accounts for 40% of the surface water resources of Jordan, including water contributed from the Syrian part of the Yarmouk basin. It is the main source of water for the King Abdullah canal and is thus considered to be the backbone of development in the Jordan valley. Other major basins include Zarqa, Jordan river side wadis, Mujib, the Dead Sea, Hasa and Wadi Araba. Internally generated surface water resources are estimated at 400 million m³/year (FAO, 1997). Figure 4 presents the main surface water basins in Jordan.

2.4.2 Groundwater resources

Groundwater is a major water resource in Jordan and the only water resource in many regions of the Kingdom. Twelve groundwater basins have been identified in Jordan, these include two fossil aquifers: Al-Disi and Al-Jafar. Some of these basins have more than one aquifer. The annual safe yield of the renewable groundwater supply is estimated to be 277MCM. An additional 143 MCM per year are considered available from non-renewable fossil aquifers that are sustainable for between 40 and 100 years. In 2005, the over-draft was about 144 MCM, consequently, the water level in several basins are declining and some aquifers are showing some deterioration of their water quality due to increased salinity. Figure 5 presents groundwater basins and sustainable abstraction per groundwater basin.

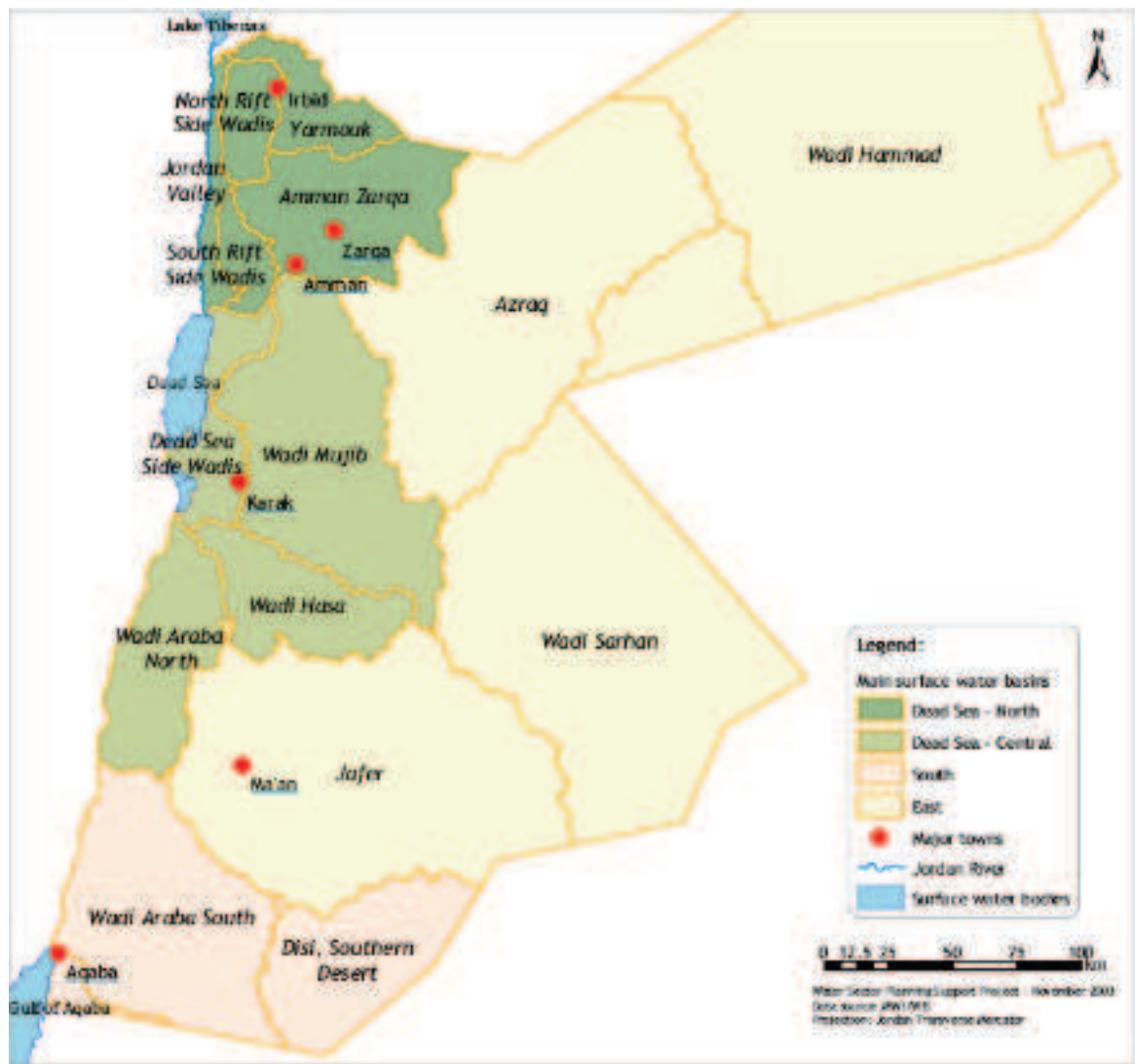


Fig. 4. Main surface water basins in Jordan. (National water Master Plan)

2.4.3 Wastewater

In a water-short country such as Jordan, wastewater is an important component of the Kingdom’s water resources. Generally, fully treated wastewater is suitable for unrestricted use in agriculture and for aquifer recharge. “Jordan’s National Water Strategy” (1997), argues that population pressure in Jordan has caused a chronic deficit in available freshwater, which has resulted in over abstraction of groundwater. Furthermore, there are limited opportunities to develop new freshwater sources and these are expensive, with high operating costs. Given this, the strategy states that treated wastewater is to be considered as a resource that, with due care for health and the environment, should be reused for agriculture, industry and other non-domestic purposes, including groundwater recharge.

The reuse of treated wastewater in Jordan reaches one of the highest levels in the world. The treated wastewater flow of the major wastewater treatment plant in the country is discharged to Zarqa River and the King Tall dam, where it is mixed with the surface flow and used in the pressurized irrigation distribution system in the Jordan Valley. Reused wastewater is becoming increasingly an essential element of Jordan's water budget.

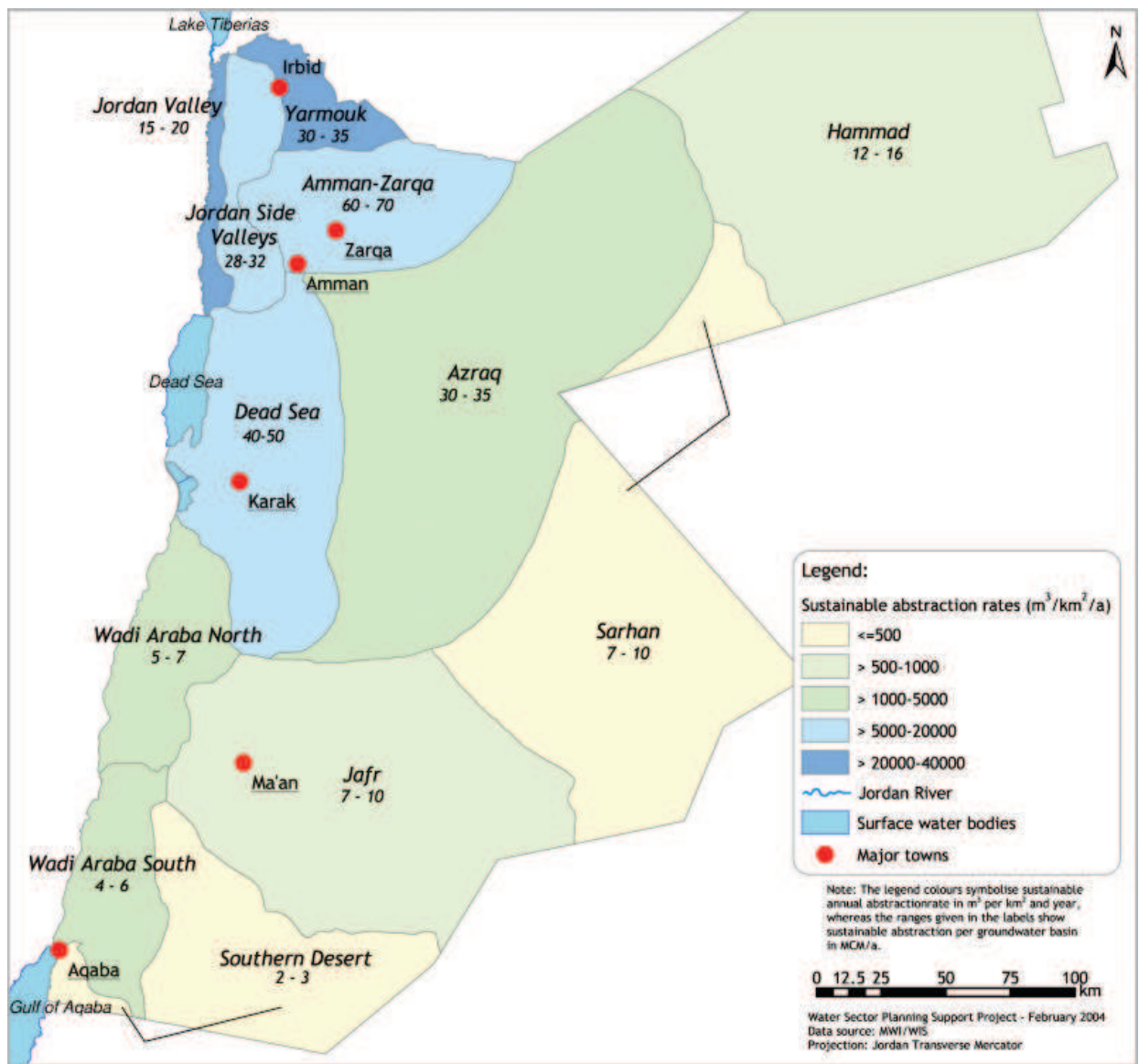


Fig. 5. Ground water basins and sustainable abstraction rate per ground water basin

In Jordan, about 84 MCM of wastewater were treated in 2005 and discharged into various water courses or used directly for irrigation, mostly in the Jordan Valley. Currently, approximately 60% of the urban population is provided with sewerage services.

Standards 893/2002 “Water-Reclaimed Domestic Wastewater” controls wastewater reuse in agriculture. The National Wastewater Management Policy (1998) allows for the Jordanian Standards on water reuse to be periodically examined to account for ambient conditions, end uses, socio-economics, environment and local conditions.

2.5 General water budget

In 2005 the total use of water in Jordan was 941 million cubic meters (MCM) or 164 m^3 /capita/year t the total 2005 country’s population of 5.47 million people. This usage included 77 MCM of nonrenewable groundwater (groundwater mining) and 83.5 MCM of treated wastewater. The total renewable freshwater resources in Jordan are estimated at 850

MCM, however the presence of groundwater mining and wastewater reuse in 2005 indicates that the demand already exceeds the availability of renewable water during that year. Table 1 shows the most recent statistical data on water use in Jordan by user sector and water source.

Source	Uses in MCM				Total Uses
	Municipal	Industrial	Irrigation	Livestock	
Surface Water	74.7	4.5	265.21	7.0	351.41
Ground Water	216.66	33.903	254.629	0.826	506.01
Treated Wastewater	0.0	0.0	83.545	0.00	83.545
Total	291.36	38.403	603.384	7.826	941

(In Million Cubic Meters per Year, MCM/year)

Table 1. Sources of Sectoral Water Use in Jordan in 2005

From the Table 1 it is clear that Jordan is facing a chronic imbalance in the population-water resources equation. The per capita use of water will continue to decline at a rate equal to that of population increase. The renewable water resources falls short of meeting actual demand, which translates into the increase of food imports where the deficit in food balance reached \$110 per capita in 1996 (Strategy, 1997).

3. Amman governorate

Amman Governorate enjoys a special position in Jordan because of its size and population, as well as its importance as the having the capital city Amman, the center of governmental institutions, communication, commerce, banking, industry, and cultural life.

Jordan is administratively divided into 12 Governorate. Figure 6 represents a map of Jordan showing the twelve Governorates. Amman Governorate is one a middle governorate and has an area of 7,579 km2. This represents 8.5% of Jordan’s area. However, the population of Amman was 2125400 in 2005 representing 38% of the population in Jordan (DOS, 2005). The population density is 280.4 persons per km2 (DOS, 2005).

During the last 10 years the amount of new building within the city has increased dramatically with new districts of the city being founded at a very rapid pace (particularly so in West Amman), straining the very scarce water supplies of Jordan as a whole, and exposing Amman to the hazards of rapid expansion in the absence of careful municipal planning.

Amman enjoys four seasons of excellent weather as compared to other places in the region. Summer temperatures range from 28 - 35 degrees, but with very low humidity and frequent breezes. Spring and fall temperatures are extremely pleasant and mild. The winter sees nighttime temperatures frequently near zero, and snow is not unknown in Amman, as a matter of fact it usually snows a couple of times per year. It typically will not rain from April to September, with blue skies prevailing. But lately it started to rain in April and the beginning of May. In fact about half the quantity of rain Amman and Jordan received in 2006 fell in April.

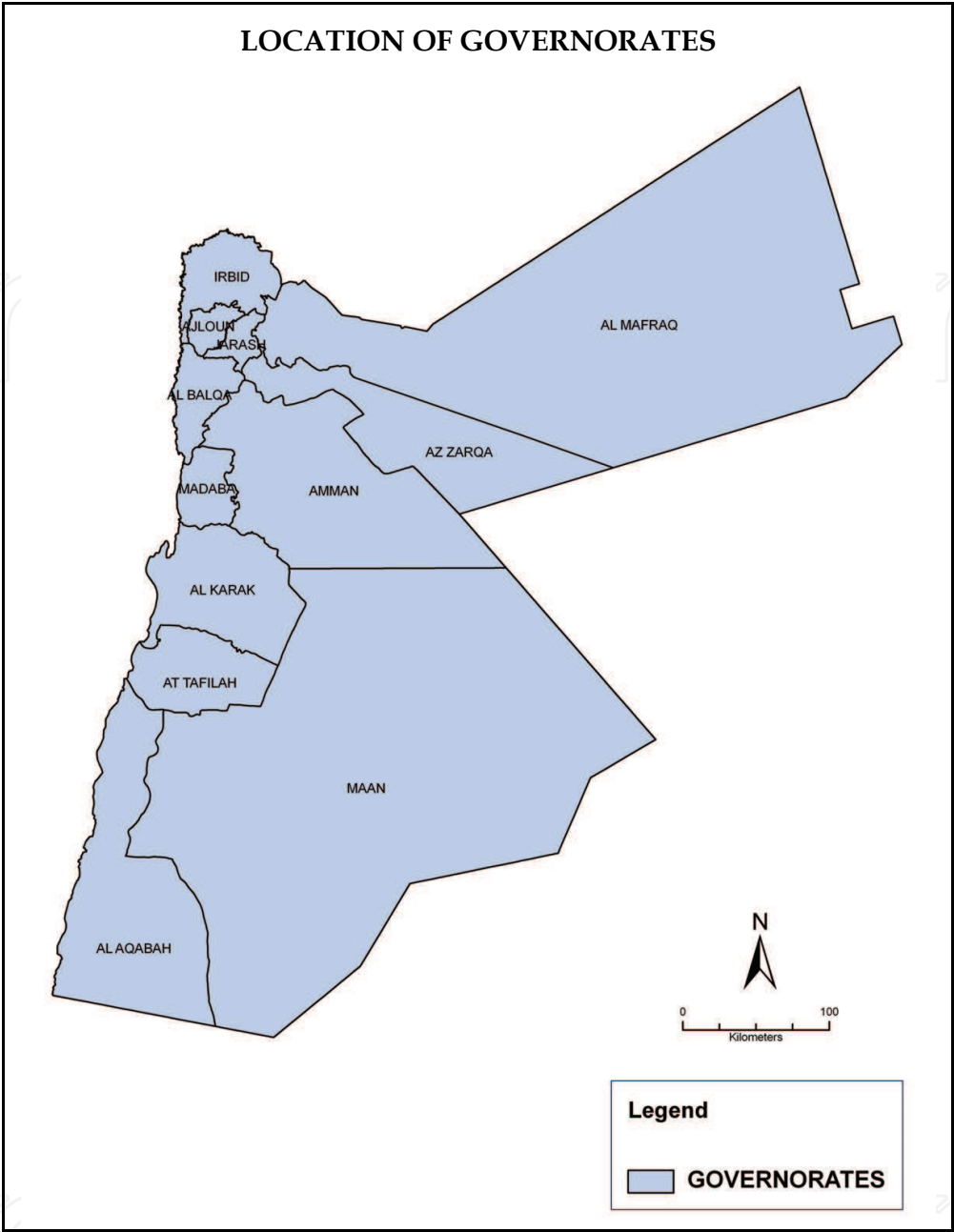


Fig. 6. Map of Jordan showing location of Amman Governorate

In Greater Amman, Lyonnaise des Eaux - Montgomery Watson - Arabtech Jardaneh (LEMA) has been in charge of public water supply since the signing of the major Water and Wastewater Supply Management Contract of Greater Amman in August 1999, till the end of 2006. Starting 2007, a governmental company "Meyahuna" was established to be in charge of the water supply in Amman.

3.1 Water in Amman Governorate

Water uses in Jordan are mainly defined as agricultural water use, municipal and industrial water use. Municipal consumption refers to the water consumed in a given year by the domestic, commercial and pastoral sectors in addition to the light industries.

In 2005, Amman Governorate total water uses amounted to 143.52 million cubic meters (MCM). The water use for the municipal sector was 119.87 MCM, the industrial water use was 1.26 MCM while water use for the agricultural sector was 22.4 MCM. The percentages of water use in each sector is as follows: 83.52% for the municipal sector, .88 % for the industrial sector 15.6 % for the irrigation sector.

Amman's total municipal and touristic uses witnessed significant increase during the past decades in both absolute and relative terms. This was mostly due to the growth in municipal consumption. Increased income and changes in way of life have also contributed to such an increase of water consumption, especially in the urban areas of Greater Amman. (Master Plan, 2004).

One third of water requirements to satisfy the municipal demands for Amman Governorate, are currently met from internal resources of Groundwater and surface water of the Governorate, while the two thirds need to be transferred from resources external to the governorate. The ability to increase water supply potential is further limited due to the over pumping of ground water resources, falling ground water levels and deteriorating groundwater quality. Thus, in order to satisfy the projected water demand in Amman Governorate, major water supply and transfer projects such as Mujib-Zara-Zarqa-Ma'in Saline Water Desalination Project and Disi Water project are needed

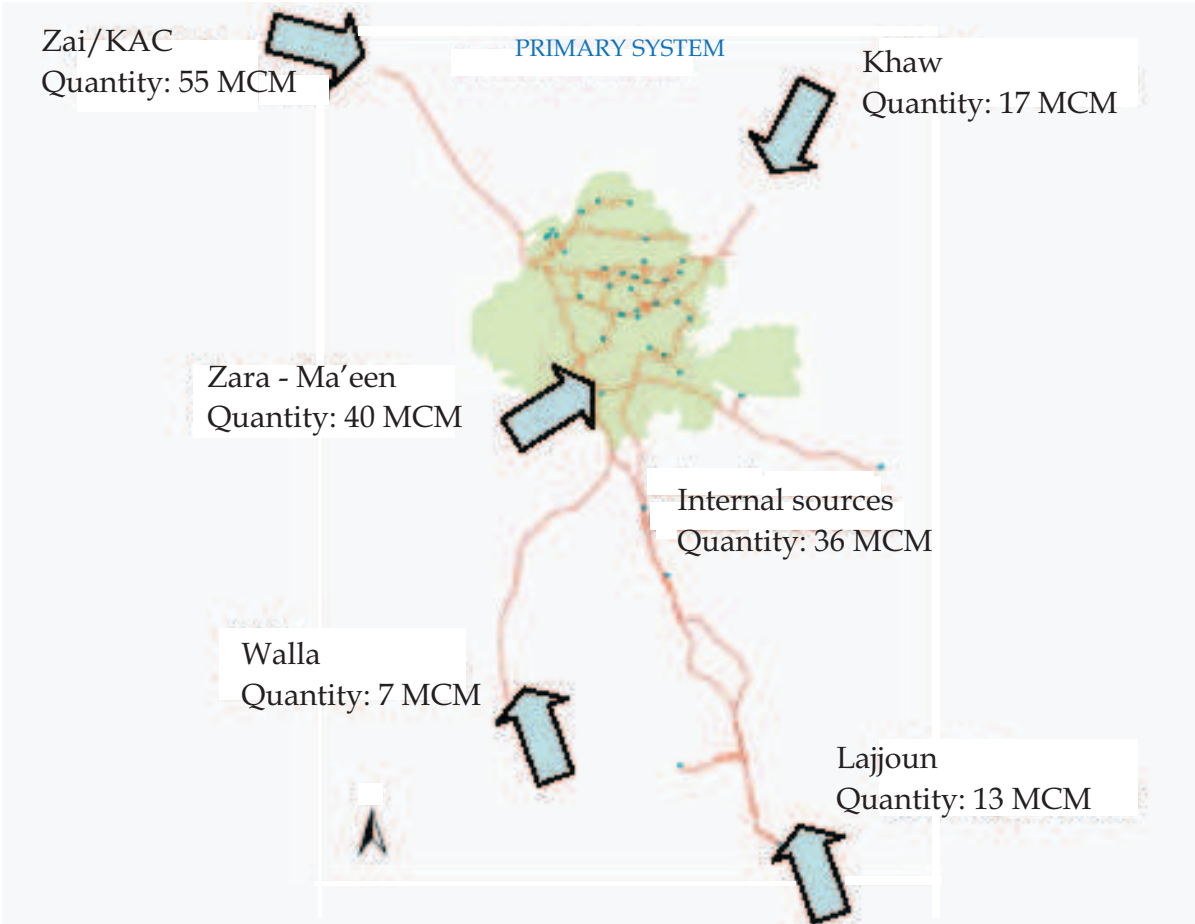


Fig. 7. Schematic location of bulk water sources in 2004. (Ministry of Water and Irrigation and USAID, 2006)

The most important water source for Amman Governorate is the Yarmouk River and water collected from 10 other sources located in the northern part of the Jordan Valley that feed the King Abdullah and ultimately the Zai water treatment plant. The intake at Deir Alla is located at 230 meters below sea level and the water is pumped through a system of 4 pumping stations to 880 meters above sea level. The Zai water treatment plant provides conventional treatment (flocculation, sedimentation, rapid filtration and chlorination. (MWI et al, 2006).

An important new water source (Zara Ma’een project) is being completed and was operational in August 2006. The project comprises a 55 MCM per year reverse osmosis treatment plant for upgrading class III raw water of salinity between 1400-2000 mg/l to no more than 250 mg/l. The plant produces 47 MCM per year of drinkable water as defined in Jordanian Standards. (MWI et al, 2006). Figure 7 is a schematic location of bulk water sources in 2004

3.2 Water services

In 2005, about 97 % of the total population in Amman Governorate were served through some 362,500 service accounts. Due to lack of water resources, water supply is rationed in most of the service area; in 2005 for instance, the average hours of supply were 66 per week. However, about 60% of customers receive water more than 36 hours per week and 55 water districts within restructured CIP area are receiving water continuously as of May 2006. (MWI et al, 2006).

The water supply through public network to Amman Governorate was 119.86 MCM in 2005 (WAJ records). However, water billed according to LEMA company was 66.3. MCM only. This translates into non-revenue water of 53.56 MCM. The nonrevenue water can be split to apparent losses and real losses

Apparent losses are however considered to be part of the consumption, since they are due to illegal abstractions, inaccurate or erroneous meter readings , non-operational meters and/or un-metered connections

In order to estimate the actual water use in Amman an assumption was made that water losses of 53.56 MCM can be split equally to real losses and apparent losses. So real losses were estimated as 26.78 MCM and apparent losses also as 26.78 MCM. Table 2 establishes a standard water balance for Amman

Own Sources 37.74 MCM	System Input 128.52	Water Exported 8.65 MCM	Authorized Consumption	Billed Authorized Consumption 66.3. MCM	Revenue Water
				Unbilled Authorized Consumption	
Water Imported 90.77 MCM		Water Supplied 119.87 MCM	Water Losses 53.56 MCM	Apparent Losses 26.78 MCM	Non Revenue Water
				Real Losses 26.78 MCM	

Table 2. Establishing a standard water balance for Amman

3.3 Water uses

In order to use the soft path method, and in view of conflicting numbers reported in different publications analysis of billing recoded to estimate water use services.

Municipal Water was estimated based on the above water balance as $(66.3 + 26.78 = 93.08$ MCM)

3.3.1 Residential water use

To estimate the residential water use in Amman, The following steps were followed:

1. Since the apparent losses adds to both residential and non residential uses. The percent of billed water residential use to the total billed water was calculated.

$$\begin{aligned}\text{Percent of billed residential water use} &= \text{residential billed water use} / \text{total billed water} \\ &= 58.5 / 66.3 * 100 = 88.2 \%\end{aligned}$$

Total apparent losses was calculated from an earlier section as 26.78 MCM

2. To obtain the apparent losses for the residential sector, an assumption was made that this amount is proportional to the percent of residential use. Thus, the percent of the billed residential water use was multiplied by the total apparent losses.

$$\text{Apparent losses for the residential sector} = 0.882 * 26.78 \text{ MCM} = 23.62 \text{ MCM}$$

3. The amount of apparent losses obtained was added to the billed residential water use. The total residential water use is estimated at

$$\begin{aligned}\text{Residential water use} &= \text{Residential billed water use} + \text{apparent losses} \\ &= 58.5 + 23.62 = 82.12 \text{ MCM}\end{aligned}$$

Further, the residential water was used to calculate the per capita water use. The population of Amman according to DOS (www.dos.gov.jo) was 2125400 in 2005.

$$\begin{aligned}\text{Per capita water use} &= \text{residential water use} / \text{population} \\ 82.12 * 10^9 * / (2125400 * 365) &= 106 \text{ liters / capita / day}\end{aligned}$$

3.3.2 Non-residential water use

The non residential water use or as defined in the literature as Industrial, Commercial and Institutional water use (ICI), according to LEMA water billing data, was 7.8 MCM. An additional 3.16 MCM can be added as result of the apparent losses using the same logic applied to residential water use. This results in ICI water use of 10.96 MCM representing 7.6 % of the total water use in Amman.

The Water Efficiency and Public information for Action Project (WEPIA) project gathered some data on the subscription base and broken them down by sector. Their breakdown is as in Table 3.

This breakout is helpful. It shows that the recorded water deliveries are primarily to residential household and that a conservation program should address this sector. However, 10 MCM of water deliveries for the non-residential sector most likely does not represent the true consumption in these sectors, as they are likely to be receiving supplementary deliveries by tanker truck. The overall usage for the non-residential sector is likely to be considerably higher. Hospitals, for example, rarely rely on municipal deliveries, and therefore their recorded data are short by magnitudes of scale

Sector	Annual Consumption (m3)	% Annual Consumption
Residential	95,459,600	82.9%
Schools	1,388,023	1.2%
Hospitals	1,170,361	1.0%
Commercial	14,626,426	12.7%
Industry	351,399	0.3%
Governmental	2,188,538	1.9%
Total	115,184,347	100.00%

Table 3. Water use broken down by sector

3.3.3 Industrial water use

Industrial water use here refers to the amount of water consumed by big industries, which utilise water produced locally, and mainly from groundwater wells. The industrial facilities in Amman Governorate include few food industries, Iron industries, Tiles industries and Pharmaceutical industries.

3.3.4 Agricultural water use

The water use for irrigation in Amman Governorate from groundwater wells and springs was 22.42 MCM according to the Ministry's Water Information System (WIS).

The Department of Statistics (DOS) implemented several agricultural surveys in 2004. The surveys included the following: cultivated area of fruit trees, cultivated areas of vegetables, and cultivated areas by field crops by type of crop in Amman governorate. For cultivated area with field crops of 321,186 dunums, it was estimated that 320,712 was non-irrigated, while the remaining 475 dunums, were irrigated using surface methods (DOS, 2004).

4. Soft path analysis for Amman

In Amman as in all Jordan, the water situation is critical. Population Growth, low rainfall, and increased economic activity are causing additional stress on the natural resources and in particular on water. In this section a soft path analysis will be developed for Amman. Three scenarios will be considered.

4.1 Scenarios for the soft path

Three Scenarios are considered for the purpose of developing a soft path analysis for Amman:

1. Maintaining water supply at the same level of 2005, but providing water services at the same level of a water use of 106 liter/capita/day. Year 2005 is considered as the base year.
2. Maintaining the per capita water use at the level of 2005 of 106 litre/capita/day, while accounting for the projected population growth, this will result in a higher water supply.
3. Maintaining water supply at the same level of 2005, but providing water services at the same level of a water use of 135 liter/capita/day.

4.1.1 Official demand projection

Table 4 represents the official water demand projection for Amman Governorate. Details of this projection will be explained in a later section.

Year	Municipal	Industrial	Touristic	Irrigation	Total Demand
2005	147.1	1.21	2.79	74.5	225.6
2010	158.2	1.5	3.18	73.8	236.7
2015	176.1	1.87	3.6	73.3	254.87
2020	195.2	2.33	4.02	72.1	273.65

Table 4. Official water demand projection for Amman Governorate

4.1.2 Scenario one

In this scenario water supply is maintained at the same level as 2005. Residential water use will be maintained at 105,379,575 m³ through the planning horizon, this will make the per capita water use drop. To supplement the drop of per capita water use per day from the level of 106 liters in 2005 to 67 liters in 2030 several options will be included in this soft path analysis. These options shall provide a total difference of 61,871,482 m³ to keep the same level of water services.

The non-residential and industrial sectors will also maintain the same level of water use. Several options need to be developed to account for the growth in these sectors while maintaining the same level of water use. The agricultural sector will not expand any further in this scenario.

4.1.3 Scenario two

In this Scenario an assumption was made that the per capita water use will remain the same level of 2005, that is 106 liter/capita/day and population will grow according to official population growth figures. The residential water use will thus be 167,251,057 m³ in 2030. In this Scenario, the assumption will be that the water requirement in 2030 will be 135 liter/capita/ day that is a total of 208,155,650 m³ and to supplement this difference several option need to be considered. These options will need to supplement the difference of 40,904,594 m³.

The non-residential and industrial sector will also grow at the same level of population growth. Options will be suggested to increase the efficiency in these sectors. The agricultural sector will not expand any further in this scenario.

4.1.4 Scenario three

In this scenario water supply is maintained at the same level as 2005. Residential water use will be maintained at 105,379,575 m³ through the planning horizon, but the water services will be kept at the same level of having 135 litre/cap/day. To make this possible, a soft path will be developed to provide the additional 102,776,076 m³ to reach the level 208,155,650 m³ necessary for a water use of 135 litre/cap/day and a population of Amman of 3665483 in 2030.

Figure 8 presents the official demand projection for Amman, along with the propped three soft paths.

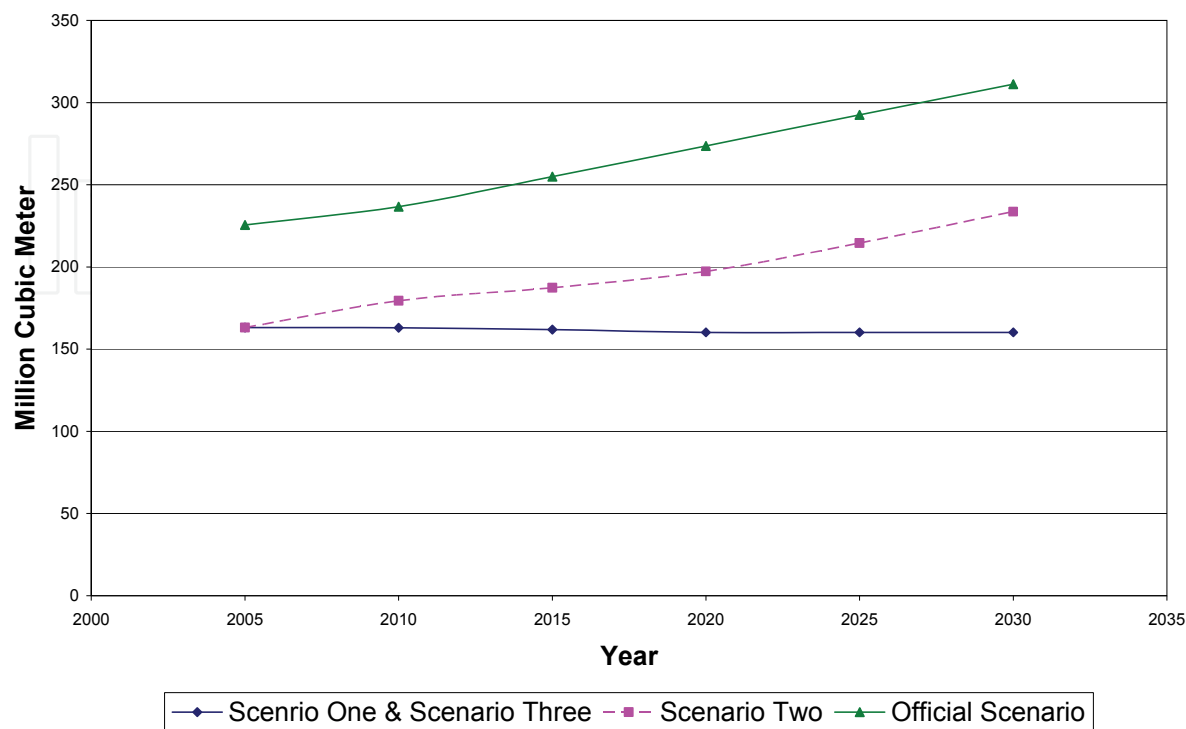


Fig. 8. Official projection and soft path scenarios for Amman Governorate

4.2 Methodology

The following basic steps for a soft path plan will be followed to develop the three Scenarios, these steps are after (Brandes et al, 2005)

1. Identify Water Services: List all services provided by water (e.g. residential indoor and outdoor, municipal parks, cooling). Some questions to answer include: Who is going to need water? For what purpose or goal water is needed? What kind of water is needed to meet a specific goal? How much water of a particular quality is needed to meet given goal?
2. Adopt a Projection for the Governorate- Look 25 years in the future of pre-existing official documents, demographic projections, and expectations of economic growth. Next, apply existing water use patterns to this projection (on a use-by-use basis), thus enabling a “business as usual” baseline.
3. Establish a Desired Future Condition: Create a desired future pattern for water supply and use. For example, a governorate might assume all future growth will be offset by conservation or efficiency and no new water sources will need to be developed.
4. Analyze Water Quantity and Quality: Establish the quantity of water required to provide the service identified for this projected future (Step 3) by applying as many of the water conserving options as can be adopted within the given time frame. Determine which uses require high water quality water notably (drinking, cooking and bathing) and which uses can proceed with lower quality water (toilet flushing, gardening, most forms of Agriculture, industrial applications, etc.)

5. Review Water Supply options: Identify all current sources of water (surface and ground) and determine whether any is being over-used or degraded. Reduce withdrawals of fresh water or releases of wastewater that threaten long-term renewable use, and reject any new sources that cross major shed boundaries or create serious threat to ecological, cultural or social values. Indicate the relevant range of future supply adjustment that may result from climate change.
6. Backcast (in contrast with forecast): Create various soft paths by designing incremental policies and programs to get from here to the future. Check each option to see whether it seems economically feasible, socially acceptable and politically achievable. This is an iterative process of backdating.

4.3 Step 1: Identify water services

The first step in preparing a soft path analysis is to establish a base line of current water use services. Looking at the water services allows us to evaluate the effect of improvements in end use technology and water demand management while maintaining the purpose for which the water is required.

4.3.1 Disaggregating consumption of sectors

4.3.1.1 Residential water use

According to earlier calculations in this section water use per capita in Amman was estimated at 106 liters/day.

Household Fixture	% Total Consumption	Total Consumption (m3)
Drinking	2.0%	2,003,728
Toilets	17.8%	17,833,179
Showers	27%	27,050,328
Clothes Washers	11%	11,020,504
Kitchen and Bath Faucets	27%	27,050,328
Outdoor	6.7%	6,712,489
Others	7%	7,013,048
Car	1.5%	1,502,796
Total	100%	100,186,400

Table 5. Indoor water consumption by end use

Understanding how the customer uses water is important to understanding how where to get conservation savings. End use information – that is, information about water flow at each specific point that the customer uses water – is important not only to analyzing conservation potential, but also to forecasting increases in water demand in the future.

No data exists of exact measures of water use services in Amman. To develop basis of estimate for water use services, prior studies in Ammam, and the results of a model developed by Rosenberg (personal contacts) were used. This model of household water use

was based on a survey; questionnaire; and data of billed water use. The resultant analysis found the following percentages of various end use consumption for an average household.

The disaggregating here is a useful indicator of water use. Toilets, faucets and showers are according to Table 5 have the highest end uses in the household – 71.8% overall – and therefore represent clear conservation program opportunities. Residential water are estimated below are for an averages household. Water used here is only potable.

4.3.1.2 Urban agriculture

A statistical survey of urban agriculture was conducted by the Department of Statistics in (1999). Thirteen thousand households were surveyed in various regions around the greater Amman area. Extrapolated to the whole population, the survey’s findings show the following:

- 50,097 households are practicing urban agriculture.
- The total cultivated area is an astounding 6,483,952 square meters.
- 86% of these households use the public network as a source of irrigation.
- Only 30% of the households suffer from water scarcity, thus leaving 70% who must be irrigating adequately or even excessively.

These findings suggest that an urban landscape program, particularly in the Amman region, may provide some water conservation potential. Although not likely to be a large quantity of water, it nonetheless would represent an area of savings worth exploring further.

4.4 Step 2: Adopt a projection for a region

The results displayed as the official demand projection part of the National Water Master Plan for Jordan of 2004, which has been produced by the Ministry of Water and Irrigation, in cooperation with the German Technical Cooperation (GTZ). Table 6 is a summary obtained reviewing different sections of the National Water Master Plan.

Year	Municipal	Industrial	Touristic	Irrigation	Total Demand*
2005	147.1	1.21	2.79	74.5	225.6
2010	158.2	1.5	3.18	73.8	236.7
2015	176.1	1.87	3.6	73.3	254.87
2020	195.2	2.33	4.02	72.1	273.65

Official Ministry of water and irrigation scenario

Table 6. Amman Governorate total water requirement (MCM)

Demand is defined as the amount of water required by a user. On the other hand, consumption represents the amount actually used "at the end of pipe". Both demand and consumption do not include any kind of physical losses. However, estimating Gross demand to be supplied need to include physical losses. In Jordan and as a result of water scarcity and rationing, water demand as defined earlier, is higher than actual water consumption. This is why the official demand projection starts at a higher value than other scenarios in figure 6.

Thus, gross municipal demand figures were based on a physical loss reduction program through systematic network rehabilitation program as presented in Table 7.

Governorate	2005	2010	2015	2020
Amman	28	22	18	15

Table 7. Physical losses per Governorate Assumption (%)

4.5 Step 3: Establish a desired future condition

4.5.1 Scenario one

The desired future for scenario one will be based on the assumption that Amman water requirements will be met with no need for extra water supplies than what is available in the year 2005. In order to maintain the water services at the same level, programs need to be designed to account for the difference of an average a per capita water use of 106 liters per capita per day (lpcd) at 2005 and 67 lpcd at 2030. This amounts to a total of 52,296,750 m3 for a population of Amman of 3665483 at 2030. Details of this scenario were presented in section 4.1.2.

4.5.2 Scenario two

The desired future for scenario two will be based on the assumption that Amman per capita water use will be the same as it was in the year 2005 that is 106 lpcd. In this Scenario, the assumption will be that the water requirement in 2030 will be 135 lpcd that is a total of 196,475,459 m3 and to supplement this difference a soft path several need to be developed. Details of this scenario were presented in section 4.1.3.

4.5.3 Scenario three

The desired future for this scenario will be based on maintaining a water supply at the same level as 2005. Residential water use will be maintained at 105,379,575 m3 through the planning horizon, but the water services will be kept at the same level of having 135 litre/cap/day. To make this possible, a soft path will be developed to provide the additional 102,776,076 m3 to reach the level 208,155,650 m3 necessary for a water use of 135 lpcd and a population of Amman of 3665483 in 2030.

4.6 Step 4: Analyze water quantity and quality

4.6.1 Scenario one

To be able to provide the per capita use of 67 l per capita per day at 2030 and be able to provide the same water services at the current level of 106 l/capita/day of 2005, the following programs need to be implemented at the residential sector. These programs will save a total of 61,871,482 m3 which is the difference between the projected gross residential use for scenario one of 105,379,575 m3 and the projected gross residential water use of 167,251,057 m3 if the water use will be maintained at 106 litre/capita/day. Savings are mainly based on savings from end uses summed across the total population according to the following assumptions as in Table 8. The programs include: retrofitting 50 % of the toilets, retrofitting 50% of the showerheads, retrofitting 50 % of kitchen and bath faucets, finding

and fixing leaks, installing efficient washing machines with a percent of 20% , turning 20% of the irrigation systems in gardens to drip irrigation systems, growing low water consuming landscapes or crops, installing greywater systems for outdoor use with 20% coverage, installing rainwater harvesting systems for outdoor use with 20% coverage, installing greywater systems for indoor use with 3.7% coverage, installing rainwater harvesting systems for indoor use with 7% coverage.

1- Retrofit Toilets					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.178	0.2	0.5	6916032.675
2- Showerhead Retrofit					
Population	Per capita	Percent used in showers	Savings	Coverage	Water Savings
3665483	106	0.27	0.2	0.5	10490611.36
3- Aerator Retrofits for Kitchen or bath faucets					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.27	0.2	0.5	10490611.36
4- Find fix and leaks					
Population	Per capita		Savings	Coverage	Water Savings
3665483	106	0.07	0.1	0.2	7770823.231
5- Install efficient water washing machines					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.11	0.1	0.2	854790.5554
6- Install Drip Irrigation System					
Population	Per capita	Percent used in	Savings	Coverage	Water Savings
3665483	106	0.067	0.1	0.2	520645.1564
7- Install low water consuming landscape or crops					
Population	Per capita	Percent used in	Savings	Coverage	Water Savings
3665483	106	0.067	0.1	0.2	520645.1564
8-install Graywater Collection System for outdoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.067	1	0.2	5206451.564
9-Install Rainwater Collection System for out door use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.067	1	0.2	5206451.564
10-Install Graywater Collection System for indoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.178	1	0.037	2558932.09
11-Install Rainwater Harvesting System for indoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.91	0.5	0.07	12375035.99
				Total Savings	62,911,031
				Required Savings	62,903,753

Table 8. Programs for soft path one

4.6.2 Scenario two

In this Scenario an assumption was made that the per capita water use will remain the same level of 2005, that is 106 l/capita /day and population will grow according to official population growth figures, that is the residential water use for Scenario 2 will be 167,251,057 m³ in 2030. In this Scenario, an assumption will made be that the water requirement in 2030 will be 135 liter/capita/ day that is a total of 208,155,650 m³ . The difference of 40,904,594 m³ will be gained from implementing the programs described in Table 9. The programs include: retrofitting 50 % of the toilets, retrofitting 50% of the showerheads, retrofitting 50 % of kitchen and bath faucets, finding and fixing leaks, installing efficient washing machines

1- Retrofit Toilets					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.178	0.2	0.5	6916032.675
2- Showerhead Retrofit					
Population	Per capita	Percent used in showers	Savings	Coverage	Water Savings
3665483	106	0.27	0.2	0.5	10490611.36
3- Aerator Retrofits for Kitchen or bath faucets					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.27	0.2	0.5	10490611.36
4- Find fix and leaks					
Population	Per capita		Savings	Coverage	Water Savings
3665483	106	0.07	0.1	0.2	7770823.231
5- Install efficient water washing machines					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.11	0.1	0.2	854790.5554
6- Install Drip Irrigation System					
Population	Per capita	Percent used in	Savings	Coverage	Water Savings
3665483	106	0.067	0.1	0.2	520645.1564
7- Install low water consuming landscape or crops					
Population	Per capita	Percent used in	Savings	Coverage	Water Savings
3665483	106	0.067	0.1	0.2	520645.1564
8-install Graywater Collection System for outdoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.067	1	0.03	780967.7347
9-Install Rainwater Collection System for out door use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.067	1	0.1	2603225.782
10-Install Graywater Collection System for indoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.178	1	0	0
11-Install Raionwater Harvesting System for indoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.91	0.5	0	0
Total Savings					40,948,353
Required Savings					40,904,594

Table 9. Programs for soft path two

with a percent of 20%, turning 20% of the irrigation systems in gardens to drip irrigation systems, growing low water consuming landscapes or crops, installing greywater systems for outdoor use with 3 % coverage, and installing rainwater harvesting systems for outdoor use with 10 % coverage.

4.6.3 Scenario three

To be able to provide the per capita use of 67 l per capita per day at 2030 and be able to provide the same water services at the level of 135 l/capita/day of 2005, the following programs need to be implemented at the residential sector. These programs will save a total of 102,776,076 m3 which is the difference between the projected gross residential use of year 2005 of 105,379,575 m3 and the projected gross residential water use of 208,155,650 m3 if the

1- Retrofit Toilets					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.178	0.2	0.5	6916032.675
2- Showerhead Retrofit					
Population	Per capita	Percent used in showers	Savings	Coverage	Water Savings
3665483	106	0.27	0.2	0.5	10490611.36
3- Aerator Retrofits for Kitchen or bath faucets					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.27	0.2	0.5	10490611.36
4- Find fix and leaks					
Population	Per capita		Savings	Coverage	Water Savings
3665483	106	0.07	0.1	0.2	7770823.231
5- Install efficient water washing machines					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.11	0.1	0.2	854790.5554
6- Install Drip Irrigation System					
Population	Per capita	Percent used in	Savings	Coverage	Water Savings
3665483	106	0.067	0.1	0.2	520645.1564
7- Install low water consuming landscape or crops					
Population	Per capita	Percent used in	Savings	Coverage	Water Savings
3665483	106	0.067	0.1	0.2	520645.1564
8-install Graywater Collection System for outdoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.067	1	0.2	5206451.564
9-Install Rainwater Collection System for out door use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.067	1	0.2	5206451.564
10-Install Graywater Collection System for indoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.178	1	0.17	11757255.55
11-Install Raionwater Harvesting System for indoor use					
Population	Per capita	Percent used	Savings	Coverage	Water Savings
3665483	106	0.91	0.5	0.25	44196557.12
Total Savings					103,930,875
Required Savings					103,808,347

Table 10. Programs for soft path three

water use was increase to 135 litre/capita/day. Savings are mainly based on savings from end uses summed across the total population according to the following assumptions as shown in Table 10. The programs include: retrofitting 50 % of the toilets, retrofitting 50% of the showerheads, retrofitting 50 % of kitchen and bath faucets, finding and fixing leaks, installing efficient washing machines with a percent of 20%, turning 20% of the irrigation systems in gardens to drip irrigation systems, growing low water consuming landscapes or crops, installing greywater systems for outdoor use with 20% coverage, installing rainwater harvesting systems for outdoor use with 20% coverage, installing greywater systems for indoor use with 17 % coverage, installing rainwater harvesting systems for indoor use with 25 % coverage.

4.7 Step 5: Review water supply options

4.7.1 Current water supplies

Groundwater resources

The estimated safe yield of renewable water resources in Amman governorate is in the order of 34 MCM/a. About 63 MCM is being abstracted from potential aquifers in the governorate (2005). Ground water quality in the area is generally good to fair quality (Total Dissolved solids (TDS) is in the range 500-1000 gm/l).

Deterioration of groundwater quality is vulnerable along the Seil region where some of the industrial waste is being disposed and as a result of the overdraft conditions that have been experienced in the governorate.

Groundwater resources from other governorate

Groundwater Resources From other Governorate are transported through pipelines to Amman Governorate from well fields in wadi Wala- Heidan (Madab Governorate), Katraneh and Lajoun (Karak Governorate) and Azraq and Corridor (Zarqa Governorate)

Surface water resources

Surface water resources in the Governorate are limited to rainfall/runoff in wadi Swaqa and al Botum. In addition, to Ras el Ain and Wadi Sir spring flows. The total potential of surface resources is estimated at about 7.4 MCM. Currently most of this is used for municipal purposes and the rest is used for irrigation.

External surface water resources

External surface water supplies is being conveyed to the Governorate from Yarmouk river via King Abdulla Canal/Dier Alla intake. About 60.3MCM of water supplies have been conveyed to Amman. The Deir Alla Zai Coveyor has the capacity of 90/a MCM.

Non conventional water resources

Wastewater

There are two existing treatments plants in Amman, Au Nsier and Wadi Sir.

- Abu Nsseir: is an activated sludge plant with a capacity of 4,000 m³/day or 1.5 MCM/year; and
- Wadi Essier: is an aerated lagoon plant with a capacity of 4,000 m³/day or 1.5 MCM/year

In addition to a small wastewater treatment plant at Queen Alia Airport.

The effluent of Abu Nsseir Wastewater Treatment Plan was about 2240.3 m³/day in 2005 and is currently used for landscaping of the medians adjacent to the treatment plant, while the effluent of Wadi al Sir was 2762 m³/day in 2005.

WAJ is developing three new wastewater treatment plants:

- As Samra secondary treatment plant, being built under a BOT scheme. This plant has four treatment trains with a total capacity of 267,000 m³/day (97 mm³/year). This plant will start operation in 2007. Additional capacity of 267,000 m³/day is planned for a later stage.
- South Amman secondary wastewater treatment plant. This plant has a capacity of 31,000 m³/day (11.3 MCM/year) and is expected to be operational in early 2008. South Amman wastewater project intended to serve more than 290,000 people living in this area.
- Giza-Talbiea secondary treatment plant. This plant has a capacity of 2,300 m³/day (0.8 MCM/year) and is expected to become operational by mid 2007.

Zara main project

Zara Main desalinated brackish water project, can make about 40 MCM of water available to Amman by the end of 2006.

Disi project

This project includes raising of water from an aquifer in the Disi-Mudawarra area in the south of Jordan and the conveyance of the water to the greater Amman area, a distance of approximately 325 kilometers. The conveyance system will have a capacity of transporting 100 MCM water per year. This project is currently under tendering.

4.7.2 Water supply options for scenario one

Year	Total Demand MCM	Local Sources (MCM)			Possible Available Sources (MCM)			
		Surface Water	Ground-Water	WW Effluent	Disi	Zai	Zara Main	From Other Governorates
2030	160.18	10	34	16.18	---	60	40	-----

4.7.3 Water supply options for scenario two

Year	Total Demand MCM	Local Sources (MCM)			Possible Available Sources (MCM)			
		Surface Water	Ground-Water	WW Effluent	Disi	Zai	Zara Main	From Other Governorates
2030	224.1	10	34	16.18	64	60	40	-----

4.7.4 Water supply options for scenario three

Year	Total Demand MCM	Local Sources (MCM)			Possible Available Sources (MCM)			
		Surface Water	Ground-Water	WW Effluent	Disi	Zai	Zara Main	From Other Governorates
2030	160.18	10	34	16.18	---	60	40	-----

4.7.5 Summary

The water requirements could be met by reducing the groundwater pumping to the safe yield of 34 MCM/year. Irrigation from ground water shall be reduced and supplemented by irrigation from reclaimed water. For Scenario One and Three water supplied and Zai and Zara Main are of critical importance and these sources need to be used to the fullest extent possible. However, for Scenario 2, meeting the water requirement will need additional water that can be only provided by Disi Project.

4.8 Step 6: Backcast

In Step 3 the desired future has been identified as scenario one or two scenario three; in Step 4 ways to make that future work were identified; and in Step 5 supply constraints were defined. In this step we need to explain how to get to that future. Each option needs to be checked to see whether it seems economically feasible, socially acceptable and politically achievable

4.9 Step 7: Write, talk and promote

The last step in soft path analysis, but can be considered the most important, is to get those conclusions to the public and especially to people who influence and make key decisions about fresh water. Considerable efforts should be put into promoting water soft path results.

5. Conclusion

The traditional approach to water supply led to enormous benefits. The history of human civilization is intertwined with the history of the ways humans have learned to manipulate and use water resources. The earliest agricultural communities arose where crops could be grown with dependable rainfall and perennial rivers. Irrigation canals permitted greater crop production and longer growing seasons in dry areas, and sewer systems fostered larger population centers (Gliet, 2002)

During the industrial revolution and population explosion of the nineteenth and twentieth centuries, the demand for water rose dramatically. Unprecedented construction of tens of thousands of monumental engineering projects designed to control floods, protect clean water supplies, and provide water for irrigation or hydropower brought great benefits to hundreds of millions of people. On the other hand, half the world’s population still suffers with water services inferior to those available to the ancient Greeks and Romans. According

to the World Health Organization's most recent study, more than 1 billion people lack access to clean drinking water, and nearly 2.5 billion people do not have improved sanitation services. Preventable water-related diseases kill an estimated 10,000 to 20,000 children each day, and the latest evidence suggests that we are falling behind in efforts to solve these problems (Gliek, 2002).

Further more, Groundwater aquifers are being pumped down faster than they are naturally replenished and more than 20 percent of all freshwater fish species are now threatened or endangered because dams and water withdrawals have destroyed the free-flowing river ecosystems where they thrive.

In the twenty-first century we can no longer ignore these costs and concerns. The old water development path—successful as it was in some ways—is increasingly recognized as inadequate for the water challenges that face humanity. We must now find a new path with new discussions, ideas, and participants. The Soft path offers this alternative. The adjective *soft* refers to the nonstructural components of a comprehensive approach to sustainable water management and use, including equitable access to water, proper application and use of economics, incentives for efficient use, social objectives for water quality and delivery reliability, public participation in decision making, and more (Gliek, 2002).

This chapter aimed at investigating the possibility of implementing this approach to Jordan and in particular in Amman Governorate. A soft path analysis was developed considering three different scenarios. Applying this analysis framework to Jordan, has demonstrated the urgent need of implementing strategies today that can reduce our dependence on more expensive supply side developments in the future. We have to start soon on establishing comprehensive water demand management program, particularly in urban areas and for the residential, commercial and institutional sectors.

Toilet retrofits program, showerhead retrofits program, aerator retrofits program, clothes washer retrofits program, audit leak detection, installing drip irrigation system, indoor and out door greywater reuse, rainwater harvesting for indoor and outdoor uses, public information programs, modifying water user behavior, reclaimed water use and recycling, a comprehensive leak detection and reduction program, and a more efficient agricultural sector.

The analysis proved that the need to improve the management of fresh water is great, and soft paths offer a way to design alternative management strategies. It also demonstrated that

- Jordan must shift emphasis from only expanding water supply to moderating water demand.
- We must learn how to get along with less water in total, and much less water per capita.
- As a water poor country we must learn how to become even more efficient than they already are.
- Making more efficient use of existing water resources through demand management is an economical and environmentally responsible way to meet growing demand for water.
- If Jordan is committed to aggressive pursuit of demand management, it would help preserve Jordan's existing valuable and limited natural water resources, and provide a readily available and low cost water resource for the coming years.

- Water savings allow new customers and new demands in Jordan to be supplied with water without taking more water from nature. Conservation of non consumptively used water create benefits that exceed the costs of conservation.

Realistically, both supply and demand approaches will be necessary, as has been demonstrated; however, the better approach will be from the demand side.

Finally, implementing this soft path requires a social choice to invest in the people, businesses, and cooperative arrangements that are needed for the maximum cost-effective water savings to become reality (Gliek, 2002). Government agencies or water suppliers must implement comprehensive, integrated economic, educational, and regulatory policies that remove the barriers and achieve the socially desirable level of water savings.

Unless demand management is fully integrated with water-supply planning, it will remain an underused and misunderstood part of our water future (Gliek, 2002).

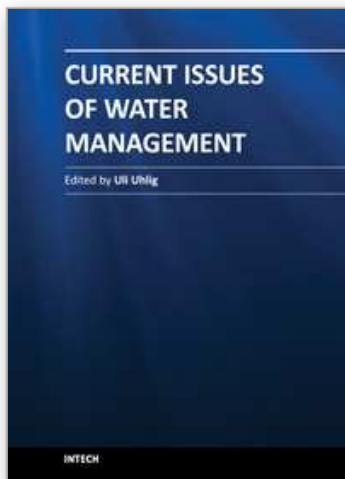
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There is an estimated 1.4 billion km³ of water in the world but only approximately three percent (39 million km³) of it is available as fresh water. Moreover, most of this fresh water is found as ice in the arctic regions, deep groundwater or atmospheric water. Since water is the source of life and essential for all life on the planet, the use of this resource is a highly important issue. "Water management" is the general term used to describe all the activities that manage the optimum use of the world's water resources. However, only a few percent of the fresh water available can be subjected to water management. It is still an enormous amount, but what's unique about water is that unlike other resources, it is irreplaceable. This book provides a general overview of various topics within water management from all over the world. The topics range from politics, current models for water resource management of rivers and reservoirs to issues related to agriculture. Water quality problems, the development of water demand and water pricing are also addressed. The collection of contributions from outstanding scientists and experts provides detailed information about different topics and gives a general overview of the current issues in water management. The book covers a wide range of current issues, reflecting on current problems and demonstrating the complexity of water management.

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