Wastewater Reuse and Management in the Middle East and North Africa

A Case Study of Jordan

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Summary

The MENA region is the driest in the world. Water resources are deteriorating while demand for water is increasing due to the rapid population growth. Irrigated agriculture consumes the largest volume of water resources as a result of continuous demand for food production. A huge potential for satisfying this increasing demand exists in the reuse of municipal wastewater in agriculture. The reuse of treated wastewater in agriculture will provide supplement water quantities for irrigation and will free amounts of freshwater to be reallocated within the municipal water sector, where higher water quality is required. Currently, some wastewater quantities in the MENA countries are already reused. However, the amounts of wastewater reused in comparison to collected and treated wastewater are still low.

The main assumptions of this research are that the extent of conflict over freshwater resources between the different water sectors can foster wastewater reuse in agriculture. In addition, the insufficiency associated with wastewater reuse has less to do with the expensive treatment processes rather than with the lack of appropriate water policies and the enabling institutional setting.

The research's main objective is the analysis of policies, legal and institutional settings and the components of wastewater reuse in agriculture. A systematic approach was used to identify existing organizational structures; roles and responsibilities of different actors involved in wastewater reuse. The in-depth-analysis is presented through the case study of Jordan. For evidence, the research focuses on an extensive review of the literature available and policy documents and laws on wastewater reuse in Jordan.

Chapter one of the book introduces the problem, state and the objectives of the research. The hypotheses, methodology and the different phases of wastewater reuse in agriculture and related fields in policy making are presented. Chapter two, follows the development of wastewater reuse on the international agenda. It explains how wastewater went through a complete cycle from being an important method of sewage disposal that was abandoned to be conceived again as resource, but causing health risks. The latest developments on the international agenda entail the adoption of appropriate and practical policies that can reduce health risks when adequate wastewater treatment is unavailable.

Chapter three assesses the current situation of wastewater reuse in the MENA region and the experiences in different countries. Most of the countries are achieving substantial improvements on the technical level, but progress is much slower on the policy and the institutional level. Large amounts of treated wastewater are disposed instead of being reused. Constraints to wastewater reuse in the MENA region and the successful Tunisian experience are discussed.

Chapter four analyzes the Jordanian experience in wastewater reuse in agriculture. It examines the nature and the level of water scarcity in Jordan and how the competition between the water sectors led to the extensive use of wastewater in agriculture. The chapter analyzes the Jordanian wastewater policy and the factors that directed it on the national policy agenda and examines the other policy alternatives. The chapter also identifies the different actors involved and their way of interaction.

Research findings and conclusions are presented in chapter five. It summarizes the advantages and disadvantages for the different actors affected by water reallocation through wastewater reuse in agriculture within the Jordanian context. The main reasons for Jordan's success are not the efficiency of the treatment plants rather than setting-up an acceptable institutional and legal framework including wastewater policy and standards. The Jordanian wastewater management policy that enables the participation of the private sector in the provision of wastewater services is pioneer in the region. The largest treatment plant in Jordan has been recently upgraded under BOT management contract. However, some hindrances still exist. The most important is the tariff of irrigation with surface and groundwater.

Table of Contents

List of Maps:

List of Boxes:

List of Tables:

List of Figures

List of Abbreviations

AQUASTAT	Global Information System on Water and Agriculture (FAO)
ASAL	Agricultural Sector Adjustment Loan
BOD	Biological Oxygen Demand
BOO	Build, Own and Operate
BOT	Build, Operate and Transfer
CSD	Commission on Sustainable Development
EECCA	Eastern Europe, Caucasus and Central Asia
EMWATER	Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries
EMWIS	Euro-Mediterranean Information System on know-how in the Water sector
EU	European Union
FAO	Food and Agriculture Organization
FAO/RNE	Food and Agriculture Organization/Regional Office for the Near East
GDP	Gross Domestic Product
GTZ	Gesellschaft für Technische Zusammenarbeit
GWP	Global Water Partnership
HABITAT	United Nations Conference on Human Settlements
IDRC	International Development Research Centre
IRCWD	International Reference Centre for Wastes Disposal
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
JD	Jordanian Dinar (1.4 US$)
JICA	Japan International Cooperation Agency
JV	Jordan Valley
JVA	Jordan Valley Authority
KfW	Kreditanstalt für Wiederaufbau
MENA	Middle East and North Africa
MCM	Million Cubic Meter
MDG	Millennium Development Goal
MoA	Ministry of Agriculture (Jordan)
MoE	Ministry of Environment (Jordan)
MoH	Ministry of Health (Jordan)
MoWI	Ministry of Water and Irrigation (Jordan)
NGO	Non-Governmental Organization
O&M	Operation and Maintenance

PASB	Pan American Sanitary Bureau
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children Fund
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
UNESCO	United Nations Educational, Scientific and Cultural Organization
WAJ	Water Authority Jordan
WHO	World Health Organization
WHO/EMRE	World Health Organization Regional Office for the Eastern Mediterranean
WSP	Water and Sanitation programme
WSSD	World Summit for Sustainable Development
WWTP	Wastewater Treatment Plant

1. Introduction

1.1. Problem Statement

The Middle East and North Africa region (MENA) is the driest in the world. In the last few decades, water resources in the region were stable and even in some water stressed countries were deteriorating, used beyond their safe yield and polluted. In spite of this, water demand in the region is constantly increasing due to the rapid population growth at an average of 2.8% and development of living standards and urbanization rate at 3.2%, which is even higher than the rate for developing countries as a whole 2.9% (Faruqui 2000). The situation is likely to get worse. Per capita water availability will decline by half by 2050, which will have serious consequences on the region's already stressed aquifers and natural hydrological systems (World Bank 2007). Those factors resulted in the overexploitation of the precious resources in an unsustainable way.

Irrigated agriculture already accounts for about 88% of water use in MENA region (Saghir et al. 2000). The high rates of population growth and the subsequent growing demand for food production will lead to higher demand for irrigation water. A huge potential for satisfying this increasing demand exists in the reuse of urban wastewater in agriculture by adopting a carefully planned and comprehensive program of management and reuse of wastewater. Planned wastewater reuse in agriculture will provide supplement water quantities for irrigation and will free amounts of the scarce freshwater resources to be reallocated within the municipal water sector, where higher water quality is required for drinking.

Currently, some wastewater quantities in MENA countries are already reused. However, the amounts of wastewater reused in comparison to the amounts of wastewater collected and treated are still extremely low and practiced in a semi-planned or unplanned manner.

Reusing insufficiently treated wastewater causes several problems. On the one hand the inherent health risks from wastewater containing bacteria, viruses, and a wide range of parasitic organisms (Sammis et al. 2001). On the other hand, the negative impacts of wastewater irrigation on certain crops and the soil due to its salinity (World Bank 2001).

To overcome those negative implications and to utilize the full benefits of agricultural wastewater reuse, regulatory practices and the necessary institutional framework on both national and local levels and their adoption need to be reviewed and different stakeholders have to be recognized within a national policy context (Raschid-Sally et al. 2001).

1.2. State of Research

The reuse of wastewater in agriculture is being discussed by several disciplines, including environmental engineering, water engineering, agricultural engineering, hydrology, ecology, biology and health. The majority of the studies, focused on the topic from a single-discipline perspective and their conception, leading to a single outcome variable. For example, most of the engineering studies have focused on the conditions and requirements for attaining an appropriate technology for treating wastewater either on large cities or small community scales (e.g. UNEP 1997, Pescod 1992, Aalbers and Sietzema 1999). Furthermore, judgments were based to a high extent on the positive/negative experiences of other developed countries. Shuval 1992, explains that the regulations of the California State Department of Public Health was not practical nor feasible at all for most developing countries, unlike the recommended guidelines for wastewater reuse of UNDP/ WHO which were more feasible and liberal and promoted wastewater irrigation in developing countries.

Studies on water demand management called for an immediate shift in water allocation of MENA countries from agricultural water sector into the municipal and industrial water sectors to avert water shortage (e.g. World Bank 1994, Mubarak 1998 and Bakir 2000). This argument is still rejected by MENA countries due to their social and political objectives including their food security and self sufficiency strategies.

Several workshops and seminars were conducted on the topic of water reuse in agriculture, where it has been concluded that wastewater reuse has become an essential element of future water resources development and management but with some challenges. Those challenges require restructuring wastewater institutions, wastewater policy reforms, raising public awareness and support successful incentive programs (World Bank 2001, Stockholm International Water Institute 2001, UNESCO International Hydrological Program 2001. Unfortunately, misunderstanding those challenges has led governments to ignore or underestimate their critical linkages with the success of a wastewater reuse program.

There is a lack of literature on institutional and policy aspects of wastewater reuse and management within the MENA region. The review of scientific publications on the subject of wastewater reuse in agriculture shows that only a small number of studies - mainly outside the MENA region - have focused on institutional and policy aspects of wastewater reuse. This becomes very vivid when the number of these studies is compared to the large number of technical studies that exist on the topic.

For the purpose of this research, studies that aimed to or succeeded in embarking upon issues related to institutional and policy aspects of wastewater reuse in agriculture are classified chronologically into two main groups according to the region that they have researched. The first group contains studies that were conducted worldwide, including countries within the MENA region. The second group includes studies that were conducted in Jordan, the case study of this research.

Worldwide Studies

Concerning the first group, the literature review showed that the pioneer study that addressed wastewater reuse policy was conducted by Johnson and published in 1980. He aimed in his paper to trace

> *"the development of federal wastewater reuse policy in the water quality planning process and its slow implementation"* (Johnson 1980).
>
> Johnson also intended to *"outline the evolution of federal wastewater reuse policy in the United States from 1972 to 1979, and to indicate the institutional and attitudinal obstacles to reuse adoption which this policy has addressed, created, or ignored"*(Ibid.).

Johnson's main conclusion expressed that it was

> *"clear that the federal wastewater reuse policy has changed since 1972, and there has been a movement toward greater stringency and required detail in water quality planning regulations"*(Ibid).

In 1981, Bruvold et al. published their study "Public Policy for the Use of Reclaimed Water" where they noticed that in previous years the debate over wastewater reuse policy within the United States

> *"have been reduced to a choice between minimal treatment with subsequent discharge into the aquatic environment or maximum treatment and direct reuse as a potable supply"* (Bruvold et al. 1981).

Their study concluded from the analysis that public policies in the United States should promote staged adoptions and move systematically starting with the less difficult and the less risky uses. They stated that

> *"Uses of reclaimed water for industrial purposes and irrigation of fodder and fiber crops are found to be most beneficial the analysis here employed, and use for aquifer recharge and direct municipal reuse are found to be most beneficial by the analysis here employed"*(Ibid).

The first study that addressed the importance of policies and institutional settings in some of the MENA countries was carried out by Arar in 1989. In his study, Arar stated that the most critical elements in the use of wastewater in irrigation inside the Near East region are public health and treatment costs. Therefore, he believed that a successful wastewater reuse should be initiated with a development of a policy designed according to the requirements of the country. This policy should be backed up by appropriate legislation identifying the measures governing wastewater collection, treatment and scope for the different governmental agencies. At another step, an institutional set-up should be capable of providing a framework for the allocation, use, quality and health and safety aspects in addition to high level of coordination and cooperation between the different agencies involved (Arar 1989).

Due to the fact that Tunisia launched a national wastewater reuse policy at the beginning of 1980s (Bahri et al. 1996). - in addition that only very few countries within the MENA region have adopted wastewater reuse policies - the number of studies that have addressed policy and institutional aspects related to wastewater reuse in Tunisia is much larger than any other MENA country.

The pioneer study in Tunisia was conducted by Bahri et al. in 1996, aimed to assess the national wastewater reuse policy and to identify reasons that hamper the reuse of wastewater in agriculture in Tunisia and to propose prospects for improving the water reuse policy (Ibid).

Another important study that focused on Tunisia's wastewater reuse sector was conducted by Neubert in 2002. The paper aimed to examine advantages and disadvantages of the wastewater reuse strategy in the view of the different actors involved to identify approaches that might reduce the risks and increase the benefits. The author posed some questions that are important for the realization a successful wastewater reuse policy which might prove to be acceptable by all actors involved (Neubert 2002).

Other papers that focused on institutional and policy aspects of wastewater reuse in Tunisia were carried out by Al Atiri et al. 2002, Chenini et al. 2003, Shetty 2004 and Neubert 2009.

Since the year 2003, the number of published studies on policy and institutional aspects of wastewater reuse within the MENA region and worldwide increased. For example, Bazza's paper published in 2003, concluded that one of the major obstacles of wastewater reuse in the Near East was the institutional framework, that entailed fragmentation of responsibilities and lack of cooperation between governmental bodies. Bazza also noticed that the adoption of a national wastewater reuse policy did not receive any attention in several countries in the Near East (Bazza 2002).

Other examples are studies that concentrated on similar regions like Choukr-Allah et al. 2003, the Mediterranean region. Hamoda 2004, south Mediterranean countries. Karra et al. 2005, Lebanon. Al Salem et al. 2006, Eastern Mediterranean Region. Brooks et al. 2007, MENA region.

In the year 2009, two important studies were published. The first one by Kfouri et al. discussed briefly the constraints and experiences of wastewater reuse in the MENA region. The study drew conclusions and policy recommendations based on the experiences of three MENA countries. This study will be discussed in Chapter 3 of this book.

The other important paper that was published in 2009 by Qadir et al. in which they pointed out the major obstacles to wastewater treatment and reuse in the MENA region. The researchers concluded that the policy process related to wastewater management and reuse in the MENA region is complicated due to three major factors. First, most of the wastewater amounts are generated outside the agricultural sector. Second, the different actors and organizations have different interests in policies related to wastewater reuse. Third, most of the consumers that produce wastewater are outside the agricultural sector (Qadir et al. 2009).

The review of scientific publications also showed that only a small number of studies worldwide tackled the issue of wastewater reuse policies and the actors involved. For example, Parkinson et al. 2003, in low income countries. Keraita et al. 2003, in Ghana. Chu et al., in China. Redwood 2004, Bahri 2009 and Qadir et al. 2010, all in developing countries.

Studies in Jordan

The second group of scientific publications that were reviewed included studies that were conducted in Jordan. The majority of publications addressed treated wastewater quality, especially the inadequacy of the effluent quality generated from As-Samra treatment plant. For example, Bannayan 1991, Shatanawi et al. 1996, Awad 1997, Preul 1997, Al-Nakshabandi 1997, van Lier et al. 1999, Jamrah 1999, Al-Kharabsheh 1999, Uleimat 2004, Mrayyan 2005, Ammary 2007, Al-Zboon et al. 2008, and Matouq 2008.

Within this group, few authors addressed non technical issues of wastewater reuse in Jordan. For example, Nazzal et al. 2000 traced in their paper the history and the development and evolution of regulatory laws and standards related to wastewater reuse in Jordan. The study of USAID 2001 suggested and recommended amendments for the standards, regulations and legislation for wastewater reuse in Jordan. Abu Madi et al. 2003 tried to assess willingness of farmers to pay for treated wastewater. McCornick et al. 2004 described the progression of treated wastewater standards in Jordan and the process of their adoption. Duqqah et al. 2005 proposed recommendations for improving wastewater treatment and disposal. Haddadin et al. published in 2006 wastewater management, governance and policy framework, which their findings will be discussed in chapter 4.

1.3. Research Objectives

The overall objective of this research is to analyze on one side the different historical, institutional, policy and socio-economical aspects of wastewater management and reuse in agriculture. On the other side it identifies the different actors involved and their interaction - based on the experiences of Jordan. These experiences will be presented as a case study because Jordan is considered one of the pioneer countries within the MENA region, with a relatively long experience in the field of wastewater treatment and reuse in agriculture. In addition, agricultural practices that exist in Jordan are similar to several other countries within the region.

1.4. Hypotheses and Research Questions

Given the state of research and based on the research objective and the literature reviewed at the beginning of the research phases, the following Hypotheses were formulated:

Hypothesis 1:

The extent of conflict over freshwater resources between the water sectors can foster wastewater reuse in agriculture.

Research Questions:

1.1 Can treated wastewater substitute freshwater/groundwater resources used in agricultural sector, when these high quality resources are needed in the municipal sector?
1.2 How did wastewater reuse in agriculture come to be seen as a problem that requires policy response in Jordan?
1.3 If wastewater substitutes freshwater in agriculture, what are the impacts on the different actors? Are the advantages/disadvantages equal for the different actors?

Hypothesis 2:

Insufficiency associated with wastewater reuse has less to do with the expensive treatment processes rather than with the lack of appropriate water policies and the enabling institutional setting.

Research Questions:
2.1 What are the main factors that contributed to the success of wastewater reuse in Jordan?
2.2 Why wastewater reuse practices were incorporated into the national water policy in Jordan?
2.3 What are the factors that brought wastewater reuse on the national political agenda in Jordan?
2.4 Who are the main actors in the Jordanian institutional setting for wastewater reuse? How do they interact?

1.5. Methodology

Obtaining answers for the research questions will require a concrete understanding the complications of the policymaking process within the MENA countries. Simplifying the public policymaking by dividing the process into separated stages would be an appropriate approach. This notion was firstly introduced by Harold Lasswell, who divided the policy process into the following seven phases:

1) Intelligence, 2) Promotion, 3) Perception, 4) Innovation, 5) Application, 6) Termination and 7) Appraisal.[1]

Also, Sabatier supports the notion of simplifying the policy process:

> *"The process of public policymaking includes the manner in which problems get conceptualized and brought to government for solution; governmental institutions formulate alternatives and select policy solutions; and those solutions get implemented, evaluated, and revised"* (Sabatier 1999).

Howlett and Ramesh observed that the main shortcoming of Lasswell's analysis that concentrated on decision-making process within governments, paid little attention to the external factors that might influence the government's behavior. Besides, they mentioned Laswell's supposition that decision-making process was limited only to few governmental officials.

Sabatier agrees with the criticisms of Howlett and Ramesh. He argues:

> *"There are normally hundreds of actors from interest groups and from governmental agencies and legislatures at different levels of government, researchers and journalists involved in one or more aspects of the process. Each of these actors (either individual or corporate) has potentially different values/interests, perceptions of the situation, and policy preferences"* (Sabatier 1999).

Despite of the above-mentioned shortcomings, Deleon, Howlett and Ramesh acknowledge that Lasswell's model highly contributed in the development of a policy science and that it also simplified the process of studying public policy (DeLeon 1999, Howlett and Ramesh 1995).

During the 1970s and 1980s, Lasswell's model was improved by several scientists such as Brewer, Jones and Anderson. As Howlett and Ramesh point out:

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[1] Harold D. Lasswell (1956): *The Decision Process: Seven Categories of Functional Analysis,* College Park, University of Maryland. Cited in Howlett and Ramesh (1995). Also cited in Parsons (1999).

> *"The operative principle behind the notion of the policy cycle is the logic of applied problem-solving"* (Table 1.1) (Howlett and Ramesh 1995).

Table 1.1: Stages of the Policy Cycle and their Relationship to Applied Problem-Solving

Phases of Applied Problem Solving	Stages in Policy Cycle
1. Problem Recognition	1. Agenda-Setting
2. Proposal of Solution	2. Policy Formulation
3. Choice of Solution	3. Decision-Making
4. Putting Solution into Effect	4.Policy Implementation
5. Monitoring Results	5. Policy Evaluation

Source: Howlett and Ramesh 1995.

Consequently, Howlett and Ramesh argue that the important advantages of the above-mentioned policy cycle model that it simplifies the understanding of the complicated public policymaking process through dividing it into a number of stages and sub-stages. In addition, each of these phases could be studied either alone or in relation to any other or all other stages of the policy cycle. Another important advantage of the model is that it allows the investigation of the role of the different actors and institutions dealing with a policy whether they were governmental or other (Ibid).

Similar to the "Problem Recognition" in the applied problem solving process, "Agenda-Setting" is considered to be the most important stage in the policy cycle since, as Cobb and Edler argue, it plays the most critical role in determining what issues and alternatives are to be considered later on by the polity.[2]

Cobb and Edler differentiated between two types of agendas: One is the systemic or public agenda, where the society discusses public problems, but is not for taking action. The other type of agenda is the institutional or the formal agenda where problems from the systemic agenda are taken by the government seriously. Therefore the institutional agenda is considered

[2] Roger W. Cobb and Charles D. Edler (1972): Participation in the American Politics: The Dynamics of Agenda-Building, Boston. Cited in: Howlett, M. and Ramesh, M. (1995).

as an agenda for action, which means that phases of the policy cycle have started.

There are various perspectives on how a problem moves from the systemic (public) agenda to the institutional (formal) agenda. These perspectives concentrate on different factors as social, political, cultural and economic types of societies, traditions, beliefs. Also, there are different arguments on how policies are initiated. Table 1.2 demonstrates the relationship between these different factors.

Table 1.2: Models of Agenda-Setting by Policy Type

Initiator of Debate	**Nature of Public Support**	
	High	**Low**
Societal Actors	Outside Initiation	Inside Initiation
State	Consolidation	Mobilization

Source: Howlett and Ramesh 1995.

Answering the research questions necessarily requires an understanding of the factors that influenced the political setting in which the problem was transformed from the systemic agenda to the institutional agenda. Besides, it is essential to define the actors that initiated the policy process, their incentives and interests that made them pushing for or against adopting a national policy.

Sabatier pointed out:

> *"In short, understanding the policy process requires a knowledge of the goals and perceptions of hundreds of actors throughout the country involving possibly very technical scientific and legal issues over periods of a decade or more when most of those actors are actively seeking to propagate their specific "spin" on events"* (Sabatier 1999).

In addition, it is important to classify the actors into "inside initiators" representing the government (i.e. Ministries, Authorities) or "outside initiators" if they were outside the government (i.e. farmers, scientists, or donors). Grouping actors into a few institutional categories, i.e. legislators, administrative agencies and interest groups will simplify the understanding of policy process (Sabatier 1999 and Scharpf 1997).

Else, it is important to understand the sequence of events and the conditions which occurred when a government decided the adoption of the wastewater reuse policy. That will require analyzing the historical development of the emergence of the problem. Sabatier noted:

> "[Policy] *process usually involves time spans of a decade or more, as that is the minimum duration of most policy cycles, from emergence of a problem through sufficient experience with the implementation,…, a number of recent studies suggest that time periods of twenty to forty years may be required to obtain a reasonable understanding of the impact of a variety of socioeconomic conditions and the accumulation of scientific knowledge about a problem"* (Sabatier 1999).

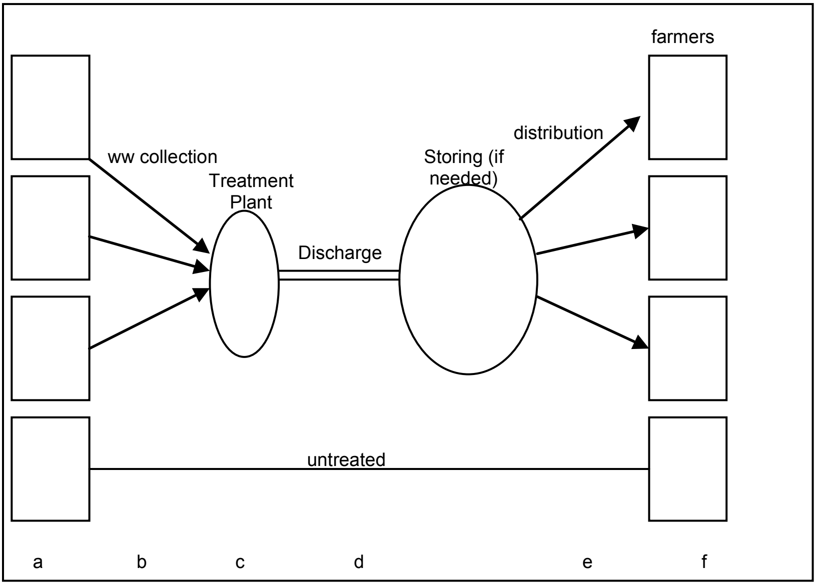
An efficient approach to wastewater reuse in agriculture is not merely relying on the availability of sufficient wastewater treatment plants. Instead, it is heavily dependent on appropriate policies, legislations, institutional frameworks and regulations.

In its latest publication of "Guidelines for the Safe Use of Wastewater, Excreta and Greywater" the WHO distinguished between four types of policy instruments for the implementation of wastewater policies, which are: 1) laws and regulations, 2) economic measures, 3) information and education programs and 4) the assignments of rights and responsibilities for providing services (WHO 2006).

Wastewater reuse in agriculture implies a high institutional coordination and the development of an integrated approach with a number of different policies. These different policies have huge impact in encouraging or discouraging wastewater reuse in agriculture.

Examples are the sanitation policy, agricultural policy, environmental policy, pricing policy and standards and health protection policies. It also requires decision making over investment in wastewater collection, selecting the most appropriate treatment technology for operation of treatment plants, constructing storage system if irrigation is practiced seasonally, distribution methods and policies on crop restriction. Figure 1.1 shows the main fields of policy making in relation to wastewater reuse in agriculture.

Figure 1.1: Main Phases of Wastewater Reuse in Agriculture and Related Fields in Policy Making



Source: Author, based on World Bank and The Swiss Development Cooperation Agency 2001.

Explanations for Figure 1.1:

a. Policies and decision-making on water supply for the municipal sector and its share of the total national water budget in comparison to the agricultural and industrial water sectors.
b. Policies and decision-making on methods of wastewater collection, investments in sewerage networks, the number of population and households (urban and rural) connected to sewerage services; pricing policies for wastewater collection and treatment services.
c. Policies and decision-making on the selection of wastewater treatment technologies; the investment in construction, upgrading and maintenance of wastewater treatment plants.
d. Policies, regulations and standards for treated wastewater for the protection of public health and the environment; policies on the

implementation of these standards and the enforcement of regulations.

e. Pricing policies for treated wastewater for irrigation; pricing policies for freshwater for irrigation.
f. Policies on imposing crop restrictions on crops irrigated with treated wastewater.

The research's focal point will be the analysis of policies, legislations, regulations and institutional settings and the components of wastewater reuse in agriculture. A systematic approach will be used to identify existing organizational structures, authorities, roles and responsibilities of different actors involved in wastewater reuse. The in-depth-analysis will be presented through the case study of Jordan.

Analyzing the case study will be carried out through an extensive review of the literature available on Jordan. Completing the analysis will be done by semi-structured interviews with the different actors involved in wastewater management and reuse in Jordan.

2. Wastewater Reuse in Agriculture on the International Agenda

The universal provision of adequate sanitation services to urban and rural population was and remains to be one of the most critical challenges worldwide. This challenge led the international community to exert efforts, cooperate in financing, and sharing experiences for providing solutions for sanitation problems. The optimal solution of this problem relies in collecting and treating wastewater. This protects existing sources of valuable freshwater, the environment and public health. Also, treated wastewater can be a valuable additional source for irrigation.

2.1. The Background of Wastewater Reuse

Wastewater reuse in agriculture was practiced in different regions several centuries ago. Despite their level of success or failure, there are indications that already 5,000 years ago, wastewater was used in certain communities as a source of irrigation (Angelakis and Spyridakis 1995, cited in Asano 1998). In China, use of human excreta for fertilizing agricultural crops has been practiced since ancient time (Shuval 1992).

In recent history, the first sewage reuse in agriculture has been practiced in Europe through “Sewage Farms”. Literature confirms that sewage farms existed in Bunzlau, Germany in 1531, in Edinburgh, Scotland in 1650, 1868 in Paris, France, 1876 in Berlin, Germany and in different parts of USA since 1871 (Shuval et al. 1986).

More than one hundred years ago, the provision of flush toilets and sewerage collection systems to urban and industrial cities in Europe resulted in pollution of water resources and other environmental problems. Collected wastewater and other collected industrial effluents were discharged without treatment into rivers and water bodies that were used as sources of potable water supply in the same time. During the 1840s and the 1850s, this practice resulted in disastrous spread of waterborne diseases like cholera and typhoid (Asano 1998).

A link between the pollution of water supply resources and the epidemic of these diseases has been established and consequently solutions for the pollution problem have been explored. Interest in “Sewage Farms” or land treatment has been increased after the report of the First Royal Commission on Sewage Disposal in England has been issued. The report stated:

> *"The right way to dispose of town sewage is to apply it continuously to the land and it is by such application that the pollution of rivers can be avoided".*

Thus it can be concluded that initial motivations of wastewater reuse in agriculture were pollution control and prevention and making use of nutrients for fertilizing rather than water conservation (Shuval 1992).

Sewage farming continued to flourish worldwide from Europe to North America. By 1875, there were about fifty sewage farms in England and several other farms in Europe. At the end of the nineteenth century, more than ten sewage farms existed in the United States (National Research Council 1996). Later on, the practice of sewage farms quickly spread to Australia, parts of Latin America like Mexico and other countries like India and Egypt. In 1916, wastewater from Cairo was transferred to a sewage farm located at the northern part of the city (Harrington 1996).

Afterwards, some inconveniences originated from sewage farms in Europe and the United States. Population growth and urban development caused expansion over sewage farm areas resulting in odor problems and health risks. In regions with large precipitation amounts, as in some areas of Northern Europe, untreated wastewater was not needed for irrigation and therefore was discharged into rivers. More importantly, public health concerns about the transmission of diseases by consuming vegetables irrigated with untreated wastewater and the innovation of biological processes for wastewater treatment that do not need large areas of land were the main reasons behind abandoning sewage farms in Europe and the United States. Therefore, by 1912 wastewater reuse was almost completely abandoned in urban areas of industrialized countries (Shuval et al. 1986).

2.2. The Evolution of Sanitation

Water pollution problems began when significantly growing population numbers transformed settlements into cities. Those cities required large quantities of water and produced great amounts of wastewater. The construction of water supply and sewers in Paris, France in 1856, resulted in a grave pollution of the Seine river (Védry et al. 2001). Another example is Copenhagen, Denmark where a proposal for the construction of a sewage system for the city was initiated in 1853. The proposal was rejected and in the same year cholera erupted in the city. Sewers were first constructed during the 1890s. Although the network contributed in reducing the direct health risk and hygienic problems, lack of sewage treatment polluted water resources and the environment of Copenhagen (Varis and Somlyódy 1997).

As WHO names it "The Sanitary Revolution"; the "Great Sanitary Awaking" started in the industrialized countries during the 19^{th} century. In the year 1852, in London, United Kingdom the Metropolitan Water Act demanded that water for potable purposes should be filtered before being supplied. In Hamburg, Germany, a relationship between polluted water and the quick spread of cholera in the city in 1892 was confirmed. The Pan American Sanitary Bureau (PASB), founded in 1902 in the Americas, recommended the enhancement of sanitation and sanitary sewage disposal services for improving health standards. In 1936 the Health Organization of the League of Nations published reports on the significance of sewage collection and treatment in improving health conditions and treatment processes. In 1948, the first World Health Assembly resulted in the establishment of the Committee on Environmental Sanitation (WHO 2003).

The development of centralized sanitary infrastructure within the industrialized cities during the 19^{th} century, mainly based on the isolation of pathogenic waste from direct human contact, has effectively lessened the risk of epidemic diseases and increased the level of public health. This was not the case within developing countries where sanitation reforms have not been successful (Rose 1999).

Although sanitation systems already existed in some cities of developing countries since colonial times, lack of wastewater treatment and rapid population growth resulted in severe environmental and health problems. For example, simple sanitation infrastructure existed in 1930 in the town of Salt in Jordan where wastewater had been collected and some treatment had been practiced by primitive physical processes. Wastewater had been collected in septic tanks and cesspits and was later on discharged to gardens causing environmental problems and polluting groundwater (MoWI 1998).

The city of Alexandria, Egypt can be considered as a good example where rapid population growth resulted in huge increase in the amounts of wastewater. The sewage system that once was initially designed to serve a city with one million inhabitants collects now wastewater generated of more than four million people (Varis and Somlyódy 1997).

Continuous progress in sanitation reforms and the reduction of water pollution had been achieved in Europe and North America. Governmental strict regulations for controlling industrial effluents in addition to the adequate treatment of collected wastewater were the most important factors that contributed to that success. In developing countries, governments failed to introduce sufficient improvements in sanitation services and wastewater collection and treatment. The lack of sewers and drains is considered the main source of water pollution (UN 2003).

2.2.1. The Sanitation Problem on the International Agenda

Since its establishment in 1948, WHO was considered the pioneer UN institution that worked for the improvement of sanitation. In the 1950s WHO concentrated its activities on rural sanitation in developing countries. Between 1954 and 1959, WHO cooperated with UNICEF in implementing projects on rural sanitation in 27 developing countries by introducing simple, but effective techniques for sanitary disposal of excreta. These techniques received acceptance within certain communities, but that was not enough to convince governments to introduce them in other regions. That was mainly because sanitation projects necessitated long term governmental investments. During the 1960s, WHO participated in the organization and management of joint pre-investment studies with UNDP (named “UN Special Fund” at that time) on wastewater disposal projects, which almost all of them were financed later (WHO 2003).

Worldwide, activities related to wastewater disposal and sanitation accelerated during the 1970s. The World Bank’s feeble involvement during the 1960s in water supply and sanitation projects was developed during the 1970s and reached about 9 % of the Bank’s total lending commitments in 1979 (WHO 2003). Additionally, the World Bank initiated a research project on “Water Supply and Waste Disposal in Developing Countries” in 1976. Different international funding organizations (i.e. World Bank, WHO and UNDP) began to cooperate and coordinate the initiation and implementation of several sanitation projects in developing countries. On another level, funding organizations realized the importance of having firm cooperation with national governments where sanitation projects were planned.

International conferences that aimed to address the issue of water supply and sanitation services within the developing countries were conducted. For example, The UN Conference on the Human Environment took place in Stockholm, Sweden in 1972, called The “United Nations Conference on Human Settlements (HABITAT II)”. The UN Conference on Water that was held in Mar del Plata, Argentina in 1977 can be considered to be the first real effort that brought water supply and sanitation to the international development agenda. It resulted in the adoption of the Mar del Plata action plan that recommended to declare the period between 1980 and 1990 as the “International Drinking Water Supply and Sanitation Decade” (Decade).

The 1970s witnessed some advances in the provision of water supply and sanitation services within some of the developing countries. In Amman, Jordan, for example, modern technology for wastewater collection and treatment was already introduced in the late sixties (MoWI 1998). Also, Isfahan, Iran, was the first city in the MENA region that obtained a full wastewater collection system (Bazza 2003).

Nevertheless, it was apparent that these improvements were not sufficient enough to provide all people in developing countries, especially the poor, with these basic services. The water supply and sanitation infrastructure gap between the industrialized nations and developing countries continued to widen. Bridging that gap necessitated raising up the issue of water supply and sanitation on the international development agenda.

2.2.2. The International Drinking Water Supply and Sanitation Decade

The Decade was officially launched at the UN General Assembly in November 1980. All countries adopted the proclaimed target of the Decade of bringing about a substantial improvement in the standards and levels of services in drinking water supply and sanitation by the year 1990. In addition, the countries agreed to develop the necessary policies and take all appropriate steps for their implementation (UN Resolution 35/18 Approved by General Assembly on 10 November 1980).

Although about $ 100 billion were invested during the Decade, the number of urban people in the developing countries who accessed water services increased about 80%, but the number of urban people with adequate sanitation increased only about 50%. Rapid population growth within urban areas was the main reason behind the offset of the improvements (World Resources Institute, UNEP and the World Bank 1996).

Different opinions occurred over the progress achieved during the Decade. Some considered it as success, others considered the Decade as a disappointment due to the modest progress achieved.

Throughout the Decade, it became apparent that costs of meeting the target were much higher than it was expected. Consequently, an international debate developed regarding finance and cost recovery of the water supply and sanitation services.

The first view was represented by water supply and sanitation specialists from WHO and UNICEF. They argued that health and social benefits from water supply and sanitation services validate that public and donor funds should be used to provide these basic services to every person. The other view, adopted by economists from the World Bank, assumed that providing water supply and sanitation services to those who cannot afford or are unwilling to pay for the costs of these services will lead to the failure of the project (International Water and Sanitation Centre 2003).

Results of the "International Drinking Water Supply and Sanitation Decade" enormously varied from one country to another. In the 22 developing countries of the Eastern Mediterranean Region,[3] sanitation service coverage within urban areas raised from 57% in 1980 to reach 82% in 1988. Coverage within rural areas has increased from 7% to reach 20% for the same period (Gur 1995) (Table 2.1).

In Jordan, through the years of the Decade, several governmental plans related to wastewater management and sanitation improvement have been implemented. Nearly 75% of the urban population received sanitation and wastewater treatment services. In rural parts of the country about 52% of the population enjoyed similar services. Raise in sanitation and wastewater treatment coverage had an immediate result on the improvement of public health and control over pollution of water resources (MoWI 1998).

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[3] The Eastern Mediterranean Region, according a study prepared by WHO Regional Centre for the Eastern Mediterranean, consists of 22 countries that include: Afghanistan, Bahrain, Cyprus, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen.

Table 2.1: Percentages of People without Sanitation Services within Countries of the Eastern Mediterranean Region for the Period of 1980 - 1988

Country	**Percentage of Population without Sanitation**		**Country**	**Percentage of Population without Sanitation**	
	1980	**1988**		**1980**	**1988**
Egypt	74	44.8	Saudi Arabia	23	13.8
Iran	32	29	U.A.E	15	5
Iraq	32	27.7	Afghanistan	99.5	99.3
Syria	55	36	Pakistan	85	82.7
Lebanon	NA	25	Somalia	89	89.1
Bahrain	14	0	Sudan	NA	88
Cyprus	0	0	Yemen	NA	91.8
Jordan	2.4	1	Djibouti	57	41
Kuwait	0	1.6	Morocco	42	44.4
Libya	39	2.2	Oman	80	49.3
Qatar	16	2.6	Tunisia	NA	55.3

Source: Gur 1995, based on information by WHO.

Several lessons were concluded from the disappointment of the "International Drinking Water Supply and Sanitation Decade". It became obvious that a new strategy with emphasis on sanitation is needed. The main component of this strategy is that sanitation projects should be integrated through programs such as rural development, primary health care and agricultural development. Combining such programs would make the costs of implementation cheaper and their impact would be greater. Otherwise, sanitation services would be neglected (Cairncross 1992). Also, at the end of the decade, some new opinions proposed the involvement of the private sector in the provision of water supply and sanitation services as an option for reducing financial inefficiencies.

According to Cairncross, who concluded in a World Bank publication over the lessons learned form the Decade, the coming important challenges of water supply and sanitation in the 1990s will not be related to technology. Challenges rather would be linked to finance and organize water supply and sanitation programs to motivate people for installing and maintaining the facilities and sustainability of the sector (Ibid.).

2.2.3. The New Sanitation Concept

International efforts that aimed to bring the sanitation problem on the international agenda did not incorporate wastewater reuse as part of sanitation projects. Only at a later stage, international conferences such as the Dublin Conference of 1992 and the UN Millennium Project, incorporated wastewater reuse within the sustainable concept of sanitation. Task Force on Water and Sanitation (2005) developed the new definition of sanitation as in Box 2.1. Including wastewater reuse projects would highly contribute in covering the costs of the new sanitation concept.

Box 2.1: The Definition of Sanitation

What is sanitation?

Most professionals agree that sanitation as a whole is a "big idea" that covers, among other things:

- Water is an integral part of sustainable development. Policies for all aspects of water should be clearly linked to policies for poverty reduction and economic growth. Governments should review the priority given to water and sanitation and to productive water infrastructure in national and international programs to tackle poverty.
- Safe collection, storage, treatment, and disposal, reuse, or recycling of human excreta (feces and urine).
- Drainage and disposal, re-use, or recycling of household wastewater (often referred to as sullage or grey water).
- Management, reuse, and recycling of solid wastes (trash or rubbish).
- Drainage of stormwater.
- Treatment and disposal, reuse, or recycling of sewage effluents.
- Collection and management of industrial waste products.
- Management of hazardous wastes (including hospital wastes and chemical, radioactive, and other dangerous substances).

Target 10 refers primarily to the first and second items on this list. It focuses on the collection, treatment, and disposal of human excreta and the drainage and disposal of household wastewater (sullage).

Source: Lenton et al. UN Millennium Project, Task Force on Water and Sanitation 2005.

2.3. Renewing Interest in Wastewater Reuse in Agriculture

After World War II, wastewater reuse became interesting again for several countries, especially those that are located within arid and semi-arid regions. The invention of new wastewater treatment technologies for public health and environmental protection, population growth and the need for crop production were considered as important reasons for renewing the interest for wastewater reuse in agriculture.

Moreover, Shuval assumes that three additional factors resulted in reviving the interest in wastewater recycling.[4] The first and most important factor was the increasing need for water in arid areas of both industrialized and developing countries. Demand for water highly increased due to the boost of agricultural projects that aimed supplying food for the growing population.

Secondly, the development of standards and guidelines for wastewater reuse for public health protection, were considered significant for reintroducing wastewater reuse in agriculture in a scientifically and socially acceptable manner.

Thirdly, the increasing public awareness to reduce pollution of surface water resources. The issue of pollution of rivers and lakes was adopted by environmental movements during the 1960s (WHO 1989).

In the 1960s wastewater irrigation proved to be efficient in substituting the scarce freshwater in water-scarce countries. In 1962, groundwater resources to irrigate citrus fruit orchards near Tunis, Tunisia became unsuitable for irrigation due to the over-pumping and saline water intrusion. Farmers had no choice other than irrigating their orchards with treated wastewater of the Cherguia treatment plant. That enabled the citrus yields to stand the dry spring and summer seasons (Bahri and Brissaud 1996).

One of several successful examples of wastewater reuse projects in the United States is within the city of Tallahasse, Florida. This reuse project was established in 1966 to prevent wastewater discharge into sensitive

[4] For more details on renewing interest in wastewater reuse after World War II see Shuval et al. (1986) and Shuval (1992).

water bodies. Instead, the treated effluent was utilized to irrigate a city-owned farmland (National Reseach Council 1996).

The grounds of the beginnings of wastewater reuse in irrigation in Jordan were similar to the ones in Tunisia. Wastewater reuse in agriculture began in Jordan in 1968, after the first activated sludge treatment plant in Amman was constructed.

Using springs feeding the Zarqa river for supplying the increasing municipal demand of water, resulted in a huge reduction of the flow. Partially, farmers had to depend on treated wastewater from treatment plants near Amman to replace the loss (EMENA Technical Infrastructure 1990).

The development in water and wastewater engineering and technologies, combined with the continuous water shortages in arid regions around the world, intensified research efforts that brought up new examples and concepts for health risk treatment and water reuse engineering (Asano 1996).

Through the 1970s, more attention was paid to the importance of wastewater reuse in agriculture. Research was directed for investigating health impacts of wastewater reuse and the invention of new and reliable wastewater treatment technologies. So, research findings brought new methods and alternatives for wastewater treatment and reuse. This resulted in the implementation of new wastewater reuse projects in different countries around the world.

Direct and indirect irrigation with untreated wastewater continued to be practiced in several countries, which in many cases led to spreading of several diseases. That was the case in Jerusalem where irrigation with raw wastewater resulted in cholera outbreak in 1970 (Fattal et al. 1986, cited in: Shuval 1990).

2.4. The Evolvement of Health Standards for Treated Wastewater

Wastewater treatment standards and wastewater reuse regulations were first introduced by the State of California in 1918. The standards were modified and became more stringent in 1948. One of the basic components of the

Californian Standards was the restriction to irrigate all crops that are eaten cooked with wastewater.

In addition, the California standards required high treatment levels of wastewater for irrigation purposes. These were almost as strict as those required for drinking water. Although, these standards were strict and unrealistic, they have been adopted by some developing countries. Applying the California standards to treated wastewater, formed a common belief within poor developing countries that the reuse of adequately treated wastewater in irrigation is extremely expensive and requires sophisticated treatment technology. This belief often resulted either in failure to plan effective wastewater reuse schemes or in reuse of untreated wastewater in agriculture. In that case, governmental departments within these countries had no choice other than turning a blind eye to the fact that raw wastewater was used for irrigation.

The stringent California Standards for treated wastewater were generally based on “zero risk” approach. Therefore, such quality of treated wastewater was attainable only in expensive treatment plants within rich countries, and did not exist in most of the poor less developed countries.

Shuval argues that many industrial countries did not oppose the fact that these standards were overly restrictive because expected economic and social benefits of wastewater reuse were only marginal in comparison with the benefits in developing countries (Shuval 1990).

Havelaar et al. argued that although California Standards were strict and not adopted on a global level, yet the standards played a major role in the acceptance and approval of treated wastewater use in agriculture by planners, engineers, health authorities and the public within the industrialized countries (Havelaar et al. 2001).

In 1971, the WHO organized the first meeting of experts to assess the impact of wastewater reuse practices on health and made recommendations on necessary safeguards. The fact that the California Standards were the only guidelines that existed at that time necessitated a re-evaluation of their credibility. It was well known that untreated wastewater was used for agricultural irrigation, either directly or indirectly, in several developing countries. It was also known that these practices imposed health risks and were unacceptable. However, there was lack of solid and reliable scientific evidence on health effects on the reuse of wastewater in agriculture (WHO 1989).

Hence, experts in that Meeting were cautious and very restrictive in their recommendations, but several important results were achieved. The first was that the Standards of the California State Department of Public Health were very strict and applying these (drinking water-type) standards for the reuse of wastewater for irrigation is unrealistic and unjustifiable. Especially since it is known, that only a small number of rivers in the world that are used for irrigation contain such a high water quality.

It was also clear for the experts of the Meeting that it was almost impossible for most of the developing countries to attain such standards of treated wastewater. In addition, the experts recommended treatment technologies such as activated sludge, trickling filtration and waste stabilization ponds to be followed by chlorination or filtration and chlorination. Still, obtaining such treatment technologies was beyond the reach of most of the developing countries. As a result, in some of these countries, and despite the possible risks, governments had no choice other than accepting the indirect reuse of untreated wastewater for irrigation (Havelaar et al. 2001).

The belief by many developing countries that wastewater treatment is extremely costly and requires advanced technology brought about two important hindrances: Firstly, halt planning wastewater reuse schemes in areas where sewerage has been installed and wastewater has been collected. Secondly, practicing unplanned wastewater irrigation after wastewater discharge in water channels (WHO 1989).

Two years later, the report of the first WHO meeting of experts was published and its recommendations were adopted by several countries as guidelines. The report pointed out that there is a potential risk of the reuse of untreated or inadequately treated wastewater for irrigation of vegetables eaten raw. But a more important result of the meeting was the official WHO declaration that adequately treated wastewater reuse in agriculture is accepted and imposes no health risks.

Scientific research on wastewater reuse continued to intensify during the second part of the 1970s and the beginning of the 1980s. Asano and Levine believed that the Pomona Virus Study and the Monetary Wastewater Reclamation Study for Agriculture, which were conducted in California during the 1970s and 1980s have resulted in the development of reliable wastewater treatment systems. They produced effluents suitable for agricultural irrigation without imposing risks to public health.[5]

Meanwhile, waste stabilization ponds had demonstrated to be a reliable, a low-cost and sustainable method for the treatment of wastewater. Particularly in many developing countries, where appropriate climatic conditions are present.

Wastewater reuse projects expanded within both developing and industrialized countries. Jewell and Seabrook pointed out that the number of wastewater reuse projects in the United States had significantly increased from only about 150 wastewater treatment plants in 1940 to reach by 1980 about 3,400 reuse projects. Mainly wastewater was used for agricultural irrigation and sometimes for industrial and recreational purposes. The rising interest in wastewater reuse in England has also resulted in a significant increase in the number of sewage farms in the country. In the 1950s only a small number of land application sites existed in England, that number increased to be about 60 sites by the year 1980 (Jewell and Seabrook 1979, cited in Shuval 1986).

Nevertheless, projects of wastewater reuse in agriculture received more attention in arid and semi-arid areas than in other regions. For example in the Federal Republic of Germany, during the end of 1970s, only about 3 % of the total amount of collected wastewater has been used for irrigation. Muller believes that this is due to the prevailing weather in the region (Muller 1977, cited in Shuval 1986).

During the 1980s, wastewater reuse in agriculture has received increasing attention by developing countries, especially the ones that fall within arid and semi-arid regions. This necessitated the development of guidance on health risks from wastewater reuse in order to improve and expand wastewater reuse practices. Consequently, research projects and cooperation among different support agencies such as WHO, UNEP, UNDP, World Bank, FAO and many others were intensified.

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[5] For details on both studies see:
a) Engineering-Science (1987): Monetary Wastewater Reclamation Study for Agriculture. Prepared for Monetary Regional Water Pollution Control Agency, Pacific Grove, California.
b) Sanitation Districts of Los Angeles County (1977): Pomona Virus Study – Final Report. State Water Resources control Board, Sacramento, CA.

A good example for such cooperation was a three-year Global Research and Development Project on Integrated Resource Recovery that was initiated in 1981 by UNDP and the World Bank. The project's aim was to achieve economic and social benefits through recycling and reusing wastewater and solid wastes. Corresponding to that project, WHO and the IRCWD initiated in 1982 a joint project that aimed to assess the health implications of excreta and sludge use in agriculture and aquaculture.

The short term purpose of that project was to introduce modern, safe and acceptable guidelines for wastewater use in agriculture and aquaculture. However, the ultimate objective of the project was that wastewater use should become an integral part of water resource and wastewater management and planning (Strauss and Blumenthal 1990).

Despite the initiation of projects and research activities during the beginning of the 1980s, that were devoted to the improvement, promotion and expansion of wastewater reuse, Alaerts et al. (1993) point out that the UN "International Drinking Water Supply and Sanitation Decade" (1981 - 1990) failed to draw enough attention to the importance of the issues of sanitation and wastewater reuse in the developing countries (cited in Rose 1999).

2.4.4. WHO Guidelines for the Use of Wastewater in Agriculture (1989)

Throughout the 1980s, the impact of wastewater reuse in agriculture on public health was the main concern of both local governments and international agencies. Yet it was also known that the existing standards for wastewater reuse in agriculture, (the California Standards and also the WHO standards published in 1973 and served as guidelines till that time) were very restrictive and should be revised.

In 1985, a multi-organization scientific group began to review the existing WHO guidelines. The group was formed from experts from different organizations such as WHO, UNDP, UNEP, World Bank and IRCWD. The experts met in Engelberg, Switzerland in July 1985 and proposed accordingly a tentative wastewater quality guideline. It became to be known as the "Engelberg Standards" or the "Engelberg Report".

In November 1987, another WHO meeting of experts took place. In that meeting, and after a careful evaluation, the experts adopted the Engelberg

Standards as basis for the new WHO guidelines for the reuse of wastewater. The new tentative guidelines were less conservative and more encouraging for the reuse of wastewater.

These guidelines were finalized and published in 1989 under the title "Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture" (Table 2.2).

Khouri et al. argue that these guidelines are important because that they can be achieved with simple and low-cost treatment technologies that are appropriate for developing countries (i.e. a series of wastewater stabilization ponds). Therefore, chances of enforcing such standards are relatively high. Consequent adoption of the standards contributed in regulating wastewater treatment and reuse and in increase the wastewater use in irrigation (Khouri et al. 1994).

The main features of the WHO (1989) guidelines for wastewater reuse in agriculture are summarized in (Havelaar et al. 2001):

- Wastewater is considered as a resource to be used, but used safely.
- The aim of the guidelines is to protect against excess infection in exposed populations (consumers, farm workers, populations living near irrigated fields).
- Faecal coliforms and intestinal nematode eggs are used as pathogen indicators.
- Measures comprising good reuse management practice are proposed alongside wastewater quality and treatment goals; restrictions on crops to be irrigated with wastewater; selection of irrigation methods providing increased health protection, and observation of good personal hygiene (including the use of protective clothing).
- The feasibility of achieving the guidelines is considered alongside desirable standards of health protection.

In spite of the fact that the WHO 1989 guidelines for wastewater reuse in agriculture are considered one of the main triggers that contributed in the promotion and regulation of wastewater irrigation, these guidelines received several criticisms: Mainly, they were more liberal than the California Standards and therefore not sufficient for health protection, especially within the industrialized countries. Moreover, they were not based on the "zero risk" concept, like the California Standards, where treated wastewater quality is close to drinking water standards. That is considered economically unsustainable and unjustified (Ibid).

Table 2.2: WHO Guidelines for the Use of Wastewater in Agriculture (1989)
Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture [a]

Category	**Reuse Conditions**	**Exposed group**	**Intestinal nematodes[b] (arithmetic mean no. of eggs per liter)**	**Fecal coliforms (geometric mean no. per 100 mfc)**	**Wastewater treatment expected to achieve the required microbiological quality**
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks [d]	Workers, consumers, public	≤ 1	≤ 1000[d]	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, pasture and trees [e]	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and fecal coliform removal

Table 2.2 (continued)

Category	**Reuse Conditions**	**Exposed group**	**Intestinal nematodes[b] (arithmetic mean no. of eggs per liter)**	**Fecal coliforms (geometric mean no. per 100 mfc)**	**Wastewater treatment expected to achieve the required microbiological quality**
C	Localized irrigation of crops in category B if exposure of workers and the public does not	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation

[a]. In specific cases, local epidemiological, sociocultural, and environmental factors should be taken into account, and the guidelines modified accordingly.
[b]. Ascaris and Trichuris species and hookworms.
[c] During the irrigation period.
[d]. A more stringent guideline (s 200 fecal coliforms/100 ml) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact.
[e]. In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used. Source: WHO 1989.

2.4.5. Other Guidelines for the Use of Wastewater in Agriculture

As a result of the criticisms of the WHO guidelines of 1989, the USEPA / USAID issued new guidelines for the agricultural reuse of wastewater in 1992 (Table 2.3). USEPA / USAID recommended the use of much stricter guidelines for wastewater irrigation in the USA (Blumenthal et al. 2000).

Standards, based on the USEPA / USAID 1992 guidelines, were adopted by many industrialized and few developing countries, but were strict and more expensive to achieve. Most of the developing countries adopted the WHO 1989 guidelines simply because they were more realistic and could be obtained by less complicated treatment technologies.

In the 1990s, other international organizations realized the importance of designing guides for wastewater reuse in agriculture that were especially suitable for developing countries. For example the World Bank published in 1994 "The Reuse of Wastewater in Agriculture: A Guide for Planners" and the FAO published in 1997 "Quality Control of Wastewater for Irrigated crop production".

Table 2.3: USEPA/USAID Guidelines for Agricultural Reuse of Wastewater

Types of Reuse	Treatment	Reclaimed Water Quality	Reclaimed Water Monitoring
Agricultural Reuse - *Food Crops Not Commercially Processed* Surface or spray irrigation of any food crop, including crops eaten raw	• Secondary[2] • Filtration • Disinfection	• = 10 mg/l BOD • No detectable fecal coli/100ml3 • 1 mg/l Cl2 residual (min.)	• BOD - weekly • Coliform - daily • Cl2 residual - continuous

Table 2.3 (continued)

Types of Reuse	Treatment	Reclaimed Water Quality	Reclaimed Water Monitoring
Agricultural Reuse - *Food Crops Not Commercially Processed* Surface irrigation of Orchards and Vineyards	• Secondary[2] • Disinfection	• = 30 mg/l BOD • = 30 mg/l SS • = 200 fecal coli/100ml[4,5] • 1 mg/l Cl_2 residual (min.)	• BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous
Agricultural Reuse - *Non Food Crops* Pasture for milking animals; fodder, fiber and seed crops	• Secondary[2] • Disinfection	• = 30 mg/l BOD[7] • = 30 mg/l SS • = 200 fecal coli/100ml[4,5] • 1 mg/l Cl2 residual (min.)	• BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous
Urban Reuse All types of landscape irrigation (e.g. golf courses, parks, cemeteries).	• Secondary[2] • Filtration • Disinfection	• =10 mg/l BOD • No detectable fecal coli/100ml3 • 1 mg/l Cl2 residual (min.)	• BOD - weekly • Coliform - daily • Cl_2 residual - continuous

Footnotes:
[1]These guidelines are based on water reclamation and reuse practices in the U.S., and they are especially directed at states that have not developed their own regulations or guidelines. While the guidelines should be useful in many areas outside the U.S., local conditions may limit the applicability of the guidelines in some countries.
[2]Secondary treatment processes include activated sludge processes, trickling filters, rotating
biological contractors, and many stabilization pond systems. Secondary treatment should produce effluent in which both the BOD and SS do not exceed 30mg/l.
[3]The number of fecal coliform organisms should not exceed 14/100 ml in any sample.
[4]The number of fecal coliform organisms should not exceed 800/100ml in any sample.

[5]Some stabilization pond systems may be able to meet this coliform limit without disinfection.
Source: Blumenthal et al. 2000.

As precisely observed by Shuval wastewater reuse in agriculture moved along a complete cycle during the last two centuries. It started with the initiation of land application and sewage farming systems in Europe and the United States and flourished to the extent that it became the most common way for municipal wastewater disposal.

The second phase started at the beginning of the twentieth century when some problems linked to wastewater reuse projects came to the surface. As a result, these projects were almost completely abandoned and the concept of wastewater reuse became worldwide unaccepted.

The last phase started after 1945 when wastewater reuse gained attention again as a mean of both preventing the pollution of water bodies and the conservation of water. Interest in wastewater reuse was intensified in developing countries in arid and semi-arid areas where wastewater is needed for irrigation. At the end of 1990s, many advantages of wastewater reuse became recognized again, but its acceptance was often based on very restrictive and unenforceable health regulations (Shuval 1990). Table 2.3 illustrates some examples of the historic development of wastewater reuse in irrigation within both industrialized and developing countries.

Table 2.4: Selected Examples of the Historic Development of Wastewater Reuse in Irrigation in Different Parts of the World:

Year	Location	Wastewater Irrigation Examples
1912	Bakersfield, USA	Irrigation of corn, Barely and cotton
1912-1985	Golden Gate Park, San Francisco, USA	Watering lawns
1915	Cairo, Egypt	Sewage Farms
1918	California, USA	California's pioneering guidelines and regulations for wastewater reuse in agriculture
1924	Port Said, Egypt	Wastewater reuse for vegetable irrigation
1929	City of Pomona, California, USA	Irrigation of lawns and gardens
1956	Kuwait City, Kuwait	Crop irrigation on a small experimental farm

Table 2.4 (continued)

Year	Location	Wastewater Irrigation Examples
1960	City of Colorado Springs, Colorado, USA	Landscape irrigation for golf courses, parks, cemeteries and freeways
1961	Irvine Ranch Water District, California, USA	Crop irrigation
1962	La Soukra, Tunisia	Irrigation with reclaimed water for citrus plants
1969	City of Wagga Wagga, Australia	Landscape irrigation for sporting fields, lawns, and cemeteries
1971	WHO	First WHO Meeting of Experts on the reuse of treated wastewater in agriculture
1973	WHO	First WHO guidelines and recommendations for reuse of treated wastewater in agriculture
1977	City of St. Petersburg, Florida, USA	Irrigation of parks, golf courses, schoolyards and residential lawns
1982	Amman, Jordan	First standards of wastewater reuse
1987	Monetary Regional Water Pollution Control Agency, California, USA	Monetary Wastewater Reclamation Study for Agriculture - agricultural irrigation of food crops eaten uncooked
1989	Shoalhaven Heads, Australia	Irrigation of gardens
1989	Consorci de la Costa Brava, Girona, Spain	Golf course irrigation
1989	WHO	Revised health guidelines for the use of wastewater in agriculture

Source: Based on selected information from Asano 2002 and Shuval et al. 1986.

2.5. Wastewater Reuse: Where Do We Stand Now?

At the beginning of this century, more than 10% of the population in the world consumed food irrigated with wastewater. The amount of wastewater that is being reused in irrigating agricultural crops is increasing continuously in both developing and industrialized countries. In its third edition of the "Guidelines for the Safe Use of Wastewater, Excreta and Greywater", the WHO identified four main driving forces behind the increase of wastewater use in agriculture (WHO 2006 Volume 2):

- increasing water scarcity and the degradation of freshwater resources resulting from improper disposal of wastewater;
- population growth and related increased demand for food and fiber;
- a growing recognition of the resource value of wastewater and the nutrients it contains;
- the MDGs, especially the goals for ensuring environmental sustainability and elimination poverty and hunger.

2.5.1. Wastewater Reuse and the Millennium Development Goals

The United Nations General Assembly adopted the MDGs in September 2000. The WHO argues that “Goal 1: Eliminate extreme poverty and hunger” and “Goal 7: Ensure environmental sustainability.” are most directly related to wastewater use in agriculture. However, other MDGs are also directly and indirectly linked (Table 2.5).

Wastewater use in agriculture would enable communities in growing more food and make use of the valuable resource and its nutrients. In addition the safe use of wastewater in agriculture would maximize public health gains and environmental protection (WHO 2006).

2.5.1.1. Goal 1: Eliminate Extreme poverty

The WHO inter-relates Goal 1 of the MDGs to wastewater reuse in agriculture by pointing out the importance of wastewater irrigation in producing more food resulting in growth of farmers’ income. To establish a link between wastewater reuse in agriculture and “Goal 1: Eliminate extreme poverty” the WHO demonstrated many examples from different case studies where irrigation with wastewater is beneficial for farmers. It introduces higher yield crops because it is rich of nutrients. These studies were conducted in different countries such as Pakistan, Mexico, India and Senegal. WHO drew the conclusion: Irrigation with treated wastewater would result in higher yield crops and more food. Therefore the food prices would go down and more people would be able to buy food. In addition, without the utilization of wastewater, many poor families would spend larger amounts of money on food and less money on their health care and education (WHO 2006).

Table 2.5: The Relationship between MDGs and Wastewater, Excreta and Greywater Use in Agriculture and Aquaculture

MDGs and their targets	Relationship to wastewater, excreta and greywater
Goal 1. Eradicate extreme poverty and hunger Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than US$ 1 a day Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	• Wastewater, excreta and greywater make up an important resource for intensive agricultural production by the urban and rural poor and thereby strengthen their livelihood opportunities. • Agricultural produce cultivated through the use of wastewater, excreta and greywater adds importantly
Goal 2. Achieve universal primary education Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	• No direct link to universal school attendance, but experiences in India demonstrate the value of the safe use of greywater to maintain a more hygienic school setting, an important factor in parents' collaboration to ensure that their children attend school. Reduction in diarrhoeal and parasitic diseases will result in increased school attendance.
Goal 3. Promote gender equality and empower women Target 4: Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015	The productivity of market gardens and other small-scale peridomestic agriculture is boosted by the use of wastewater, excreta and greywater, and in many parts of the world this particularly favors the economic position of women.

Table 2.5 (continued)

MDGs and their targets	Relationship to wastewater, excreta and greywater
Goal 4. Reduce child mortality Target 5: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate	• The combination of improved sanitation and the safe use of wastewater, excreta and greywater helps reduce the burden of sanitation and hygiene-associated ill-health. • Improved nutrition and food security reduce susceptibility to diseases in children.
Goal 4. Reduce child mortality Target 5: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate	• The combination of improved sanitation and the safe use of wastewater, excreta and greywater helps reduce the burden of sanitation and hygiene-associated ill-health. • Improved nutrition and food security reduce susceptibility to diseases in children.
Goal 4. Reduce child mortality Target 5: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate	• The combination of improved sanitation and the safe use of wastewater, excreta and greywater helps reduce the burden of sanitation and hygiene-associated ill-health. • Improved nutrition and food security reduce susceptibility to diseases in children.

Table 2.5 (continued)

MDGs and their targets	Relationship to wastewater, excreta and greywater
Goal 7. Ensure environmental sustainability Target 9: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking-water and basic sanitation Target 11: Achieve significant improvement in lives of at least 100 million slum dwellers by 2020	• The safe use of wastewater, excreta and greywater contributes to less pressure on freshwater resources and reduces health risks for downstream communities. • Improved sanitation in support of safe excreta use reduces flows of human waste into waterways, helping to protect human and environmental health. • Improved water management, including pollution control and water conservation, is a key factor in maintaining ecosystem integrity. • Waste-fed periurban agriculture can contribute importantly to improving the livelihood of slum settlers.
Goal 8. Develop a global partnership for development Target 12: Developing open trading and financial systems Targets 13 and 14: Addressing special needs of less developed countries, landlocked and small island developing countries Target 15: Managing debt relief and increasing official development assistance Target 16: Creating productive youth employment Target 17: Providing affordable medicine Target 18: Spreading benefits of new technologies, especially information and communications	• Development agendas and partnerships should recognize the fundamental role that safe use of wastewater, excreta and greywater in agriculture and aquaculture and basic sanitation play in economic and social development. • Options for self-employment are enhanced if the opportunities for the safe use of waste in agricultural production are stimulated. • Compliance with the methods and procedures in the WHO Guidelines facilitates international trade in waste-fed agricultural produce.

Explanations for Table 2.5:

[a] Schistosomiasis is a chronic, usually tropical, disease characterized by disorders of the liver, lungs, urinary system or central nervous system. Filariasis is a disease caused by thread-like worms, which are transmitted by mosquitoes and invade the lymphatic vessels, causing chronic swelling of the lower extremities. Trachoma is a contagious infection of the cornea and conjunctiva caused by a bacterium and causing granulation and scar formation.

Source: WHO volume 1 policy and regulatory aspects.

In another publication, WHO concluded that the use of excreta and greywater in agriculture would possibly contribute to poverty elimination by:

- improved household food security and nutritional variety, which reduces malnutrition;
- increased income from sale of surplus crops (the use of excreta and greywater may allow cultivation of crops year-round in some locations);
- money saved on fertilizer, which can be put to other productive uses (WHO 2006).

2.5.1.2. Goal 7: Ensure environmental sustainability

The reuse of wastewater in agriculture contributes to environmental sustainability in many ways. Irrigation with wastewater would reduce the amounts of wastewater that would have been discharged into surface water bodies or the environment, causing harm to the quality of surface water resources that may be used for drinking purposes. This is also valid for groundwater resources (WHO 2006).

Goal 7 of the MDGs aims also to halve the number of people without access to safe drinking water or to proper sanitation. The reuse of wastewater in agriculture can promote achieving this goal by using wastewater for irrigation and thus releasing scarce freshwater resources that have higher quality for drinking purposes. In addition, international sanitation targets received always less attention and reduced amounts of funding in comparison to water supply targets. Incorporating planned wastewater reuse in agriculture as part of improved sanitation projects by supplying farmers with a valuable scarce resource could both provide additional funding and increase attention to improved sanitation targets (Rijsberman and Lebel 2004).

2.5.1.3. Are the Wastewater Management Targets of the Millennium Development Goals Realistic?

As mentioned in Box 2.1, the concept of improved sanitation developed by the Task Force on Water and Sanitation of the UN Millennium Project included treatment and reuse of household wastewater and sewage effluents (Lenton et al. 2005).

Nowadays, it is estimated that only less than 10% of the total generated wastewater worldwide is being treated. The main reason is the lack of wastewater treatment plants in most of the developing countries. If existed, the vast majority of treatment plants within developing countries are overloaded and effluents do not meet acceptable treatment levels. According to the definition of UN Millennium Project of basic sanitation, meeting the target of halving the proportion of people without sustainable access of wastewater treatment by 2015 would be totally unrealistic (Toubkiss 2006).

The World Water Council published a study in 2006 that compared estimated costs of eleven different regional and national cost assessments for achieving target 10 of MDG on water supply and sanitation (Table 2.6). The study pointed out that seven out of these eleven did not include the costs of household wastewater treatment in their cost estimations and therefore did not consider that the concept of basic sanitation should include wastewater treatment. The organizations that included wastewater treatment costs estimated that up to 80 billion US$ would be needed annually till 2015 only for collecting and treating wastewater and for preserving the global environment through integrated water resources management approach.

Governments and donors should allocate more funding for the sanitation sector is another main conclusion of the World Water Council study. It was common to all of the eleven reviewed reports that costs of meeting the sanitation target will be two to five times higher than attaining the water target. The main challenge for the sanitation target would be within the urban areas. Costs of achieving target 10 of the MDGs in cities will be two to three times higher than in rural regions (Ibid.).

Table 2.6: List of Reports Reviewed by World Water Council Study on Costs of MDG Target 10 on Water Supply and Sanitation and Estimated Costs of Wastewater Treatment

Report	**Estimated cost of wastewater treatment if included and region**
Asian Development Bank: Asia Water Watch 2015: Are Countries in Asia on Track to Meet Target 10 of the MDGs? 2005.	Approx. 8.11 billion USD per year for water supply and sanitation including primary wastewater treatment for Asia and Pacific region.
Danish Ministry of Environment / COWI, Financial needs of achieving the MDGs for water and sanitation in the EECCA region, draft main report, 2004.	2.2 billion EUR for sanitation and wastewater treatment for the Eastern Europe, the Caucasus and Central Asia for the period 2002-2015.
UN Millennium Project, Task Force 7 on Water and Sanitation: Health, Dignity and Development: What Will It Take?, 2005.	7 million US$ per year for wastewater treatment in Ghana
Global Water Partnership (GWP): Towards Water Security: A Framework for Action, 2000.	70 billion US$ per year for wastewater treatment worldwide

Source: Based on information from World Water Council, Toubkiss 2006.

2.5.2. Hyderabad Declaration and the New Findings

The International Water Management Institute (IWMI), together with the International Development Research Centre (IDRC) conducted the international workshop “Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environment Realities”. It took place in Hyderabad, India in November 2002 and was attended by more than 35 participants (including researchers, practitioners, policy makers and donors) representing 18 countries and 27 national and international institutions (including WHO). Detailed case studies from different countries on wastewater use in agriculture were presented in order to discuss and share gained experiences and potential options. The objectives of the international workshop were (Scott et al. 2004):

- To critically review experience in the use of wastewater for agriculture worldwide.
- To present lessons learned from specific field-based case studies, including the environmental and health impacts and risks of wastewater use in agriculture
- To refine a methodology developed and applied by IWMI for selected countries that seeks to assess the global extent of wastewater use in agriculture
- To evaluate the institutional arrangements, constraints, and policy implications for sustained livelihoods based on wastewater use in agriculture
- To build a wastewater "community of practice", integrating a variety of research, implementation and policy institutions and partners.

At the end of the workshop, the participants adopted the "The Hyderabad Declaration on Wastewater Use in Agriculture" (Box 2.2). IWMI considered two major breakthroughs in wastewater management:

- The commitment of WHO to take into account the new evidence in reviewing the guidelines for wastewater use in agriculture
- The Hyderabad Declaration contained a common vision and agenda for the future.

Box 2.2: The Hyderabad Declaration on Wastewater Use in Agriculture, 2002.

The Hyderabad Declaration

The International Water Management Institute (IWMI) in collaboration with the International Development Research Centre (IDRC) convened a meeting of minds through an international workshop entitled *Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities,* which was held in Hyderabad, India from 11-14 November 2002. The workshop objective was to critically review experiences with the widespread use of untreated wastewater in agriculture focusing on the livelihoods of the poor, and health and environmental risks. Participants were diverse with a presence of 47 groups of researchers and practitioners from 27 national and international institutions.

Box 2.2 (continued)

The livelihood implications of wastewater irrigation as well as the human health and environmental impacts are clear. Management options identified with partners and stakeholders consider the common situation of wastewater use without options for treatment and include improved health safeguards, awareness raising, cropping restrictions, appropriate techniques, low-cost alternatives (also on-farm), and pollutant-source management. However, many involved in wastewater-treatment, agriculture, sanitation and urban planning have ignored the practice and its implications.

A number of case studies covering different regions of the world, and comprising applications of wastewater ranging from the treated to the untreated were extensively discussed and debated. Three workgroups addressed issues of assessing the global use of wastewater, the health and environmental implications and related guidelines, and institutions and future research directions. Two major breakthroughs were:

(1) a common vision and agenda for the future contained in the Hyderabad Declaration which follows below; and

(2) the discussion with the World Health Organization (WHO) to take into account the realities in reviewing the guidelines for wastewater use in agriculture.

The Hyderabad Declaration on Wastewater Use in Agriculture

1. Rapid urbanization places immense pressure on the world's fragile and dwindling fresh water resources and over-burdened sanitation systems, leading to environmental degradation.

We as water, health, environment, agriculture, and aquaculture researchers and practitioners from 27 international and national institutions, representing experiences in wastewater management from 18 countries, recognize that:

1.1 Wastewater (raw, diluted or treated) is a resource of increasing global importance, particularly in urban and periurban agriculture.

1.2 With proper management, wastewater use contributes significantly to sustaining livelihoods, food security and the quality of the environment

1.3 Without proper management, wastewater use possesses serious risks to human health and the environment.

2. We declare that in order to enhance the positive outcomes while minimizing the risks of wastewater use, there exist feasible and sound

Box 2.2 (continued)

measures that need to be applied. These measures include:
2.1 Cost-effective and appropriate treatments suited to the end use of wastewater, supplemented by guidelines and their application.
2.2 Certain activities to take place where wastewater is insufficiently treated, and until treatment becomes feasible:
(a) development and application of guidelines for untreated wastewater use that safeguard livelihoods, public health and the environment;
(b) application of appropriate irrigation, agricultural, post-harvest, and public health practices that limit risks to farming communities, vendors, and consumers; and
(c) education and awareness programs for all stakeholders, including the public at large, to disseminate these measures.
2.3 Health, agriculture and environmental quality guidelines that are linked and implemented in a step-wise approach.
2.4 Reduction of toxic contaminants in wastewater, at source and by improved management.3. We also declare that:
3.1 Knowledge needs should be addressed through research to support the measures outlined above.
3.2 Institutional coordination and integration together with increased financial allocations are required.
4. Therefore, we strongly urge policy-makers and authorities in the fields of water, agriculture, aquaculture, health, environment and urban planning, as well as donors and the private sector to:
Safeguard and strengthen livelihoods and food security, mitigate health and environmental risks and conserve water resources by confronting the realities of wastewater use in agriculture, through the adoption of appropriate policies and the commitment of financial resources for policy implementation

14 November 2002, Hyderabad, India.

Source: Scott et al. 2004.

Carr et al. argued that the importance of the Hyderabad Declaration on Wastewater Use in Agriculture is recognizing the reality that untreated or insufficiently treated wastewater is used for crop production in many countries without an official approval of health authorities. Banning this practice would be unlikely to stop it and would make it more difficult for the authorities to supervise and interfere when it is needed. Additionally, Carr et al. pointed out that the Declaration recognized the differences in social, economic and environmental conditions within the different countries where wastewater is used for irrigation. The declaration recommended a holistic approach to the management of wastewater use in irrigated agriculture (Carr et al. 2004).

Furthermore, Faruqui considered that the recommendations included in the Hyderabad Declaration have changed the views of policy-makers, even among the ones that took part in the initiation of 1989 WHO guidelines (Faruqui 2004).

Raschid-Sally et al., conducted a study entitled “Productive Use of Wastewater by Poor Urban and Peri-Urban Farmers: Asian and African Case Studies in the Context of the Hyderabad Declaration on Wastewater Use”. The study aimed to assess the role of the Hyderabad Declaration on wastewater use in agriculture and its implications for maximizing the benefits and decreasing the risks of wastewater irrigation. Two case studies were presented, one from Asia (Hubli-Dharwad, India) and the other one from Africa (Yaounde, Cameroon).

In their findings, Raschid-Sally et al. believed that the rationale behind the adoption of the Hyderabad Declaration was well illustrated in both case studies (Raschid-Sally et al. 2004):

- Wastewater is a resource of increasing global importance.
- Wastewater contributes to sustaining livelihoods, food security and environmental quality.
- Without proper management, wastewater use poses serious health and environmental risks.

In addition, Raschid-Sally et al. and Drechsel et al. pointed out that the Hyderabad Declaration does not only include these above mentioned principles, but it also offers suggestions towards sustainable use and management of wastewater (Raschid-Sally et al. 2004).

2.5.3. The New WHO Guidelines Based on the Stockholm Framework

Until the end of the last century, as discussed before, scientists and researchers had different positions regarding the health guidelines of wastewater reuse in agriculture. One group were the supporters of the 1989 WHO guidelines who rejected the standards that were based on California wastewater reclamation criteria, considering it too stringent, not based on scientific evidence and almost impossible to be met by developing countries.

The other group consisted of the opponents of the 1989 WHO guidelines that were the supporters of the California criteria. Members of this group criticized the 1989 WHO guidelines considering them as inappropriate for industrialized countries and insufficient for a maximum and full protection of human health.

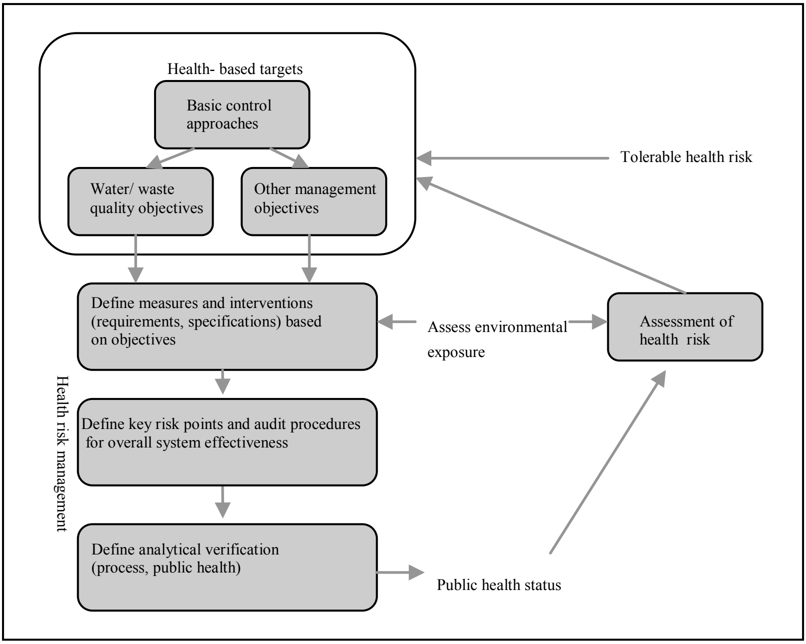
At the beginning of this century, the discussion on wastewater reuse guidelines took a new direction between 1999 and 2001 where an international group of experts discussed new approaches on assessment and management of water-related microbial hazards. These discussions resulted in the development of a harmonized framework, became to be known as "Stockholm Framework". It was intended to inform the process of development of guidelines and standards for water related microbiological hazards with a series of recommendations for its adoption (Bartram et al. 2001).

The Stockholm Framework encourages a more flexible approach for countries to establish guidelines that are more suitable for their own local social, economic, cultural and environmental circumstances. Therefore, Carr et al. argue that in particular situations treatment of wastewater (according to the 1989 WHO guidelines of unrestricted level) requires more advanced wastewater treatment technologies that are costly and beyond the reach of several poor developing countries because they lack sufficient resources for wastewater treatment facilities (Table 2.7). In such cases, Carr et al. believe, according to the Stockholm Framework, other measures for health protection would result in better benefits and should be given higher importance (Carr et al. 2004).

After the WHO published "Reuse of Effluents: Methods of Wastewater Treatment and Public Health Safeguards" in 1973 and "Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture" in 1989, the third edition of the WHO Guidelines for the "Safe Use of Wastewater, Excreta, and Greywater in Agriculture and Aquaculture" was published in 2006 in four volumes. The guidelines were updated by a group of experts that took into consideration the latest research results from epidemiological studies, contemporary thinking on risk management and new health evidence.

The third edition of WHO guidelines has adopted the recommendations of the Stockholm Framework and most of the findings of the international workshop "Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environment Realities" that was held in Hyderabad, India in November 2002.

Figure 2.1: The Stockholm Framework for Developing Harmonized Guidelines for the Management of Water-related Infectious Disease



Source: WHO 2006, adapted from Bartram et al. 2001.

Table 2.7: Wastewater Treatment Gaps in the World

Region	**Percentage of sewered population in large cities**	**Percentage of sewered wastewater that is treated to secondary level**
Africa	18	0
Asia	45	35
Latin America and the Caribbean	35	24
Oceania	15	Not reported
North America	96	90
Europe	92	66

Source: Agriculture Development Notes, based on WHO and UNICEF 2000.

Therefore, it was expected that the new WHO guidelines should be more practical and offer other solutions than wastewater treatment in order to minimize the health hazards, but maintain the substantial benefits of using the resource.

Indeed, the new WHO guidelines are more flexible. They clearly reflect the regional differences of wastewater reuse and realize the socio-cultural, economic and environmental differences from one country to another. As it is stated in the preface of the new WHO guidelines:

> *"Overly strict standards may not be sustainable and, paradoxically, may lead to reduced health protection, because they may be viewed as unachievable under local circumstances and, thus, ignored"* (WHO 2006).

As Mougeot argues, wastewater is a resource that is virtually being ignored by all except farmers (Mougeot 2006). Therefore, abstain from recognizing this fact will enhance the problem. Although treatment technologies exist to treat wastewater for the desired level, many of the less developed countries have no sufficient funds for the treatment costs. In such countries, policy makers should adopt other available options for wastewater management that would help in avoiding health and environmental risks. For example measures like the introduction of new irrigation practices, the enforcement of crop restrictions and the creation of awareness among farmers and consumers. Such activities are always affordable and research proved them to be efficient in minimizing the adverse impacts of irrigation with wastewater.

2.6. Future of Wastewater Reuse

Although wastewater reuse in agriculture has been practiced since a long time in several communities around the world, it is becoming significantly an important means for facing the future water challenges (Table 2.8). Its role is vital in achieving a reliable and sustainable integrated water resources management in modern societies.

Table 2.8: Factors Driving the Future of Wastewater Reuse

- Increasing pressure on existing water resources due to population growth and increased agricultural demand.
- Growing recognition among water and wastewater managers and the public of the economic and environmental benefits of using recycled water.
- Recognition that reclaimed water can be a reliable source of water supply even in drought years.
- Increasing awareness of the environmental impacts associated with over-use or overdraft of water supplies.
- Greater recognition of the environmental and economic costs of water storage facilities such as dams and reservoirs.
- Preference to recycling over effluent disposal, coupled with tighter controls on the quality of any effluent discharged to the environment.
- Community enthusiasms for the concept of water reuse and water conservation.
- The growing numbers of successful water reuse projects in the world.
- The introduction of new water charging arrangements that better reflect the full cost of delivering water to the consumers, and the widespread use of these charging arrangements.
- Increased costs associated with upgrading wastewater treatment facilities to meet higher water quality standards.

Compiled from various sources including Asano 1998 and Queensland Water Recycling Strategy 2000.

Wastewater reuse will continue to be a valuable resource for a large number of countries and the volume of reused water is expected to increase further especially in water stressed countries where cities are gradually displacing agriculture mainly due to the increasing demand for freshwater. This transfer of water to the cities results in the generation of additional amounts of wastewater. It is estimated that cities dispose around 80% of the water resources as wastewater (Molle and Berkoff 2006). Sadeq believes that about 90% of the wastewater in developing countries is discharged without any treatment (Sadeq 1999).

The main challenge for wastewater reuse in agriculture remains in finding cheap and appropriate wastewater treatment systems that can improve the quality of wastewater to be safely used in irrigation without imposing risks on health or the environment.

Banning irrigation with insufficiently treated wastewater will unlikely be stop it. Effective wastewater treatment might not be available for many years within a number of developing countries where wastewater is being used for crop irrigation. Therefore, governments must adopt appropriate and practical policies that offer other solutions, when adequate wastewater treatment is beyond their reach.

3. Wastewater Reuse in MENA: Assessment of the Current State

The MENA region (Map 3.1) is not only considered extremely arid, but also experience high population growth (about 3%). The region has a share of a bit less than 5% of the total world population, but receives only 1% of the world's renewable water resources. Water scarcity and the demographic dynamics impose huge challenges of water resource management in the region that received different policy responses by governments. Wastewater reuse in agriculture is a common practice and is increasingly becoming recognized as a main source for irrigation.

However, this important resource is not fully developed. Large amounts of treated or insufficiently treated wastewater are disposed into the environment or seas, instead of being reused. This is mainly due to the fact that most of MENA countries lack of clear policies that encourage and promote wastewater reuse in agriculture.

On the other hand, in some MENA countries where appropriate policies have been adopted, treated wastewater became a vital aspect and a strategic component within the national water budgets.

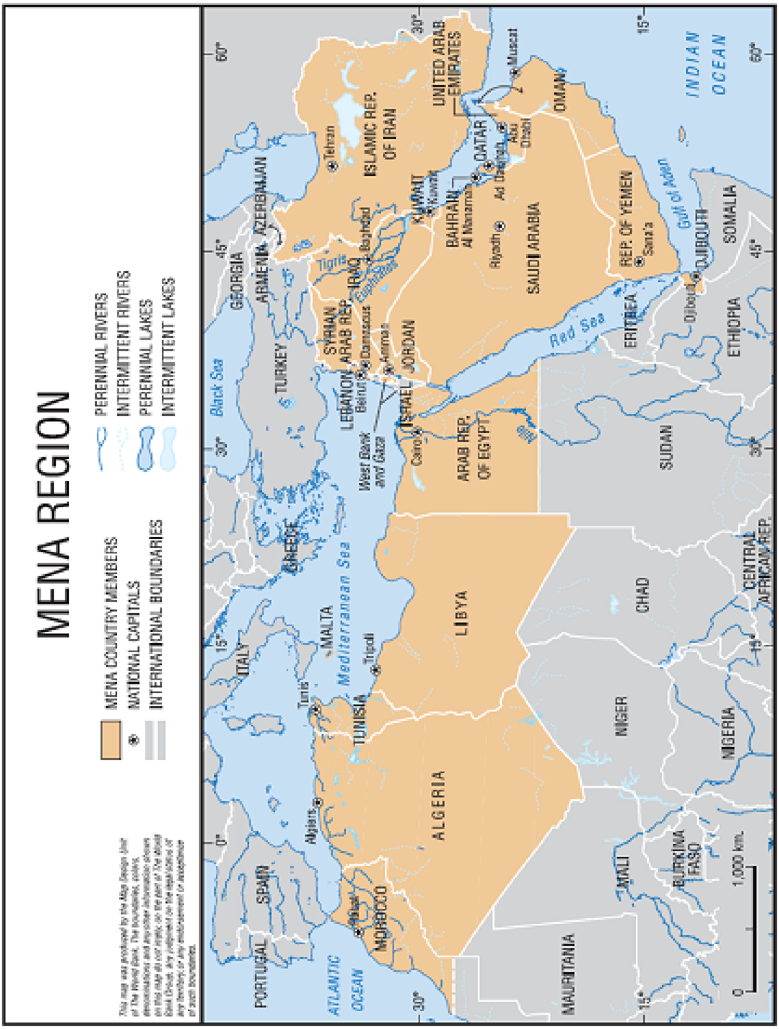
3.1. Water Scarcity and Population in MENA

The MENA region is considered to be the driest in the world. Water scarcity is generally determined by the low amounts of rainfall, which is estimated at 2148000 MCM/year. The regional average amount of rain received in the region and the regional average of annual precipitation is about 56 mm/year (4th World Water Forum 2006).

In the last few decades, water resources in the region were stable and even in some water stressed countries they were polluted and deteriorating and used beyond their safe yield.

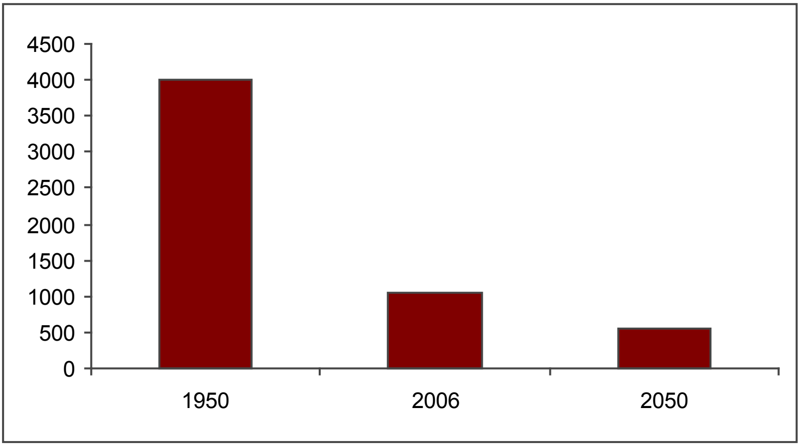
In addition, water demand in the region is increasing constantly due to the rapid population growth at an average of 3%. Projections indicate that the per capita share of water resources will highly decrease by the year 2050 (Figure 3.1).

Map 3.1: MENA Region



Source: World Bank 2007

Figure 3.1: Per Capita Share of Freshwater in m^3 and Year in the MENA Region



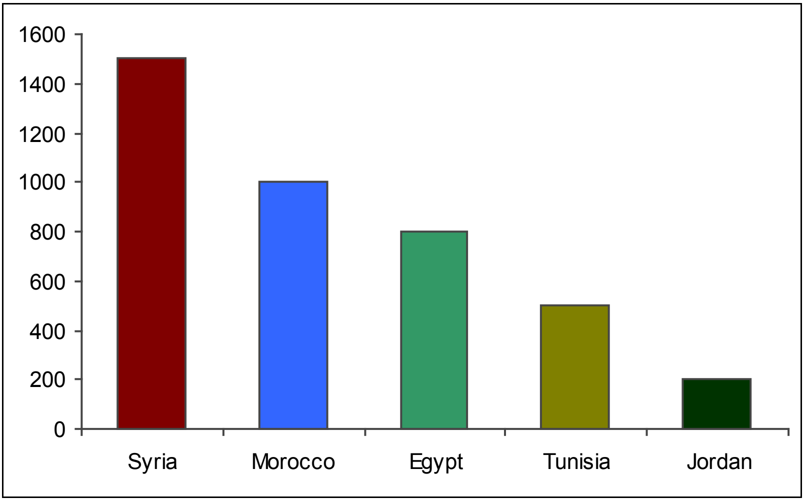
Source: 4th World Water Forum 2006.

Despite being considered one of the driest regions in the world, the available per capita share of freshwater differs hugely from one country to another (Figure 3.2). Only seven countries, in the region exceed the rate of 1000 m^3/capita. Additionally, more than half of the renewable water resources originate in international rivers outside of the region. Several countries excessively overused their fossil groundwater resources. At present most of the groundwater aquifers are used beyond their safe yield. This means that the large extracted amounts of groundwater exceed natural recharge. Both the quantity and the quality of groundwater resources are deteriorating. If overdraft continues, aquifers will eventually be lost forever (4th World Water Forum 2006).

According to a study of the World Bank, MENA countries can be classified into three main groups based on the level of water scarcity and water management challenges. The most important are those related to environmental protection, allocation, and managing services (World Bank 2007).

The first group of countries has sufficient amounts of renewable water at the national level but with variation between different parts of the country and over time. This group includes countries like Algeria, Djibouti, Iran, Lebanon, Morocco, Tunisia, and the West Bank. The biggest challenge for these countries is the internal distribution of water resources, both geographically and temporally.

Figure 3.2: Per Capita Renewable Water Resource Available in m^3 in some MENA Countries



Source: World Bank 2007, based on information from FAO AQUASTAT.

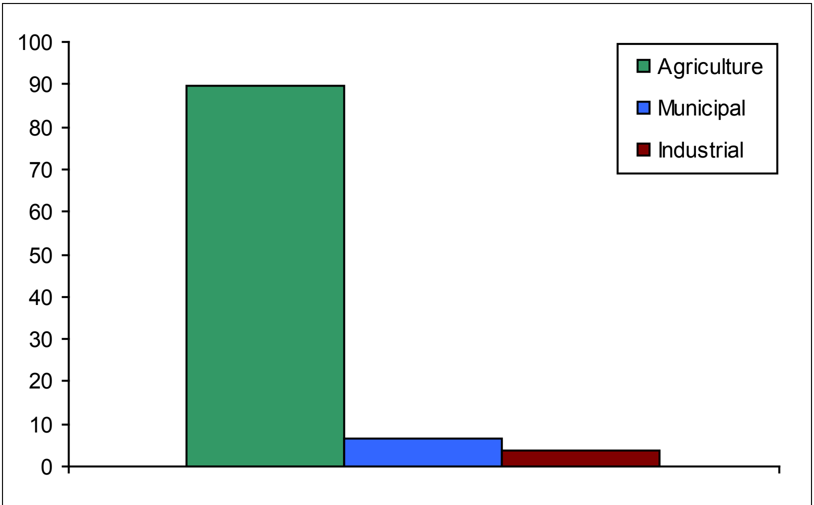
The second group of countries like Bahrain, Gaza, Jordan, Kuwait, Libya, Oman, Qatar, Saudi Arabia, the United Arab Emirates, and Yemen has very low levels of renewable water resources. Countries classified within this group depend heavily on non-renewable groundwater resources and / or obtain additional amounts of water supply by desalination of sea or brackish water. Main challenges for this group are managing non-renewable groundwater extractions. Challenges differ between countries with relatively high per capita incomes as the Gulf countries and Libya, and those with lower incomes (Gaza, Yemen, and Jordan).

The third group contains countries in which large amounts of their renewable surface or groundwater resources are shared with other countries. This group includes Egypt, Iraq and Syria. Their water resources are highly influenced by decisions made upstream or elsewhere in the aquifer. The MENA region has the highest dependency on international water bodies in the world, but, about two thirds of its annual renewable surface water comes from outside the region.

3.2. Water Use in Agriculture

Most of the water resources in the MENA region are allocated to irrigated agriculture. The agricultural sector consumes more than 88% of the available water resources in MENA region (Saghir et al. 2000) (Figure 3.3). However, agriculture is contributing a relatively small and declining share of national income and low shares in employment and export.

Figure 3.3: Percentage of Total Water Consumption in the MENA Region According to Sectors in 2004



Source: Presentation The Middle East Water Report to the 4th World Water Forum in Mexico 2006.

Agriculture in MENA region is a quite diverse sector whose contribution to economic development is important considering the stage of development in which the countries of the region are. Its contribution to GDP is relatively diverse ranging from a high of about 24% for Syria and 16% for Morocco to a low of less than 2% for Jordan and 7% for Saudi Arabia (FAO AQUASTAT Database).

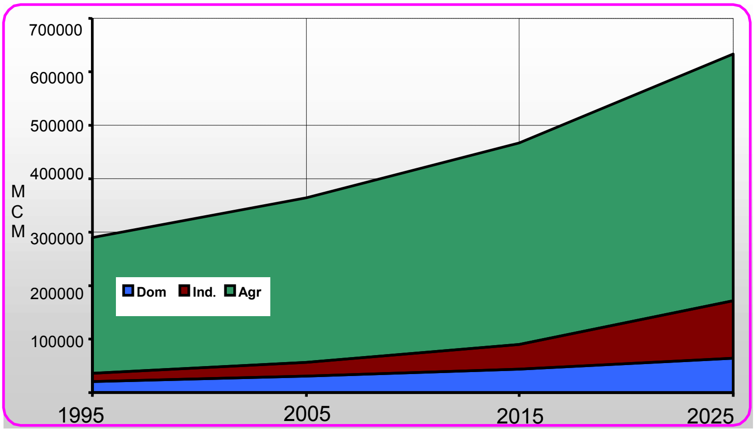
This relatively limited contribution to GDP does not reflect the high importance of agriculture in employment. In some countries such as Egypt and Morocco, more than 90% of the economically active population is working in agriculture. Thus, despite the small contribution of the agricultural sector to GDP, it is still considered the key to development in many developing regions including the MENA region (Ibid).

There is a big difference between amounts of water used in the agricultural sector within MENA countries. Some countries depend on tourism and oil production rather than agriculture. Therefore, these countries use less water in agriculture than the MENA average. For example, Bahrain uses 29%, Qatar uses 59% and Lebanon uses 60% of their renewable water resources in agriculture. On the other hand, Iran with 92%, Egypt with 86% and Iraq with 79% are the MENA countries with the highest percentage of water use in agriculture (Qadir et al. 2009). Table 3.1 shows the percentages of agricultural water use in some MENA countries in previous years.

Countries with high water use in agriculture will have to depend on water with lower qualities for irrigation in the coming years. The high rates of population growth and the subsequent growing demand for food production will lead to a higher demand for irrigation water. However, the agricultural sector will not receive the same percentages of water supply (almost 90%) as in the past. Increasing demands by municipal and industrial water sectors will reduce the share of agricultural sector (Figure 3.4).

Since the need for water is large in the countries belonging to the MENA region, it is imperative to adopt a new approach of water resources management practices to conserve and use freshwater more efficiently. Also the modification of water policies to preserve the right of future generations of having access to freshwater is inevitable for pursuing development in the region. One of the most promising sources that may provide the countries with additional amounts of water relies on a comprehensive and carefully planned program of wastewater management and reuse in agriculture.

Figure 3.4: Projections of Water Use among Different Water Sectors in MENA Region



Source: World Bank 2000.

Table 3.1: Percentages of Agricultural Water Withdrawal in some MENA Countries as Percentages of total Water Withdrawal and Year

Country	1988-1992	1993-1997	1998-2002	2003-2007
Algeria	60 (1990)		64 *(2000)	
Bahrain	56 (1990)		56 *(2000)	44.54 (2003)
Egypt		80 (1993)	80 (2000)	
Iran		90 (1995)	90 (2000)	90 (2004)
Iraq	92 (1990)		70 (2000)	
Jordan	74.8 (1992)			64.95 (2005)
Kuwait		60.2 (1994)	53.86 (2002)	
Lebanon		67.6 (1994)	66 * (2000)	59(2005)
Libya	89 (1990)	80 (1994)	82.8 (2000)	
Mauritania			80*(2000)	
Morocco	92 (1992)	87.7 **(1995)	87 (2000)	
Oman	93.8 (1991)		90 * (2000)	88.4 (2003)
Qatar		73.92(1994)	72 *(2000)	59 (2005)
Saudi Arabia	89 (1992)			88 (2006)

Table 3.1 (continued)

Country	1988-1992	1993-1997	1998-2002	2003-2007
Sudan	96 (1990)	90 (1995)	96 *(2000)	
Syria		88 (1997)	88 (2002)	87 (2003)
Tunisia	88.7(1990)		82(2000)	
UAE		66.7(1995)		82.8 **(2005)
Yemen	90 (1990)		90 (2000)	

* Modeled Data ** FAO Estimate

Source: FAO AQUASTAT Database (several years).

3.3. Viewing Wastewater as a Resource

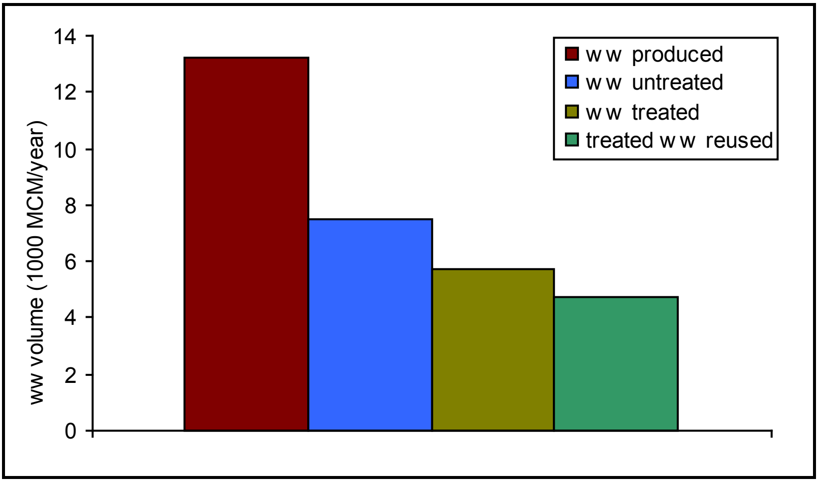
Wastewater is a potential resource of great importance, with volumes rising increasingly. The current volume in the MENA region differs from one country to another (Table 3.2). This amount is expected to double within the next 12 to 15 years due to growing urban populations, the expansion of drinking water and sewer networks, and the rise of per capita consumption of drinking water in the major cities as standards of living climb (Faruqui 2000).

According to Qadir et al., about 43% of the wastewater generated in MENA is treated (see Figure 3.5). This share is larger than Asia 35%, Latin America/Caribbean 14% and Africa 1%. The reason behind, is the oil rich MENA countries have the sufficient resources for wastewater collection and treatment (Qadir et al. 2009).

Under prevailing water scarcity in the MENA region, treated wastewater can be a valuable resource for the following reasons: First, it conserves the high quality and expensive freshwater for the highest value purposes as for drinking. Second, collecting and treating wastewater prevents the pollution of freshwater sources, protects the environment in general and improves public health. Third, if adequately treated, wastewater can have under certain circumstances a higher value for irrigation than some freshwater sources. The minerals that treated wastewater contain, may result in higher yields than freshwater irrigation with savings in the costs of adding fertilizers (4th World Water Forum 2006).

The World Bank estimated the cost of secondary level treatment for domestic wastewater in the MENA region, an average of US$ 0.5/m^3. For many MENA countries this is cheaper than developing new water supplies. Adequate conventional treatment exists in many countries within the MENA region. However the amounts of treated wastewater in comparison to the amounts of wastewater generated differ from one country to another (Table 3.2 and Table 3.3).

Figure 3.5: Volume of Wastewater Produced, Treated, Untreated and Reused in Agriculture



Source: Based on data from Qadir et al. 2009.

Table 3.2: Produced Volumes of Wastewater in some MENA Countries in MCM and Year

Country	1988-1992	1993-1997	1998-2002	2003-2007
Algeria			820 (2002)	
Bahrain	44.9 (1991)			
Egypt		3430 (1993)	3760 (2001)	
Iran			3075(2001)	
Jordan			82 (2000)	
Kuwait		119 (1994)		244 (2003)
Lebanon	165 (1991)		310 (2001)	
Libya			546 (1999)	
Morocco	220 (1992)	370 (1994)	650 (2002)	

Table 3.2 (continued)

Country	1988-1992	1993-1997	1998-2002	2003-2007
Oman	58 (1991)		90 (2000)	
Qatar		47.6 (1994)		55 (2005)
Saudi Arabia			730 (2000)	
Syria		935 (1993)	1364 (2002)	
Tunisia			187 (2001)	
UAE		500 (1995)		
Yemen	37 (1992)		74 (2000)	

Source: FAO AQUASTAT Database (several years).

Table 3.3: Treated Volumes of Wastewater in some MENA Countries in MCM and Year

Country	**1988-1992**	**1993-1997**	**1998-2002**	**2003-2007**
Bahrain	44.9 (1991)			61.9(2005)
Egypt		650 (1993)	2971 (2001)	
Iran			130 (2001)	
Jordan			72 (2000)	107.4 *(2005)
Kuwait		103 (1994)	152 (2002)	250 (2005)
Lebanon	4 (1991)			4 *(2006)
Libya			40 (1999)	
Mauritania			0.7 (1998)	
Morocco			40 (1999)	
Oman			9.8 (2000)	37 (2006)
Qatar		25.2 (1994)	43 (2001)	58 *(2006)
Saudi Arabia	454 (1991)		547.5 (2002)	
Syria		370 (1993)	550 (2002)	
Tunisia		96 (1993)	148 (2001)	215 (2006)
UAE		108 (1995)	192.6 (2000)	289 (2006)
Yemen	20 (1990)		46 (1999)	

* Estimated figures by FAO.

Source: FAO AQUASTAT Database (several years).

Table 3.4: Sewerage and Wastewater Treatment in MENA and Other Selected Countries

Country	Sewerage rate *(%)* Urban	Sewerage rate *(%)* Rural	**Treatment rate** *(% collected)*	**Volume treated** *MCM/yr*	**Type of treatment**	**Notes**
Algeria	78-85	65	73	6001	Secondary	Mostly lagoons
Bahrain	70-77		100	44.9	Secondary	Activated Sludge, some tertiary (ozone)
Djibouti	5	4	0	0	None	None
Egypt	68	42	79	2971	19%Primary	Activated Sludge,ponds, trickling filters
Iran	17-20	11	4	130		
Jordan	70	50	88	72	Secondary	Lagoons and Activated Sludge; overloading frequent
Kuwait		85	87	103	Tertiary	
Lebanon		40	2	4	Secondary	Planning treatment and reuse around Beirut and Ba'albeck
Libya	54	54	7	40		
Morocco	70	40	6-8	40	Secondary	Effluents/raw sewage mostly discharged to sea and surface waters
Oman	90	81	13	9.8	Secondary	Activated Sludge, aerated ponds

Table 3.4 (continued)

Country	Sewerage rate *(%)* Urban	Sewerage rate *(%)* Rural	**Treatment rate** *(% collected)*	**Volume treated** *MCM/yr*	**Type of treatment**	**Notes**
Qatar		80		43		
Saudi Arabia	45	37	75	548	Secondary	Activated Sludge, aerated ponds
Syria	96	71	57-67	550	Secondary	Activated Sludge, lagoons Significant dumping of untreated waste; Damascus upgrade for reuse of tertiary-treted effluents
Tunisia	68	50	79	148	Secondary	Mostly activated sludge, ponds; moving to tertiary
UAE	91	87	22	193	Secondaray, tertiary	
West Bank and Gaza	25	23	34-54	14-24	Primary, secondary	Sludge drying beds , ponds, frequent overloading, O&M problems
Yemen	40	12	62	46	Secondary	Ponds, frequent overloading
Israel		92-95	79	296	Secondary, some tertiary	Ponds, activated sludge, natural filtration+ recharge
Cyprus	73	60	100	6	Mostly tertiary	
Malta		95	13	2.5	Secondary, some tertiary	Piloting RO to promote industrial reuse

Source: Kfouri et al. 2009.

3.4. Assessment of the Current State of Wastewater Reuse

In the MENA region, wastewater reuse in agriculture is common. In many countries, especially those where water shortage is severe, access to freshwater for irrigation is limited and instead farmers use wastewater. But this is done in a semi-planned or unplanned manner. The primary problems associated with reusing insufficiently treated wastewater are the inherent health risks from wastewater containing bacteria, viruses, and a wide range of parasitic organisms (Sammis et al. 2001), and the negative impacts of irrigation with wastewater on certain crops and the soil (World Bank 2001). To overcome those implications and to utilize the full benefits of agricultural wastewater reuse, regulatory practices and the necessary institutional framework on both national and local levels and their adoption need to be reviewed and different stakeholders have to be recognized within a national policy context (Raschid-Sally et al. 2001).

Shares of reused wastewater and the practicing approaches differ from one country to another (Table 3.5). Figure 3.5 provides a general overview of the quantities of wastewater produced and the quantities that are being reused within MENA countries. The difference between quantities that are being produced and being reused are directly or indirectly discharged into the sea or evaporate from streams and reservoirs (World Bank 2001).

Also, experiences with wastewater reuse differ. Some of the MENA countries are already practicing planned wastewater reuse through specifically designed projects to treat, store, convey and distribute treated wastewater for irrigation. A good example of planned wastewater reuse scheme can be found in Tunisia. Other countries are practicing partly planned reuse of wastewater. This it is the case in Jordan, where almost all sewage collected and treated is being reused in agriculture. However, treatment levels are sometimes insufficient and effluent usually is discharged into watercourses to get diluted before being reused for irrigation (Ibid).

Third example of wastewater reuse can be found within countries where wastewater treatment plants are not operated and not maintained adequately, making wastewater unsuitable for unrestricted irrigation even where it has passed through a treatment plant. For instance in Morocco and as well as in Algeria, Syria, and Yemen most of the wastewater is untreated.

Table 3.5: Volumes of Treated Wastewater Reused in some MENA Countries in MCM and Year

Country	1988-1992	1993-1997	1998-2002	2003-2007
Bahrain	8 (1991)		8 * (2000)	16.3 (2005)
Egypt		200 (1993)	2971 (2000)	
Jordan	47 * (1992)	50 (1993)	64.9 (2000)	83.5 (2005)
Kuwait		52 (1994)	78 (2002)	
Lebanon	2 (1991)	2 * (1994)	2* (2000)	2 * (2005)
Oman	0 * (1991)		8.6 (2000)	37 (2006)
Qatar		29 (1997)	29 * (2000)	43 (2005)
Saudi Arabia	0 * (1992)		122.6 (2002)	166 * (2006)
Syria		370 * (1997)	550 (2002)	550 * (2003)
Tunisia	0 * (1990)	18 (1993)	21 (2001)	
UAE		108 (1995)	185.3 (2000)	248 (2005)
Yemen	0 * (1990)		6 * (2000)	

* Estimated figures by FAO.

Source: FAO AQUASTAT Database (several years).

3.5. Constraints to Wastewater Reuse in the MENA Region

In view of the huge water shortage that the MENA region is facing and the rapid population growth and urbanization rates, volumes of wastewater generated are continuously increasing. However, shares of wastewater reused in agriculture are low in many countries within the region. Different studies tried to identify the constraints and obstacles that are leading to that, like (Neubert 2002, Bazza 2003, Qadir et al. 2009 and Kfouri et al. 2009). After reviewing and analyzing related scientific publications, obstacles and constraints to wastewater reuse in the MENA region were categorized as follows:

Incomplete economic analysis of the wastewater treatment and reuse projects

The situation of the national economy has a great impact on wastewater treatment and reuse in agriculture. Wastewater collection and sufficient treatment that is required for unrestricted irrigation to prevent negative impact on the general health entails huge costs. Treatment of wastewater is the optimal solution to the problems associated with wastewater reuse in agriculture. However, experiences in the poor MENA countries reveal that adequate wastewater treatment is far beyond the financial capability.

Economic analyses that are conducted are usually restricted to only financial feasibility. Therefore, complete economic analysis should depend on studies such as cost effectiveness analysis and cost-benefit analysis that include several benefits that may be gained from wastewater treatment and reuse projects. Some of the frequently excluded benefits from wastewater reuse in agriculture are the benefits of replacing freshwater with treated wastewater and environmental benefits such as the conservation of freshwater and groundwater resources (Bazza 2003 and Kfouri et al. 2009).

High costs of developing wastewater collection networks and wastewater treatment plants with the lack of wastewater cost recovery mechanisms

The high costs of the construction of sewerage networks collection and wastewater treatment plants that are capable of producing effluent with acceptable standards is one major obstacle for wastewater reuse. Although the majority of MENA countries have connected most of their urban households with sewerage networks, the share of wastewater treated to the collected is low (Kfouri et al. 2009) (see Table 3.4).

As mentioned before, the World Bank estimated the cost of secondary level treatment for domestic wastewater in the MENA region, an average of US$ 0.5/m^3 and for the most of MENA countries this amount is cheaper than developing new water supplies.

Treating collected wastewater to international standards requires high levels of funding for both, capital costs and O&M costs. Most of the sanitation costs including treatment are partially recovered through tariffs imposed on households. In countries without sanitation tariffs at all or extremely low tariffs, sanitation and wastewater treatment utilities remain financially dependent on subsidies from the government. This leads to low maintenance of treatment plants and low effluent quality.

Bazza pointed out that Tunisia and Jordan are the only MENA countries that provide a promising example of recovering O&M costs and part of the capital costs of wastewater collection and treatment. According to estimations, it is expected that Tunisia will recover the whole costs within ten years (Bazza 2003). At the time being, households have paid the costs of wastewater treatment that is reused in irrigation. If wastewater will be treated to serve the needs of the farmers, they might have to cover part of these costs (Neubert 2002).

Low demand for treated wastewater

Kfouri et al. noted that experiences from several wastewater reuse projects proved that although treated wastewater contains valuable fertilizers, the demand for treated wastewater is lower than it is for alternative resources of freshwater (mainly due to crops restrictions and salinity). In addition people in the MENA countries are suspicious about the wastewater quality that is reused in agriculture (Kfouri et al. 2009).

This uncertainty is revealed clearly in Tunisia, where treated wastewater is sold at a very low price that is far beyond the real cost of wastewater treatment (Ibid). Moreover, the water law prohibits farmers from reusing wastewater in irrigating vegetables that are valuable source of income for most farmers (Bahri and Brissaud 1996). Also, Neubert explained that Tunisian farmers have several preservations over using treated wastewater for irrigation. One of the most important reasons is the legal restriction of irrigating vegetables, which are seen by farmers as the most profitable and the most easy-to-market crops in Tunisia (Neubert 2002).

In other MENA countries like Syria or Yemen, the low demand for wastewater led the governments to provide wastewater free of charge for farmers to encourage reuse.

Cheap prices of freshwater

One of the major constraints of the reuse of wastewater in agriculture is that freshwater prices within the MENA countries do not reflect its real value due to its scarcity, especially when it is used for low value crops within the agricultural sector. Kfouri et al. noticed that there is not even one single country within the MENA region that charges irrigators with the full supply price of water that is delivered. Moreover, several MENA countries do not charge farmers for groundwater abstractions. This is the situation in Morocco, Palestine, Tunisia and Yemen (Kfouri et al. 2009).

The fact that the freshwater tariffs are extremely low and sold below cost does not provide incentives for farmers to use wastewater for irrigation. Tariffs of wastewater in most of the MENA countries are lower than the tariffs of freshwater (if wastewater is not offered for free) since farmers believe that wastewater is inferior to freshwater due to crop restrictions and salinity.

Abu-Madi et al. concluded that increasing the low pricing of freshwater in MENA countries in a way that does not jeopardize agricultural feasibility would promote the reuse of wastewater in agriculture, even if wastewater is sold at increased prices. Expanding the gap between wastewater and freshwater tariffs will make wastewater on one side more attractive. On the other side, revenues will be used for funding the investment costs of infrastructure needed for appropriate wastewater treatment and distribution (Abu-Madi et al. 2008).

3.6. Adopting Policies on Wastewater Reuse

As it was pointed out in sub-chapter 3.5, the low rate of wastewater reuse in agriculture in the MENA region is mainly caused by different obstacles. Experiences proved that countries may overcome these constraints through adopting improved policies and institutional coordination. Therefore, wastewater reuse in agriculture should be incorporated into any sustainable and integrated water resources management policy (Bahri 2009).

Most countries in the MENA region are achieving substantial improvements on the technical level. But policy and institutional progress within the water sector is much slower. Only very few governments are currently implementing innovative water policies and institutional changes that are showing promising results. Table 3.6 shows different MENA countries and the level of adoption of IWRM policies.

There are several reasons contributing to the negative results. The changes have only been partial since most countries reject to address some of the most important reforms (i.e. water tariffs). These issues have proved to be politically untouchable. The reasons differ from one country to another. In most cases, politically important actors are opposing the changes and reforms. For example, some powerful groups benefit from subsidized services or existing allocations of water and want to maintain the status quo. On the other hand, those who might benefit from reforms —like farmers, and poor households— have not been able to form effective lobby groups. In some cases, they lacked awareness about the problem or they lacked good organization (World Bank 2007).

Since the year 2001, the policy and institutional aspects of wastewater reuse received more attention within the MENA region and also worldwide. The World Bank, in cooperation with the Swiss Development Cooperation Agency organized a workshop on “Water Reuse in the Middle East and North Africa”. One of the main findings of the workshop was that one of the major obstacles of wastewater reuse in the MENA region was the weak legal and institutional frameworks - if they existed at all - and the fragmentation of responsibilities and lack of cooperation between governmental agencies.

In the year 2009, two important studies were published on that regard. The first one was published by Kfouri et al. The main conclusion of the study, based on the experiences of three MENA countries, that despite the challenges and obstacles for wastewater reuse in MENA region, some of these countries were able to promote wastewater reuse by adopting flexible policy frameworks according to the situation they are facing (Kfouri et al. 2009).

The other important paper that was published in 2009 by Qadir et al. concluded that the policy process related to wastewater management and reuse in agriculture within the MENA region is difficult to adopt due to three major factors. First, most of the wastewater amounts are generated outside the agricultural sector. Second, the different actors and organizations involved have different interests - that are often in conflict - associated to the policies of wastewater reuse. Third, most of the consumers of the produced wastewater are outside the agricultural sector (Qadir et al. 2009).

Table 3.6: MENA Countries and their Adoption of IWRM Policies

Country	**Plans/Strategies/Policies/ Documents towards IWRM**	**Status of IWRM Plans Development**			
		1*	2*	3*	4*
Algeria				X	
Bahrain	National Strategy for Environmental Protection of Water Sector; Bahrain Water Sector, 2003		X		
Djibouti	Strategy for Reducing Water Poverty; Water Law Water Action Plan for City of Djibouti				
Egypt	Integrated Water Resources Management Plan; Ministry of Water Resources & Irrigation, 2005; National Water Resources Plan; Ministry of Water Resources & Irrigation, 2004.; Main Features for the Water Policy towards Year 2017; Ministry of Water Resources & Irrigation, 2000	X			
Iraq				X	
Jordan	Water Strategy & Water Policies in Jordan; Ministry of Water & Irrigation. The National Water Master Plan; Ministry of Water & Irrigation, 2003	X			
Kuwait				X	
Lebanon	Work Plan for Ministry of Hydraulic and Electric Resources, Years 2000-2009; Ministry of Water and Electricity, 1999		X		
Libya	National Strategy for Water Resources Management, 2000-2025; 1999		X		
Mauritania					X
Morocco	Water Law, 1995	X			
Oman				X	

Table 3.6 (continued)

Country	**Plans/Strategies/Policies/ Documents towards IWRM**	**Status of IWRM Plans Development**			
		1*	2*	3*	4*
Palestine	National Water Plan (NWP); Palestine National Council, 2000. Water Law 3/2002, IWRM Plan 2003, Water Tariff System	X			
Qatar				X	
Saudi Arabia	Phase I: Water Sector Strategy and Action Plan; Ministry of Water and Electricity, 2004		X		
Somalia					X
Sudan	Sudan National Water Policy		X		
Syria	Water Sector Analysis in Syria; Ministry of Irrigation, 2000		X		
Tunisia	The Long Term Strategy for the Water Sector in Tunisia; Ministry of Agriculture, 2003	X			
UAE			X		
Yemen	Country Water Resources Assistance Strategy (CWRAS), Ministry of Water and Environment, 2005. National Water Strategy & Investment Program, Ministry of Water and Environment, 2004. Law 23 for Year 2002 Regarding Water, Ministry of Legal Affairs, 2002	X			

Source: based on information from 4th World Water Forum, Middle East and North Africa Regional Document. Mexico 2006..

Explanations of Columns 1 to 4 Table 3.6:

1 Countries having national water plans, strategies, or policies that incorporate most elements and requirements of an IWRM plan. These countries have on-going committees and/or projects advancing on finalizing their IWRM plans.

2 Countries having water plans, strategies, or policies (not necessarily on a national level) that require major enhancements to satisfy the requirements of an IWRM plan. These countries posses the awareness of the WSSD target for developing IWRM plans and are currently progressing to develop their own IWRM plans.

3 Countries that may not have developed national water plans, strategies, or policies. However, considering the advanced level of country awareness of WSSD target for developing IWRM plans, country water capacity, and national economical standard, these countries are likely to have an on-going attempt to develop their IWRM plans.

4 Countries that may not have developed national water plans, strategies, or policies. However, considering the lagging level of country awareness of WSSD target for developing IWRM plans, country water capacity, and national economical standard, these countries are not likely to have an on-going attempt to develop their IWRM plans.

Wastewater policies across the MENA region need to focus more on integrated management of water resources and on regulation rather than treatment. It is essential to adopt a national policy that devotes appropriate guidelines. Standards specifically related to wastewater reuse should be developed. Wastewater reuse in agriculture has become part of integrated water resource management policies in some MENA countries. In Jordan, wastewater is considered as a resource and it is already included in the national water budget (Box 3.1).

The scientific publications of Qadir et al. 2010, Qadir et al. 2009, Kfouri et al. 2009, Bahri 2009, Redwood 2004, Bazza 2003, Neubert 2002, World Bank and Swiss Development Cooperation Agency 2001 and Bahri 1996 considered Jordan and / or Tunisia as pioneer MENA countries in wastewater reuse in agriculture because they have adopted a national wastewater reuse policy, which became an integral component of the integrated water management strategies.

In this chapter the Tunisian successful experience will be briefly presented and analyzed, while in the next chapter the Jordanian experience, the case study of this work, will be presented and analyzed in details.

Box 3.1: Main Features of Wastewater Management and Reuse Policy in Jordan.

Wastewater Treatment and Reuse Policy:

- Treatment of wastewater shall be targeted towards producing effluent fit for reuse in irrigation in accordance to WHO and FAO Guidelines as minimum.
- The use of treated wastewater in irrigation shall be given the highest priority and shall be pursued with care.
- Effluent quality standards shall be defined based on the best attainable treatment technologies calibrated to support or improve the ambient receiving conditions.
- Treatment technologies shall be selected with due consideration to operation and maintenance and energy savings.
- Jordanian standards are benchmarks against which treatment and reuse were evaluated. They should be reviewed and modified to reflect special ambient conditions or end use.
- "Polluter pays" principal shall be established.

Wastewater Management Policy:

- The role of the government is fine-tuned, and its involvement shall be reduced to be regulatory, and the private sector role shall expand with management contracts, BOT, BOO and other forms of private sector participation.

Source: 4th World Water Forum, Middle East and North Africa Regional Document. Mexico 2006.

The Tunisian Experience in Wastewater Reuse

According to Qadir et al., Tunisia launched its national water reuse program in the early 1980s. Most municipal wastewater is from domestic sources and receives secondary biological treatment and most of Tunisia's treatment plants are located along the coast to protect coastal resorts - that are extremely important for tourism - and to prevent marine pollution. In 2003, 187 MCM (78%) of the 240 MCM of wastewater collected in

Tunisia was treated. About 30 - 43% [6] of the treated wastewater was used for agricultural and landscape irrigation (Qadir et al. 2010).

Regulations in Tunisia do not allow the use of treated wastewater for irrigating vegetables, whether eaten raw or cooked. Therefore, treated wastewater is used to irrigate industrial and fodder crops, cereals and fruit trees. Treated wastewater is also reused in irrigating golf courses.

Tunisia solved the problem of institutional fragmentation in wastewater reuse through establishing an independent wastewater agency that many of the tasks of a number of different institutions were assigned to. One of the important results of this consistent policy is that today about 80% of Tunisia's urban wastewater is treated. Overlapping tasks, which still exist in Tunisia, are coordinated by a committee with representatives from the different ministries and agencies, the municipalities and representatives of the farmers. This committee has been set up at both national and regional levels, which is one important reason that explains why Tunisia is pioneer country in the field of wastewater reuse in the MENA region (Ibid).

In addition to that and to foster the institutional support, in 2002 the Ministries of Agriculture, Environment, and Water resources were consolidated into one single ministry to oversee integrated water resources management and wastewater reuse (World Bank 2005).

Box 3.2: Main Features of Wastewater Management and Reuse Policy in Tunisia.

> Due to water scarcity and the need for new sources for irrigation, Tunisia became one of the first countries in the MENA region to pioneer policy related to wastewater reuse. The reuse of wastewater in agriculture dates back to the early1960's and is increasing. Use of treated effluents is seasonal in Tunisia (spring and summer when irrigation is needed). This can explain the relatively low shares of wastewater reused in irrigation (in 1992 was estimated with 20%).

[6] A World Bank publication in 2005 estimated that only 18 % of the treated wastewater is used in Tunisia.

Box 3.2 (continued)

Part of the success of Tunisia's wastewater reuse policy has been the combination of having a strict national policy regarding the use of raw wastewater, while clearly defining which crops can be irrigated with treated wastewater. Irrigation with wastewater of vegetables that might be consumed raw is prohibited by the National Water Law. The Regional Departments for Agricultural Development supervise all irrigation water distribution systems and enforce the law.

The national strategy for wastewater reuse includes:

- technical aspects (additional treatment, less restrictive reuse, increase of reuse options...etc)
- institutional aspects (improving co-ordination between different water sectors, increasing private sector involvement, cost recovery on equitable and fair distribution of cost)
- social aspects (participation of public and awareness, communication and education)
- environmental aspects (reduce negative impacts, adequate and reliable treatment, health control).
- price incentives (subsidizes the use of wastewater by farmers by paying US\$0.01/m^3, while the treatment cost is US\$0.14/m^3)

Source: Based on information from 4th World Water Forum, Middle East and North Africa Regional Document, Mexico 2006 and Redwood, 2004.

3.7. The Way Forward

Successful wastewater reuse in agriculture can never be achieved without its adoption in a national policy. Responsible authorities should develop appropriate guidelines based on the WHO guidelines. If such capacities within the country are unavailable, authorities should move gradually towards their achievement. In countries that lack treatment facilities, governments should develop a progressive approach by defining the suitable targets, within their abilities, and head for meeting them. Governments should recognize that the prohibition of wastewater reuse is ineffective because it is extremely difficult to impose. Instead, the policy should legitimize wastewater reuse when basic levels of treatment exist.

Such policy consideration can promote better practices and support initiatives to reduce the risks. High treatment levels in wastewater policy are stringent and financially unattainable. Experience proved that strict standards that pay no attention to the reality of national capabilities are useless (Redwood 2004).

Additionally, tariffs for irrigation with wastewater should be introduced, but they should be lower than the tariff of freshwater. It is true that wastewater contains nutrients that can save fertilizer costs for farmers. But in many cases wastewater has a higher degree of salinity which has negative impacts on crop yields. If those conditions are not fulfilled, farmers are not likely to be willing to pay for reclaimed wastewater.

Sufficient treatment is considered the ideal solution to most of the problems associated with wastewater reuse in agriculture. However, experiences in the MENA region and other poor developing countries demonstrate that adequate wastewater treatment is far beyond the financial capability of the vast majority of these countries. On the other hand, in water scarce countries farmers will continue to use untreated wastewater for irrigation. To overcome this dilemma, governments must adopt appropriate wastewater policies and develop suitable guidelines to mitigate health risks associated with wastewater reuse in agriculture.

Also, experiences with wastewater reuse differ from one MENA country to another. The Tunisian example shows that the strong institutional setting and governmental support are major prerequisites for practicing planned wastewater reuse through specifically designed projects to treat and distribute treated wastewater for irrigation. However, this can never guarantee high demand for treated wastewater by the agricultural sector.

Other countries are practicing partly planned reuse of wastewater. This is the case in Jordan, where almost all sewage collected and treated is being reused in agriculture. However, treatment levels are sometimes insufficient and effluent usually is discharged into watercourses to get diluted before being reused for irrigation (World Bank 2001).

It can be concluded that there are different reasons behind the very low demand for treated wastewater in Tunisia (World Bank estimated that only 18% of the treated wastewater is reused). Most importantly is the restrictions imposed on farmers from reusing wastewater in irrigating vegetables that they consider a valuable source of income.

Kfouri et al. also noticed that water scarcity in Jordan is much higher that it is in Tunisia. In Tunisia the renewable freshwater available is about 450m^3/capita/year, while in Jordan it is 150m^3/capita/year. Also, in the year 2002, Tunisian withdrawals were about 58% of the total renewable resources and in Jordan it was 116% for the same year. In addition farmers in Tunisia have alternative water sources and can decide on the quality of water they want to use. Unlike Jordanian farmers who have no other alternative since wastewater replaced freshwater resources that were used by them and were pumped to the municipal sector (Kfouri et al. 2009). This is consistent with the first hypothesis of this research. It assumes that the extent of conflict over freshwater resources between the water sectors can foster wastewater reuse in agriculture.

As discussed in this chapter, many MENA countries view wastewater as a major source for irrigation. However, the share of wastewater reused in agriculture in the region remains low. Different factors were discussed and it was concluded that one of the main obstacles for the promotion of wastewater reuse is the lack of national or local policies in most of the countries, resulting in a lack of clear guidelines that can promote wastewater reuse in agriculture.

4. Wastewater Management and Reuse in Jordan

4.1. Background

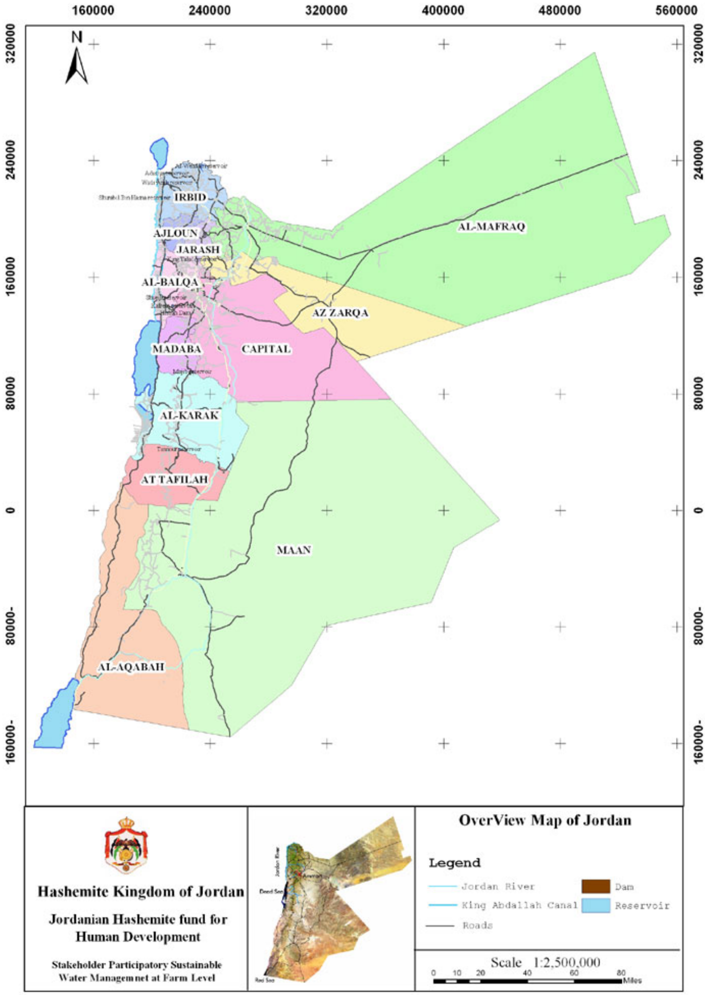
The Hashemite Kingdom of Jordan has a total area of about 89 342km^2, and is administratively divided into 12 governorates. These are Amman the capital, Zarqa, Irbid, Balqa, Madaba, Mafraq, Jarash, Ajloun, Karak, Tafiela, Ma'an and Aqaba. (Map 4.1)

The population of Jordan reached approximately 5.6 million inhabitants in the year 2006 with a high population growth rate about 3.5%. Additionally, the waves of refugees that arrived due to the different wars that occurred in the region have resulted in unpredicted population growth.

About 70% of the total population of Jordan lives within urban areas (Figure 4.1). The population is concentrated within the two main cities, Amman, the capital, and Zarqa are inhabited with about 53.7% of the total population. About 91% of the population lives in the north - western part of the country (Table 4.1). This settlement pattern is hugely influenced by the availability of water resources. This uneven distribution necessitated the costly process of conveying water resources for long distances in some areas, these distances exceeded 100 km in order to meet the increasing demand (EMWIS 2006).

Jordan can be divided into three main topographic and therefore different climatic zones. Firstly, the mountain region that forms the central part of the country and is inhabited by most of the population, living in the cities of Amman, Zarqa, Irbid and Karak. This mountain region extends between the northern and southern parts of the country with elevations between 1200 - 1500 meters above sea level. The mountain region receives the highest amounts of rainfall that passes as surface water through the slopes towards the Jordan Valley.

Map 4.1: Overview Map of Jordan



Source: The Jordanian Hashemite fund for Human Development.

Table 4.1: Estimated Population of Jordan by Governorate for the year 2006

Governorate	Total (1000)	% of Total
Amman	2172.8	38.8
Balqa	375.2	6.7
Zarqa	834.4	14.9
Madaba	140	2.5
Irbid.	996.8	17.8
Mafraq	263.2	4.7
Jarash	168	3.0
Ajloun	128.8	2.3
Karak	218.4	3.9
Tafiela	78.4	1.4
Ma'an	106.4	1.9
Aqaba.	117.6	2.1
Total	5600	100

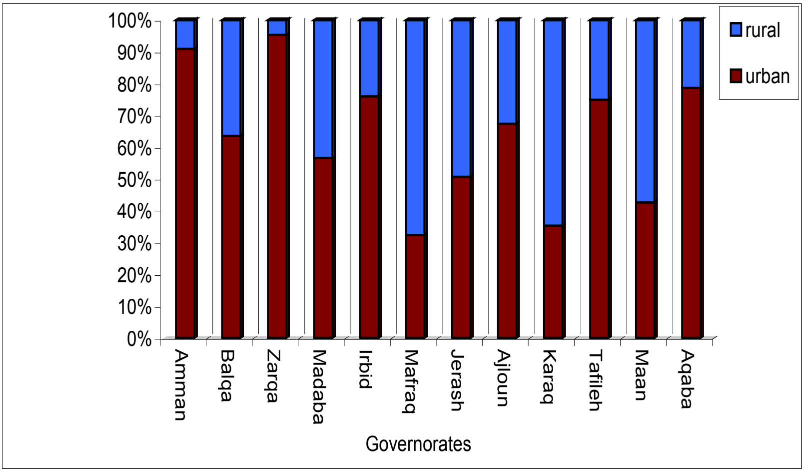
Source: Department of Statistics, Census 2006.

Secondly, the Jordan Valley region, which is the most cultivated area, located in the western part of Jordan. The Jordan Valley extends from Lake of Tiberias in the north and passes through the Dead Sea, the lowest point on earth, to end south at the Gulf of Aqaba on the Red Sea. The importance of the Jordan Valley derives from the Jordan River that is the country's main resource of surface water.

Thirdly, the Desert Region, which is the largest region; covering between 75% - 80% of the total area of Jordan and is located at the eastern part of the country. The Desert Region receives few amounts of rainfall. Therefore Jordan's climate can be described between arid to semi-arid climate, where summer is hot and dry and winter is relatively cold, with two short autumn and spring seasons.

The temperatures vary from one region to another. The only region in the country that enjoys a Mediterranean climate is the mountain region. The mean summer temperature is 25°C, while it drops in winter to around 8°C. The maximum temperature during summer months can reach up to 40°C, with relative humidity that makes high temperatures more tolerable. In winter, it may reach up to few degrees below 0°C.

Figure 4.1: The Percentages of Urban and Rural Population in Governorates of Jordan



Source: Bataineh et al. 2002.

South from the Jordan Valley towards Aqaba on the Red Sea, the climate gets very hot and arid in summer. The temperature may reach 45°C. The annual average temperature is 24°C. In winter, temperature may drop down to few degrees above 0°C and frost might sometimes take place in the region.

The climate in the desert region is like in the Jordan Valley hot and arid in summer. There is a vast difference between day and night temperatures. In summer, day temperature exceeds 40°C. It is not uncommon that night temperatures in winter season drop below 0°C.

Likewise the temperature, precipitation in Jordan varies from one region to another according to the topographic characteristics of the each region. While snow falls sometimes on the high mountains, more than 90% of the total area of the country receives less than 200mm of rainfall annually. In general, rainfall in Jordan decreases from north to south and from west to east. Rainfall mostly takes place during autumn and winter months.

In the Jordan Valley area, the annual rainfall ranges between less than 100mm to maximum 400mm in few areas. The average annual rainfall in the Jordan Valley is about 250mm per year. In the desert region rainfall amounts are very low. Most of the region receives less than 100mm of rainfall per year.

The mountain region receives the highest rainfall amount in the country. Rainfall usually extends between October and April every year, the highest amounts of rainfall during the months of January and February. Ajloun Mountains receive the maximum amounts of rainfall, approx. 600mm per year, while in Amman the average precipitation rate is 400mm.

However, nearly 85% of the rainfall evaporates. Only a small share flows into rivers (about 11%) or recharges groundwater resources (about 4%) (EMWIS 2006).

4.2. Water Resources

The geographic location of Jordan, its climate, annual rates of precipitation, its high evaporation rates and the lack of surface water resources like lakes or rich rivers in addition to the high population growth rate, make Jordan one of the most water scarce countries worldwide. The total renewable freshwater resources in Jordan were estimated in the year 2002 at 850 MCM. The share of capita was estimated 167 m^3/capita/year (Abedel Khaleq and Dziegielewski 2006). (Kfouri et al. 2009, estimated the share with 150 m^3/capita/year).

Jordan shares its two main surface water resources with its neighboring countries: The Jordan River at the western border of the country and the Yarmuk River at the northern border.

Additionally, Jordan shares, in some areas, its groundwater resources with other countries. For example in the Disi area, fossil groundwater is shared with Saudi Arabia. The recharge of some groundwater aquifers, like in the Yarmuk basin, takes place beyond the country's territories.

4.2.1. Water Demand and Supply

Jordan faces a clear gap between the demand on water and its supply (Table 4.2) due to the lack of surface water resources and its deteriorated quality, the high population growth and urbanization rates. The country has to depend to a large extent on groundwater resources to satisfy its demand for water. This resulted in the excessive use of some fossil water and groundwater resources beyond their safe yield capacity.

Table 4.2: Projected Supply, Demand and Deficit

Year	Supply(MCM)	Demand(MCM)	Deficit (MCM)
1995	882	1,104	(222)
2000	960	1,257	(297)
2005	1,169	1,407	(238)
2010	1,206	1,457	(251)
2015	1,225	1,550	(325)
2020	1,250	1,658	(408)

Source: EMWIS 2006 and Alkhaddar et al. 2005.

In average, the total renewable freshwater resources of the country amount to 750 MCM per year, while the average per capita share of water is 160 m^3/year and declines at an equal rate of the population growth, which is approximately 3.5% (EMWIS 2006).

Water resources in Jordan consist mainly of surface water resources and groundwater resources in addition to treated wastewater, which is mainly used for irrigation in the Jordan Valley after being blended with freshwater.

Jordan's total water resources consist of surface water estimated with about 692 MCM/year, groundwater about 277 MCM/year, fossil aquifers about 143 MCM/year and brackish aquifer about 50 MCM/year. The brackish aquifer is not yet fully exploited and would be suitable for use after desalinization (Ibid).

4.2.2. Surface Water

Jordan lacks any rich regional or local river. However, the Jordan and Yarmuk Rivers are the country's most important water resources which are shared unequally with neighboring countries.

Jordan's water resources are distributed unevenly on 15 different basins. The Yarmuk Basin is considered Jordan's major source of surface water, contributing with about 40% of the total annual surface water resources. This also includes water contributed from the Syrian part of the Yarmuk Basin (Bilbeisi 1992).

While the water of the Jordan River is saline (due to water discharged from saline springs) and polluted (due to release of insufficiently treated wastewater) it is not suitable for use without treatment. The water quality of the Yarmuk River is greatly better.

The Yarmuk River is the main water provider to King Abdullah Canal. This is considered vital for water distributed for agricultural irrigation in the Jordan Valley. The Canal is 110 km long and was constructed on several phases. In 1957 was the first construction phase and the completion was in 1988.

Other surface water resources are the heavily polluted Zarqa River, which is the second source- after the Yarmouk River - of surface water supply for Jordan. The catchment area for the Zarqa River is the most densely populated area in Jordan; it inhabits about 65% of the total population. Furthermore, almost 80% of the country's industries are located within the area. The river flow increases by insufficiently treated wastewater discharged from wastewater treatment plant, and other effluents discharged from industries which do not meet the required standards. (Tutundjian 2001).

The flow of the Zarqa River ends in King Talal Reservoir, where the large quantities of wastewater and industrial effluent mix up with freshwater from the reservoir. The percentages of the insufficiently treated wastewater to freshwater in King Talal Reservoir vary from 45-50% wastewater in winter to 55-60% in summer. The diluted water is principally used for irrigation in the area of the Jordan Valley (Ibid).

The Jordanian government almost fully utilized surface water resources. In order to store water that flows in wadis before being discharged into the Dead Sea or the Jordan River, a number of dams were constructed, mainly used for irrigation purposes in different wadis in the Jordan Valley.

4.2.3. Groundwater

The main source of water in Jordan is the groundwater. Groundwater resources are distributed among twelve groundwater basins, consisting of several groundwater aquifer systems. About 80% of Jordan's groundwater resources are located within three major aquifer systems, which are Amman - Wadi As Seer, Basalt and Rum Aquifer (EMWIS 2006).

Jordan does not only share its surface water resources, but also its groundwater resources. The recharge of some groundwater aquifers takes place beyond the Jordanian territories i.e. the Yarmuk Basin. Also, Jordan shares its major non-renewable fossil aquifer in Disi area with Saudi Arabia.

Groundwater resources in Jordan consist of two main types, renewable groundwater resources and non-renewable or fossil groundwater resources. The renewable groundwater resources are rechargeable aquifers by annual rainfall, surface water flows, irrigation or artificial recharge with either freshwater or treated wastewater. The amount of water that can be safely withdrawn each year from the renewable groundwater aquifers depends on the amount of recharge that the aquifer receives.

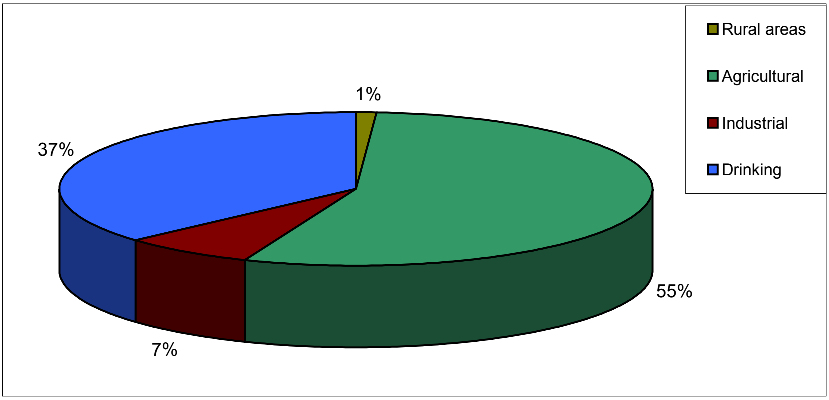
The other type of groundwater resources is the non-renewable fossil water resource in deep aquifers. They were formed in earlier ages when different climatic conditions existed in the area. At present, these fossil aquifers have no, or in few situations very few recharge rates.

The major non-renewable groundwater aquifer in Jordan is located in the southern part of the country in Disi area. This fossil aquifer is shared between Jordan and Saudi Arabia and supplies Aqaba, coastal town on the Red sea, with 14 MCM/year for municipal and industrial uses and 51 MCM/year for irrigation purposes. Studies have concluded that the annual safe yield of 125 MCM can be supported over a 50 year period. At the time being, a large project is under construction to convey Disi water to Amman for municipal use. In Saudi Arabia, annual abstractions are estimated to exceed 700 MCM/year. The second non-renewable aquifer in Jordan is located in Jafer basin. It is estimated that this aquifer can supply Jordan with 18 MCM/year over the next 40 years (Tutundjian 2001).

More than 50% of the total groundwater resources are being used for irrigation (Figure 4.2). The quantity of groundwater exploited for agriculture in all parts of Jordan in the year 2000 was estimated 252 MCM.

Since the 1980s, Jordan has overexploited some of its groundwater resources, exceeding their safe yield. This resulted in the significant deterioration in groundwater quality, increasing salinity and the decline of groundwater levels within the aquifers. In the future it will endanger the sustainable use of these resources. In other cases, the over extraction resulted in the abandonment of many municipal and irrigation water wells. Therefore, groundwater resources should be preserved and used in a sustainable way.

Figure 4.2: The Percentages of Groundwater according to its Usage



Source: Bataineh et al. 2002.

4.2.4. Wastewater

As the demand of the municipal sector and the urbanization rate in Jordan is increasing constantly, the volume of generated wastewater also grows. If sufficiently treated, wastewater will be suitable for different uses depending on the level of its quality. Common uses of wastewater are in irrigation, industry and aquifer recharge.

Wastewater in Jordan is collected and treated in sixteen wastewater treatment plants. The As-Samra wastewater treatment plant is the largest in Jordan and the major provider with treated wastewater for agricultural reuse in the Jordan Valley. Due to the urban population concentration, the plant currently serves about 70% of Jordan's connected population and treats about 76% of the total wastewater that Jordanian treatment plants receive.

Treated wastewater is considered an important component of Jordan's water resources. According to FAO estimates, the amount of wastewater generated in Jordan for the year 2005 was about 107.4 MCM, of which about 83.5 MCM were used in the same year. By the year 2020, it is expected that the volume of available treated wastewater will increase to 220 MCM/year. The largest portion of the treated wastewater will continue to be used in irrigation and will substitute the demand on renewable groundwater resources (EMWIS 2006).

4.3. Water Use

Due to water scarcity in Jordan and the deficits between water demand and supply, competition among the different water sectors became intense. Demand on water is constantly increasing while water resources are limited. Therefore, water allocation among the different water sectors requires effective planning and efficiency. Table 4.3 shows the water use in Jordan according to source and sector for the year 2007.

There are different projections and estimations on the amounts of future demand and supply for water. However, all of the projections agree that there is an alarming gap between demand and supply and bridging it will not easily be achieved (World Bank 1997).

4.3.1. Municipal Water Use

Water demand of the municipal sector is rapidly increasing at about 7.4% per year. This is due to the high population growth and urbanization rates. According to the World Bank estimation in 1997, the average daily supply for the municipal water sector was is 157liter/capita/day. In their study, Bataineh et al. estimated the average per capita per day share of drinking water was 125liter for the year 2000. While the annual report of the WAJ for the year 2006 indicated that the average daily supply for the municipal water sector was 139liter/capita/day (World Bank 1997; Bataineh et al. 2002; WAJ 2006).

Although the above mentioned figures are considered very low, the real per capita consumption is much lower than that. About 52% of the supplied water is unaccounted for and is lost before reaching the consumers through leakages in the public water networks.

Table 4.3: Sources of Water Use in Jordan for the Year 2007

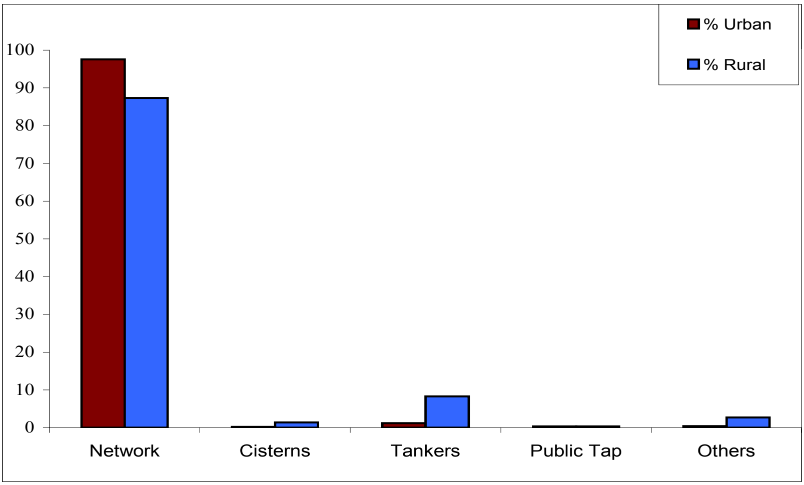
Source	**Uses MCM**				**Total uses MCM**
	Municipal	**Industrial**	**Irrigation**	**Livestock**	
1- Surface Water	**79.75**	**4.3**	**253.85**	**7**	**344.88**
• Jordan Valley	40.6	3.53	176.4	0	220.53
• Spring	39.15	0.76	36.7	0	78.6
• Base & Flood	**0**	0	40.75	7	47.75
2- Groundwater	**214**	**44.894**	**244.81**	**0.745**	**504.45**
• Renewable	185.805	29.591	202.896	0.681	430.154
• Nonrenewable	28.195	15.303	41.913	0.064	74.29
• Desalination	11.181	0	0	0	0
3- Treated Wastewater	**0**	**0**	**90.97**	**0**	**90.97**
Total	**293.75**	**49.194**	**589.63**	**7.745**	**940.3**

Source: MoWI 2007.

During more than six months, demand of the municipal sector for water can not be met. Water consumption is reduced by providing discontinuous supply for households. Water is available once or twice every week and therefore should be stored in roof tanks to be available when water supply through network is interrupted. About 8.3% of the households in rural areas purchase water from private vendors via tanker trucks (World Bank 1997) (Figure 4.3).

Almost 75% of the water used for in this sector is groundwater. According to the WAJ's annual report 2006, almost 97% of the urban and rural population were connected to the municipal network in Jordan in the year 2005 (WAJ 2006).

Figure 4.3: Water Supply Methods in Urban and Rural Areas in Jordan



Source: Bataineh et al. 2002.

4.3.2. Agricultural Water Use

The semi-arid climate and low amounts of rainfall that Jordan receives causes difficult problems for the agricultural sector without irrigation. Therefore, the agricultural water sector consumes, since many years, much larger water amounts than other sectors. Irrigated agriculture in Jordan depends mainly on groundwater water resources in the highlands. Surface and groundwater resources are used in the Jordan Valley.

Irrigated agriculture has been practiced in the Jordan Valley since ancient times. Archaeological remains of irrigation networks and water storage systems that were constructed before Christian times can still be seen.

In the Jordan Valley, the government also supported agricultural activities since the late 1950s. The major objective was to secure stable agricultural production in a desert country and to secure jobs for the growing population (Abu-Sharar and Battikhi 2002).

The major irrigation project was initiated in 1954/1955 by a U.S. grant to the construction of East Ghor Canal, renamed King Abdallah Canal Project in 1986. The project and an extension of it took place between 1959 and 1988 with grants and loans from different donors as USAID, KfW, Kuwait Fund, Saudi Fund, and Government of Italy. Later on, between 1986 and 1996 the Government of Jordan received loans and grants from the Arab Fund and the Government of Japan to rehabilitate the older parts of the project and to upgrade the surface canal networks into pressure pipe distribution networks. Consequently, the population of the Jordan Valley increased by almost four-fold from 70,000 in 1973 to about 220,000 in 2001 (Ibid).

The practice of crops irrigation with groundwater in Jordan goes back to the 1960s when the governmental institutions dug pilot wells for irrigation. Later on, both individual farmers and the private sector obtained licenses to dig wells for vegetables plantation in the desert areas at the expense of renewable and non-renewable groundwater resources (Al-Hadidi 2002).

The governmental desire to promote irrigated agriculture in order to achieve self sufficiency and additional employment in the rural areas was at the cost of Jordan’s very limited water resources. They became overexploited (World Bank 1997).

In the year 1985, the Government encouraged agricultural utilization of non-renewable fossil water resources to cultivate vegetables within desert areas that are located far away from population centers. Licenses were issued for a number of agrarian companies, the major agricultural investors in Jordan. The quantity of water exploited for this purpose was estimated at 50 MCM per year. Digging wells for agricultural purposes became uncoordinated and went out of control. The policy harmed groundwater resources. In 1992, digging new wells for agricultural purposes was prohibited all over the country (Al-Hadidi 2002).

A study of the World Bank indicated that highland irrigation expanded from 3,000 ha in 1976 to reach about 33,000 ha in 1997 (World Bank 1997).

However, since the mid-1980s, agricultural production in Jordan faced many obstacles. The major constraint was crops marketing in the neighboring Gulf countries, the chief importer of Jordanian crops. The situation worsened during the 1990s and farmers suffered from the low economic returns especially after the Second Gulf War 1990/1991 (Abu-Sharar and Battikhi 2002).

The World Bank described the state of water resources in Jordan and the situation of the agricultural sector during the 1990s:

> *"The water sector was in serious trouble. Sound water and agricultural management is important to the Jordanian economy. In the early 1990s, agriculture generated about 8 percent of GDP and 14 percent of employment and used 75 percent of Jordan's water for irrigation. Yet national water consumption was 60 percent above sustainable levels, a situation likely to get worse with a high rate of population growth and rapid urbanization. Heavy agricultural subsidies, import restrictions and low water tariffs provided few incentives for more water-efficient and higher productivity agriculture and this hindered development of efficient markets and export potential. The Jordan Valley Authority (JVA), responsible for all development in the valley, recovered only 10 percent of its costs from users, and as the nation's irrigation agency, it was able to collect only 18 percent of operation and maintenance costs"* (World Bank 2003).

The reform in the water and the agricultural sectors was extremely important. Water use among the agricultural sector was not optimal. In 1997, the World Bank published the report "Water Sector Review" for Jordan containing a reform program for the Jordanian water sector. It analyzed various problems and suggested more than 50 practical recommendations. The report stated that the reform program will be painful for many, but necessary. Wastewater is an undervalued resource was one of the main findings. High priority was given to the policy and strategy for wastewater treatment and reuse (World Bank 1997).

4.3.3. Industrial Water Use

Industry consumes only about 5% of the water supply. More than half the industrial use of water is devoted to the potash and phosphate industries in the southern parts of Jordan. The remainder share is used for electrical power plants.

4.4. Water Pricing

Water is a relatively expensive commodity in Jordan due to the limitation of availability. For municipal and industrial uses water must be either abstracted from deep boreholes in the highlands or pumped from the Jordan Valley, a lift of 1,350 meters total dynamic head (Ibid.). The cost of water treatment and distribution is relatively high in Jordan.

The Government argues that Jordanian consumers' ability to pay is lower compared to the mean per capita share of national income. Hence, the consumers are not able to fully cover the real costs of water. Water is heavily subsidized in municipal, industrial and irrigation water sectors. Thus, revenues - till the time being - do not fully cover O&M in addition to the capital costs in all water sectors.

In general, the long term objective of the Jordanian national water pricing policy is to cover O&M costs. Also - with the highest possible percentage - the capital costs of water supply and wastewater collection and treatment. However, MoWI realized that this aim will be impossible to achieve if the different water tariffs will remain low. Therefore, an increasing block tariff structure is adopted. It imposes higher charges for higher water consumption in order to create strong incentive for water conservation among the different sectors.

The Government’s annual subsidies to the main two institutions WAJ (responsible for water supply for the municipal sector) and JVA (responsible of irrigation water supply in the Jordan Valley) is estimated with about 60 million JD, of which three quarters is to support WAJ. Only 50% of the total cost (O&M cost + depreciation + interest payments) of water sector operations are covered from tariffs and other related fees (MoWI/GTZ 2004).

It is worthwhile to point out that WAJ has already achieved O&M cost coverage in water supply, wastewater collection and wastewater treatment. On the contrary, the financial performance of JVA shows a deteriorating situation with a continuous decline of the O&M cost coverage ratio from 34% in 1997 to 21% in the year 2000, leaving the rest of the amount to be subsidized by the Jordanian treasury. In addition, there are indirect energy subsidies given to farmers reaching a sum of 4 million JD annually (Ibid.).

The reform in water pricing is always considered a very sensitive issue in Jordan. The World Bank indicated that the government was reluctant to undertake quick reforms of water tariffs. Especially rising irrigation water prices is a politically sensitive problem, while pricing subsidies regarded as extremely important for protecting rangeland farmers (World Bank 2003).

The World Bank and other lenders - such as KfW - considered increasing water tariffs within the different water sectors - to achieve cost recovery of water services - as a crucial condition in offering new loans for the development of the water sector in Jordan. Under this pressure from donors and lending organizations, the Council of Ministers issued a new water tariff in 1997. Though, the amount of tariff increase was seen by the lending institutions as inadequate on the long run for full cost recovery. On the other hand, the process and the amount of an increased water tariff proved to be a factor of difference and disagreement among the World Bank and KfW for funding the new phase of the Agricultural Sector Adjustment Loan to Jordan.[7] In the assessment report for this project, the World Bank admitted that its credibility has been harmed since it supported unrealistic targets linked to the wrong instruments (World Bank 2003).

The appropriateness of the current water pricing for agricultural and other water sectors and its political sensitivity remains a major policy question for policy makers in Jordan.

4.4.1. Municipal Water Tariffs

It is estimated by WAJ that about 97% of the total population of Jordan is served with piped water networks (WAJ Annual Report 2006). However, it

[7] See World Bank report on Agricultural Sector Adjustment in Jordan during the mid-1990s.

should be noted in this context that the water quantity billed by WAJ is roughly only half of the quantity produced due to technical losses through leakages in the public water networks. Financial losses result from the illegal connections and the inefficient billing system. This means that WAJ loses half of its potential income - around 50 million JD - to the virtual "Unaccounted for Water consumer" (MoWI/GTZ 2004).

As mentioned before, the Jordanian government increased water tariffs so that the average rate of the lowest consumption block reaches US$ 0.49/m^3 (Table 4.4). Salman et al. (2006) estimate that the water users in the municipal sector are able to pay about 2% of their total income for water and wastewater services. They also estimated that at the time being, households pay about 1.34% of the total expenditures on water and wastewater services. Therefore Salman et al. believe that there is potentiality for an increase on the current water tariffs (Salman et al. 2006). Almost 55% of the total water charge is added to the water bill for paying the wastewater collection and treatment services.

Table 4.4: Development of Average Municipal Water Charges from 1980 to 2003 in US$/$m^3$

Water Block (m^3)	**Block midpoint (m^3)**	**1980 - 1985**	**1986 - 1988**	**1988 - 1990**	**1990 - 1996**	**1997 - 1999**	**1999 - 2001**	**2001 - 2003**
0 - 20	10	0.30	0.28	0.28	0.28	0.41	0.41	0.49
21 - 40	30	0.32	0.27	0.24	0.24	0.24	0.24	0.31
41 - 70	55	0.44	0.40	0.38	0.38	0.41	0.68	0.72
71 - 100	90	0.58	0.55	0.54	0.58	0.62	1.10	1.12
101 - 150	125	0.72	0.71	0.69	0.78	0.82	1.37	1.38
151 - 250	200	0.81	0.83	0.83	0.95	1.03	1.75	1.77

Source: Salman et al. based on information from WAJ 2004.

4.4.2. Agricultural Water Tariffs

At the beginning of the 1990s and after the 1991 Gulf war, the Jordanian water sector was facing different problems. The World Bank and other donors reported that the main problems identified were in the lack of a national water policy and the competition among the different sector institutions. Agriculture consumed about 75% of Jordan's water for irrigation purposes and the water consumption was about 60% beyond sustainable levels. Additionally, the low water tariffs for irrigation provided few incentives for using water efficiently. Therefore, pricing irrigation was chosen as an instrument to reduce demand for water (World Bank 2003).

The MoWI opposed a large increase in water tariffs. Since the World Bank and other donors insisted on the raise, the government agreed to heighten the tariff gradually. The water tariff was raised in 1995 for more than double. Still, the tariff charged did not cover O&M costs (Ibid.). The average price for agricultural water users increased from about US$ 0.0052/m^3 in the year 1989 to US$ 0.031/m^3 in 1995 and reached about US$ 0.04/m^3.in the year 2000 (Salman et al. 2006, based on information from JVA 2005). Table 4.5 shows the actual tariffs for agricultural water use.

Table 4.5: Tariffs for Agricultural Water Use in Jordan (Freshwater or Water Blended with Treated Wastewater)

Block (m^3)	**Tariff**
0 - 2500	08 fils/m^3
2500 - 3500	15 fils/m^3
3500 - 4500	20 fils/m^3
> 4500	35fils/m^3

Source: Taha and Bataineh 2002.

4.4.3. Industrial Water Tariffs

Generally, industrial, commercial and tourist enterprises pay higher tariffs than households for water amounts that they receive from WAJ. The average tariff for such establishments is about 300 fils/m^3 (Taha and Bataineh 2002).

4.5. Wastewater Management and Reuse

4.5.1. Wastewater Collection

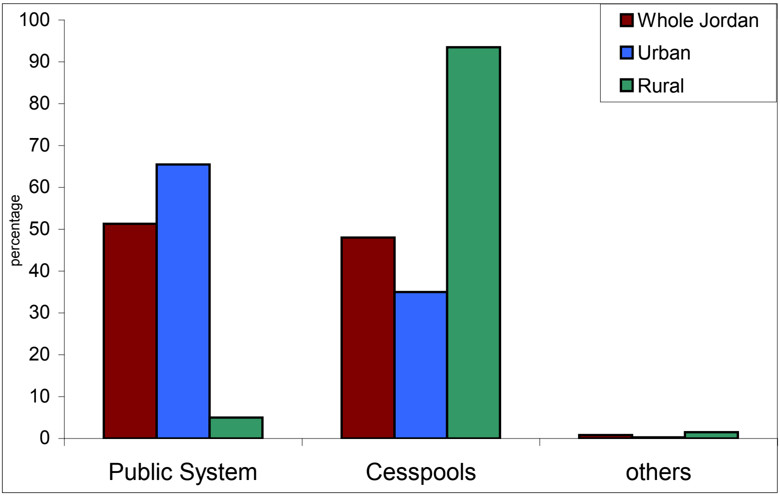
The beginning of wastewater collection goes back to 1930 where simple sanitation infrastructure existed in the town of Salt in Jordan. Wastewater had been collected and some treatment had been practiced by primitive physical processes. Mainly, wastewater had been collected in septic tanks and cesspits and was later on discharged to gardens causing environmental problems and polluting groundwater. Pollution due to lack of sanitation and wastewater treatment became more severe by the rapid population growth. For example, the population of the Jordanian capital, Amman, increased from 50,000 inhabitants in 1940 to reach 800,000 in the year 1985 (MoWI 1998).

The first collection system in Jordan was constructed in the late 1960s. It consisted of a sewage network that collected and transported wastewater by gravity to the lowest point in Amman, where the first treatment plant was built (Ibid.).

During the United Nations International Drinking Water and Sanitation Decade (1980-1990), the Government of Jordan carried out significant and comprehensive plans related to the different issues of wastewater management and the improvement of sanitation. Almost 65% of the urban population and 50% of the total population of Jordan was served with wastewater collection and treatment systems (Bataineh et al. 2002). Another factor that necessitated the expansion of wastewater networks and wastewater treatment was the cholera outbreaks that took place in 1978 and again in 1981 (Haddadin and Shteiwi 2006).

Due to the raise in wastewater collection and treatment levels, public health was improved and pollution of surface and groundwater resources within the areas served by wastewater facilities was immensely reduced. At the time being, about 51% of the total Jordanian households (of which about 65% are located in urban areas) are served with public sewerage systems. The large majority of the rural population (about 93.5%) is served with cesspools (Figure 4.4).

Figure 4.4: Methods of wastewater disposal in Jordan



Source: Bataineh et al. 2002.

However, a joint study that was conducted by FAO and WHO in 2003 indicated that the difference between produced wastewater and collected wastewater is quite huge. The study reported that wastewater produced in Jordan was about 300 MCM 1993 and the volume of treated wastewater available was about 50 MCM in the same year, and 69 MCM in 1995 (FAO/RNE and WHO/EMRO 2003).

4.5.2. Wastewater Treatment

As mentioned in chapter 4.5.1, the first wastewater collection system and a treatment plant was established at Ain Ghazal area, utilizing the conventional activated sludge treatment process. The network transferred collected sewage by gravity force to the treatment plant. It was designed with an average capacity of 60,000m^3/day for a population of 300,000 people. The treated effluent was discharged to Seil Zarqa. The quality of the effluent of Ain Ghazal wastewater treatment plant deteriorated tremendously due to the high concentration of the raw sewage. This resulted in bad odors and deterioration in the surface and groundwater resources in the area near the treatment plant (Bataineh et al. 2002). Therefore, the Ain Ghazal wastewater treatment plant was taken out of service and its wastewater load was transferred to As-Samra treatment plant.

The first relatively large wastewater treatment plant was constructed in 1985 at Khirbit As-Samra as a short term solution before designing a more efficient treatment plant. This treatment plant became permanent and was overloaded in short time with amounts of wastewater that are beyond of the treatment capacity (Haddadin and Shteiwi 2006).

This dramatic increase of wastewater amounts was connected to the rapid population growth. The diversion from the Ain Ghazal treatment plant to As-Samra treatment plant increased sewage amounts pumped by tanks and dumped into the As-Samra wastewater pond.

Now, As-Samra treatment plant receives about 75% of Jordan's generated wastewater amounts. When constructed in 1985, the design capacity of As-Samra was 68,000m^3 /day. At the time being it receives 186,081m^3 /day. The overload of the treatment plant resulted in a poor quality effluent. Replacement of existing wastewater treatment plant, to be constructed, operated and maintained according to a 25-year (BOT) agreement. Total budget for the project is US$169 million, almost half of which financed by USAID. The project was officially opened in August 2008.

At the time being, there are 19 wastewater treatment plants (Map 4.2) distributed among the cities and towns in Jordan. It is estimated that only about 60% of the amounts of water supplied to households return as wastewater to treatment plants. The difference is mainly lost due to leakages in the sewers system.

Some of the wastewater treatment plants in Jordan are overloaded and operate beyond their design capacity due to the increase in population. This situation led into huge variation in the efficiency of the plants and into the effluent quality that is discharged (Table 4.6). Most of the overloaded treatment plants do not meet the standards set by the government. (Table 4.7 shows existing wastewater treatment plants in Jordan, operation year and the type of treatment).

This resulted in major health and environmental problems, such as the cholera outbreaks in the years 1978 and 1981. As-Samra treatment plant was a major source for environmental pollution, because of the insufficiently treated effluent that was discharged into the Zarqa River and the odor that was produced by the plant.

Other environmental problems caused by insufficiently treated wastewater are the groundwater contamination especially in areas of where cesspools exist and wastewater infiltrates into the groundwater.

Therefore, treatment plants are being or have been already upgraded, especially As-Samra. The As-Samra project is the first Jordanian experience in involving the private sector in wastewater management and treatment services under BOT system.

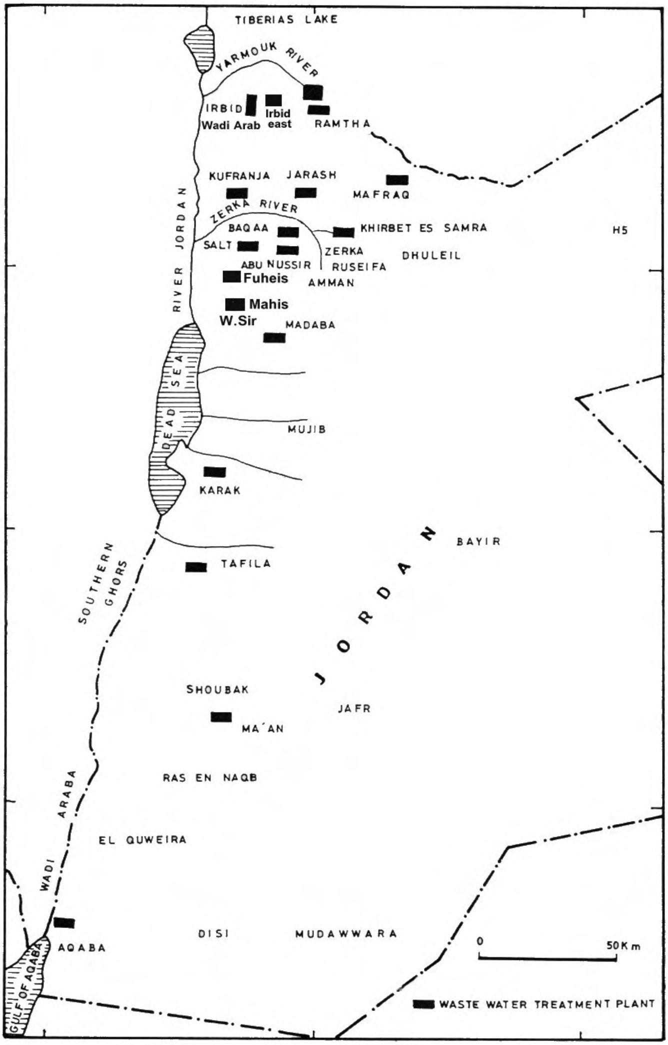
According to a report prepared by the MoWI, amounts of collected wastewater are expected to increase annually by about 2.5% due to the construction of new wastewater networks, maintenance of existing ones and the connection of new households to the sewers network. It is also estimated that the inflow of wastewater into treatment plants will increase from 146 MCM in the year 2005 to reach about 247 MCM in the year 2020 (Figure 4.5).

4.5.3. Wastewater Treatment Costs

Households pay almost 55% of the total water bill for wastewater collection and treatment services. The treatment and collection costs are only paid for water supplied by water networks. Households that purchase additional amounts of water, or depend completely on water from tankers do not pay any charges for wastewater collection and treatment.

Raw wastewater quality in Jordan is classified as strong, with high concentrations with BOD_5 . This is mainly caused by the very low per capita consumption of freshwater as a consequence of water scarcity. This results in higher cost of wastewater treatment per cubic meter.

Map 4.2: Location of the Main Municipal Wastewater Treatment Plants



Source: EMWATER Project 2005.

Table 4.6: Existing Treatment Plants, their Design Capacity, Number of Population and Wastewater Production

Plant	**Design Capacity m^3/d**	**Inflow m^3/d**	**BOD_5 g/m^3**	**Population Served**	**Average L/C/d***
As-Samra	68000	186081	709	1,830,000	102
Irbid	11000	5081	1173	91,692	55
Aqaba	9000	9310	373	53,400	174
Salt	7700	3598	868	48,000	75
Jerash	3500	2743	1231	52,000	53
Mafraq	1800	1892	683	19,880	95
Baqa'a	12000	11516	1026	181,800	63
Karak	785	1275	697	11,900	107
Abu-Nuseir	4000	1800	522	15,300	117
Tafila	1600	736	630	14,500	60
Ramtha	1920	1888	849	25,500	75
Ma'an	1600	1556	518	12,400	125
Madaba	2000	4611	927	65,800	70
Kufranja	1900	1863	1186	34,000	55
Wadi Al-Sir	4000	1401	431	9,300	150
Fuheis	2400	1217	750	14,000	86
Wadi Musa	3400	532	608	5,400	98
Wadi Hassan	21000	280	978	4,200	66
Wadi Arab	1600	5735	653	57,600	100
Total		216420		2,612800	95

* L/C/d: Liter/Capita/day
Source: Bataineh et al. 2002.

Table 4.7: Existing Wastewater Treatment Plants in Jordan, Operation Year and the Type of Treatment

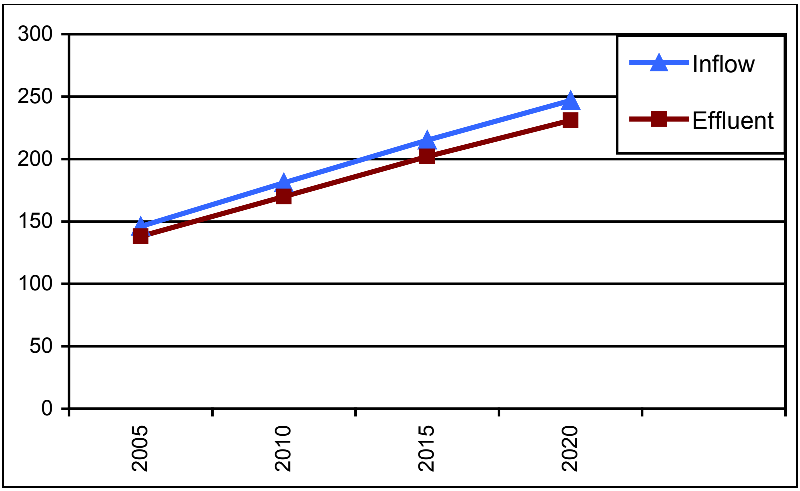
Plant	**Operation**	**Type of treatment**
As-Samra	1985	WSP
Abu Nusir	1988	A.S
Wadi Al Sir	1996	Aerated Ponds
Wadi Arab	1999	A.S
Irbid	1987	B.F + A.S

Table 4.7 (continued)

Plant	Operation	Type of treatment
Ramtha	1988	WSP
Salt	1981	A.S + P.P
Baqa'	1988	B.F + P.P
Fuhais	1996	A.S
Ma'an	1989	WSP
Wadi Mousa	2001	A.S
Mafraq	1988	WSP
Jarash	1983	A.S + P.P
Kufranja	1989	B.F + P.P
Madaba	1989	WSP
Karak	1988	B.F + P.P
Tafila	1988	B.F + P.P
Aqaba	1987	B.F + P.P
Wadi hassan	2000	AS

WSP: Waste Stabilization Ponds. *A.S*: Activated Sludge. *B.F*: Biological Filter. *P.P*: Polishing pond.
Source: Bataineh et al. 2002.

Figure 4.5: Projected Flows of Wastewater in MCM for the Years 2005 to 2020



Source: MoWI 2004.

Another characteristic of wastewater in Jordan is salinity. Average salinity in Jordan is higher than in other countries due to the relatively high salinity in domestic water supplies. However, few concentrations of toxic pollutants and heavy metals can be found in Jordanian wastewater because of industrial discharge to sewers are controlled through pre-treatment regulatory requirements (WHO 2005). The cost of wastewater treatment depends mainly on the treatment technology used and the size of the treatment plant (Table 4.8).

Table 4.8: Treatment Plants in Jordan, Type of Treatment and Cost of Treating 1m^3 Wastewater

No.	Plant	Type of treatment	Cost Fils/m^3
1	As-Samra	WSP	3.9
2	Irbid	B.F + A.S	102.1
3	Aqaba	B.F + A.S	218.7
4	Salt	A.S + P.P	152.7
5	Jerash	A.S + P.P	90.9
6	Mafraq	WSP	63.8
7	Baqa'a	B.F + P.P	110.5
8	Karak	B.F + P.P	139.9
9	Abu-Nuseir	A.S	132.1
10	Tafila	B.F + P.P	223.5
11	Ramtha	WSP	206.4
12	Ma'an	WSP	61.4
13	Madaba	WSP	166.6
14	Kufranja	B.F + P.P	112.2
15	Wadi Al-Sir	Aerated Ponds	34.7
16	Fuheis	A.S	180.4
17	Wadi Arab	A.S	100.6
18	Wadi Hassan	A.S	573.8
19	Wadi Musa	A.S	95.9

Note: 1000 fils = 1 JD = US$ 1.42
Source: MoWI Annual Report 2007.

A study by WHO estimated the average cost of wastewater treatment in stabilization ponds ranged from US$ 0.021/m^3 to US$ 0.179/m^3. For treatment plants operating with activated sludge and trickling filters processes the average cost hugely varied per cubic meter. The highest reported costs of wastewater treatment were at the newly constructed treatment plants with relatively small treatment capacities. In addition, further studies should be conducted on overloaded treatment plants in order to estimate the real costs to achieve better effluent quality according to the Jordanian standards (WHO 2005).

The National Water Master Plan reported that the highest share of the O&M costs for wastewater treatment are dominated by staff (46%) and electricity (28%) of the expenses (MoWI/GTZ 2004).

However, wastewater treatment costs are expected to hugely increase in the coming years. The upgrading of wastewater treatment standards and regulations, which require higher treatment of effluent for agricultural use are difficult to achieve by low cost treatment methods and by the already overloaded wastewater treatment plants (Bataineh et al. 2002).

Wastewater in Jordan is considered strong. Salinity is higher than the average in other countries. These facts make treatment for higher standards difficult and more expensive. Two main reasons are causing this. First, the average per capita consumption in the municipal sector is low. Second, the main treatment technology used in Jordan is stabilization ponds, which results in high levels of wastewater evaporation. The high salinity might result in negative impacts on crops and soils.

4.5.4. Wastewater Reuse Tariff

Based on the WAJ Board decision number 3 dated 20.06.1999, and approved by the Prime Minister, the tariffs of treated wastewater are determined as follows (MoWI):

1. Treated wastewater tariff is 10 fils/m^3 for irrigation purposes.[8]
2. Treated wastewater tariff is 50 fils/m^3 for industrial reuses including power generating and cooling.
3. Treated wastewater is free of charge for research and study purposes, under condition that water quantity does not exceed 200 m^3/day and a copy of the research results are to be submitted to the WAJ.

[8] The price of treated wastewater for irrigation differs from the price of diluted wastewater with freshwater that is distributed from King Talal Dam to Jordan Valley and used for irrigation.

4.5.5. Wastewater Reuse in Agriculture

The beginnings of wastewater reuse in agriculture started in the late 1960s when the first modern technology for wastewater collection and treatment was established at Ain Ghazal area near Amman. Treated effluent was discharged into Amman stream that has been already dried up. After the dried stream has been recharged, farmers irrigated again their plants with the effluent - without governmental permission - as they did before when they used freshwater from the river. This practice of wastewater irrigation continued without problems till the late 1970s when the government destroyed the planted fields of vegetables as a result of a cholera outbreak. Despite the cholera outbreak, same farmers continued in the following years irrigation with the inadequately treated wastewater simply because they had no other alternative. Therefore, it can be understood that the governmental policy at that time accepted wastewater irrigation as long as no outbreak of diseases occurred (Haddadin et al. 2006).

However, the government officially started promoting wastewater reuse in agriculture in 1977, after taking the decision to pump up freshwater that was used in the Jordan Valley for irrigation purposes to the municipal water sector in Amman. Due to the population growth, the city of Amman needed more water resources and therefore water was transferred from East Ghor Canal in the Jordan Valley. As a result, irrigation water was rationed and the official governmental decision to reuse wastewater in agriculture in the Jordan Valley was made in order to partly compensate farmers for the diverted freshwater to Amman (Haddadin 2006).

Later on the construction of King Talal Dam on the Zarqa River assisted in raising the effluent quality that was discharged from As-Samra, the largest wastewater treatment plant. Inadequately treated wastewater is discharged to Zarqa stream that flows into King Talal Dam. At a later stage the blended wastewater is transferred by piped distribution network to farmers in the Jordan Valley. (Figure 4.6).

Since that time, this approach of wastewater reuse was adopted by the government to compensate farmers for freshwater resources that were taken by the municipal sector in Amman. Thus, treated wastewater has been considered as a resource for the agricultural sector - mainly after blending - and became part of the Jordanian water budget.

Gradually, the government constructed additional wastewater treatment plants at different Jordanian cities. However, some of the existing treatment plants became overloaded and operated beyond their capacity, which resulted in deterioration of the effluent quality. Some of these treatment plants are currently under upgrading.

The qualities of most wastewater treatment plants effluent comply with the Jordanian standards and the WHO Guidelines for restricted irrigation. However, treated wastewater in Jordan violates the standards for unrestricted irrigation (i.e. irrigation of vegetable eaten raw) (Bataineh et al. 2002).

The total amounts of treated wastewater reused in agriculture was about 71 MCM and formed about 14% of total water amounts used for irrigation in the year 2002 (about 511 MCM) (MoWI/GTZ 2004).

Treated wastewater is reused for restricted irrigation in areas directly near the treatment plants or in areas downstream of the plants without being mixed with freshwater. The total treated wastewater quantity used for restricted irrigation is about 10 MCM (Table 4.9).

Table 4.9: Size of Areas Irrigated with Treated Wastewater under Restriction, their Location and Type of Irrigated Crops

Irrigation restriction	**Area / dunum[1]**	**Cropping type**		
		Cereal and Fodder	**Forest Trees**	**Fruits**
Restricted Agriculture near treatment plants	6654	1770	3187	1697
Restricted Agriculture below treatment plants	9000	2000	500	6500
Total	**15654**	**3770**	**3687**	**8197**

[1] One dunum = 1000 m^2

Source: Based on information from Bataineh et al. 2002.

For unrestricted irrigation, mostly taking place in the Jordan Valley, the effluent is firstly diluted in reservoirs to increase its quality, before being distributed for farmers. Table 4.10 shows total quantities of reused wastewater for unrestricted irrigation in the Jordan Valley after dilution in the different reservoirs.

Figure 4.6: Phases and Problems of Wastewater Disposal and Reuse in Jordan

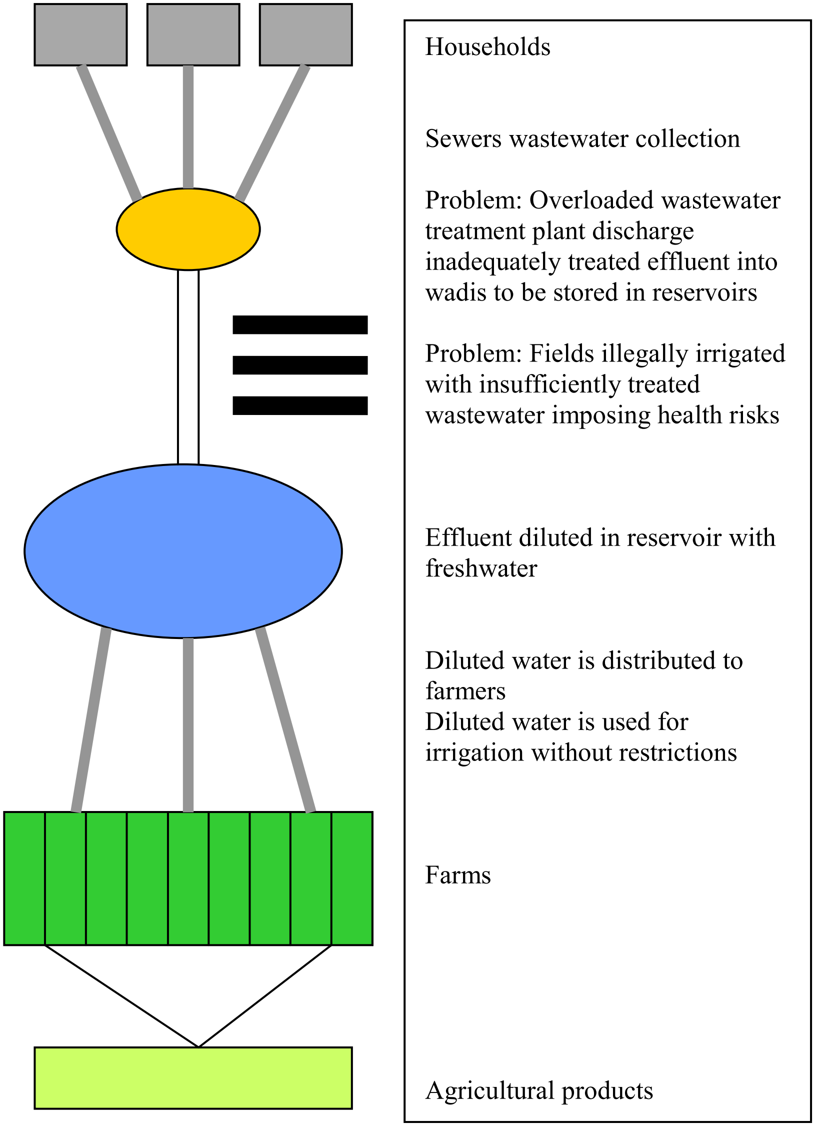


Table 4.10: Quantities of Reused Treated Wastewater for Unrestricted Irrigation in the Jordan Valley after Dilution in Reservoirs

Reservoir	**Effluent Source**	**Effluent Stored MCM**
King Talal	As-Samra, Baq'a and Jerash Treatment Plants	57
Wadi Shueib	Salt and Fuheis Treatment Plants	1.9
Kafrein	Wadi Essir Treatment Plant	0.5
TOTAL		**59 ***

* Deducted 8% losses during transmission and storage (irrigation in the Jordan Valley.
Source: MoWI/GTZ 2004.

However, the export market of Jordanian crops has suffered huge losses when the neighboring Gulf countries imposed restrictions and prohibitions on importing Jordanian crops and vegetables. The reason behind that decision was the use of wastewater or inadequately treated wastewater for the irrigation of these products. More recently, standards set by EU on importing crops became more strict. To address that issue, the Jordanian Government launched a series of activities aiming to upgrade and rehabilitate wastewater treatment plants in the country (McCornick et al. 2004).

In some cases, illegal unrestricted irrigation practices take place alongside the wadis below the treatment plants and before the effluents reach the reservoirs. This practice forms one of the major obstacles facing wastewater reuse in agriculture in Jordan.

There is a clear competition among the different sectors on water resources available in Jordan. The agricultural sector will be the most affected and its share of water will dramatically drop.

Obviously, the agricultural sector in Jordan has no other alternative than utterly replacing the scarce freshwater used for irrigation with treated wastewater and desalinated brackish water. In a long process, farmers in Jordan started to accept this fact as inevitable. The MoWI made projections for wastewater reuse as it is indicated in Table 4.11.

Table 4.11: Projected Flows of wastewater in MCM in Jordan

	2005	2010	2015	2020
Inflow to treatment plants	146	181	215	247
Treatment effluent	138	170	202	231
Effluent inflow into reservoirs [a]	- 71	- 86	- 100	-114
Total wastewater contribution [b]	67	84	102	117

[a] Counted as part of base flow (surface water) and reservoir yields.
[b] Increment in water resources over and above reservoir yields.
Source: Haddadin et al. 2006, based on information from MoWI 2004.

4.6. Analysis and Discussion

As stated in previous parts of this chapter, Jordan has been facing a permanent problem with the available amounts of water resources. During the 1960s, policy makers in Jordan, similar to many other developing countries at that time, have addressed water shortage by supply side measures such as dam construction and digging wells that were largely overexploited. These supply side efforts were implemented in unplanned manner and lacked adopting clear water policy for about thirty years. The measures failed to meet the increasing demand for water.

This situation continued till the 1990s, when the government noticed that supply management measures alone can never meet the demand for water. Additionally, some of the implemented projects entailed huge costs and in some cases harmed the environment. Therefore, there was a shift from large water supply projects towards demand management measures.

In this part of the chapter the analysis will concentrate on wastewater reuse in agriculture as part of the Jordanian water policy. First, a historical development of wastewater related laws and standards will be given. Second, the main points in the Jordanian wastewater management policy will be analyzed. Third, actors involved in wastewater management and reuse in the Jordanian agricultural sector will be identified and analysis of the interactions between the actors will be provided. Fourth, the reasons that made Jordan one of the advanced countries in the region will be categorized. Fifth, the existing bottlenecks in wastewater reuse in Jordan will be presented at the end of the analysis.

4.6.1. The Evolution of Wastewater Related Laws, Institutions and Standards

As mentioned before, wastewater collection in Jordan started during the 1930s and sometimes wastewater was discharged into gardens causing health and environmental problems (see 4.5.1). In 1955, the Municipality Law No. 29/1955 gave the government authorities of Amman and other formed municipalities the right to own and operate water systems in addition to set standards for water construction systems and to determine fees for water use and to construct sewers and their management. In 1965, the Natural Resources Agency was formed. Among of its tasks was policy setting on water resource development and irrigation. The Public Health Law No. 21 for the year 1971 gave the MoH the authority to monitor and regulate treated wastewater and designing wastewater treatment systems. This authority is in charge till today (Nazzal et al. 2000).

The JVA was established in 1977 by Law No. 18/1977. This law entitled JVA to plan and implement infrastructure projects within the Jordan Valley. Over a long time, JVA has directed and managed the construction and management of wastewater systems and constructed advanced water and wastewater management systems in the Jordan Valley area (Ibid.).

Between the years 1957 and 1990, Jordan has been under emergency law. The prime minister was entitled to act as a military governor in emergency situation. The use of inadequately treated wastewater for irrigation of vegetables that were eaten raw has resulted in Cholera outbreak in the year 1978. The prime minister used his power to manage the situation and ordered the prohibition of such irrigation practices. The planted fields were ploughed by a national defense order (Haddadin and Shteiwi 2006). In 1982, Martial Law No. 2 for the year 1982 was enacted to control discharges from industries into natural water systems, especially in Amman-Zarqa area. The importance of this law results in the establishment of the first set of broad standards for wastewater reuse (Nazzal et al. 2000).

In 1983 the Temporary Law No. 34/1983 established the WAJ. This Authority began to prepare water and wastewater standards. In 1988, a more comprehensive law was developed, named Water Authority Law No. 18 of 1988. Under this law, WAJ was entitled to provide sewer systems and was tasked to formulate a Jordanian water and wastewater policy. Under the same law, the first standards for industrial wastewater disposal were developed. Later on, the Government of Jordan established the MoWI in

1992, under by-law No. 54/1992. This aimed to integrate the management of water resources in Jordan under one institution and under the responsibility of the Minister of Water and Irrigation. Previously, the management of water resources was executed by different institutions, including WAJ, JVA, MoA and the MoH. Among the responsibilities that were assigned to the newly established MoWI were to regulate wastewater treatment and reuse activities (Ibid.).

At the time being, the following standards are directly related to wastewater management and reuse in Jordan:

Reclaimed Domestic Wastewater (JS-893) for the Year 2002

These standards replaced the Jordanian Standards JS 893/1995, which were the first Jordanian standard for wastewater reuse. Prior to JS 893/1995, the WHO 1989 "Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture" were in use. By the year 1995, the first Jordanian Standards for water reclamation were developed and contained specification for the following irrigation purpose: Irrigation of vegetables eaten cooked; Irrigation of fruit trees, industrial crop forests and grains; Irrigation of public parks and irrigation of fodder. The JS 893/1995 standards prohibited irrigation of crops eaten raw (i.e. tomato, cucumber, lettuce, …); also the standards prohibited irrigation during a period of two weeks before harvest and sprinkler irrigation (McCornick et al. 2004).

A detailed review of the reuse standards by national and international experts and different agencies, resulted in the approval of the new standards by the Jordan Institute of Standards and Metrology. They enacted in the year 2003 JS893/2002 to replace JS 893/1995.

According to McCornick et al. 2004, the main reason that was behind revising the JS 893/1995 standards was the prohibition imposed on importing fruits and vegetable grown in Jordan by importing countries, like the Gulf countries. Therefore, there was a need for newer standards that provided not only farmers with improved health and safety, but also their consumers.

Industrial Wastewater (JS-202) 1991

These standards entail specification and qualities of industrial wastewater that might be disposed or reused for irrigation purposes.

Uses of treated Sludge in Agriculture (JS-1145) 1996

According to (JS-1145) 1996, this standard is concerned with the conditions that must be available in the sludge resulting from the stations for the treatment of sewage water intended to be used in agricultural land.

4.6.2. The Challenge of Standards Implementation

There is no doubt that appropriate standards for the use of treated wastewater in agriculture are crucial for the protection of the public health of farmers and consumers. However, the enforcement of these standards and regulations is much more important and more difficult than their formulation. In the Jordanian context, lack of implementation of existing standards - mainly due to the overload of some wastewater treatment plants - has resulted in closing export markets for Jordanian fruit and vegetables.

In order to lift the prohibition on importing Jordanian agricultural products by neighboring Gulf Countries, strict implementation of the Jordanian standards have to be implemented. In addition, the implementation of the standards is also highly important for the protection of both the Jordanian consumers and farmers using the effluent for irrigation. The enforcement of Jordanian Standards will maximize the benefits of wastewater reuse in agriculture and will provide health protection for farmers and consumers.

Upgrading the overloaded wastewater treatment plants and the construction of new ones in areas that inhabit small communities is not the only factor that can contribute to standards enforcement.

Reviewing wastewater reuse standards periodically, which was permitted by the Jordanian wastewater policy, will incorporate the latest national and international research findings in the wastewater reuse sector. Additionally, securing participation of the different actors will assist experts to identify major problems and constraints faced by farmers.

4.6.3. The Formulation of Jordanian Water Strategy and Wastewater Policy

Water has always been considered as “State Property” in Jordan. To put this policy into practice, several laws have been adopted, which indicated that the government holds the water of Jordan in trust for its inhabitants. At the time being, the government represented by the MoWI, regulates water use within the country (Salman et al. 2006).

The most important policy objective in Jordan is stability both on regional and domestic levels. Jordan's geographic location within a region, where several wars were experienced, has a major influence on achieving the country's social and economic development plans. These factors in addition to others, which are beyond the country's control - like the severe raise in oil prices - directly influence water policy in Jordan.

As Schiffler argues:

> *"Such objectives as regional and domestic stability are of overriding importance for a small-country in a conflict-ridden region. Where concerns about political stability and water resources management clash, the former are bound to take precedence"* (Schiffler 1998).

The Jordanian water policy can be characterized as:

> *"A mixture of investments for supply expansion and instruments for demand management"* (Schiffler 1998).

After gaining independence in 1946, Jordan's water policy aimed to focus on projects to utilize the Yarmouk River and the development of irrigation in the Jordan Valley. In 1953, Jordan and Syria signed a bilateral agreement on the utilization of the Yarmouk River. Furthermore, a well-drilling department was established to manage groundwater resources. The government at that time was eager to utilize the groundwater resources (Haddadin 2006).

During the 1960s, policy makers in Jordan, similar to many other developing countries at that time, has addressed water shortage by supply side measures such as dams construction and digging groundwater wells that were largely overexploited. These supply side efforts were implemented in unplanned manner and lacked adopting clear water policy for about thirty years failed to meet the increasing demand for water.

Through the 1970s, the serious need for municipal water in Amman resulted in pumping up water from the Jordan Valley to the highlands. This situation necessitated establishing a new plan to recompense farmers for the amounts of water that were lost. At that time, planners initiated the idea of collecting used water from municipal sector, treat it to reasonable standards and let it flow to the reservoir of King Talal Dam and then let the diluted water flow to the Jordan Valley and use it for irrigation. This policy was presented and discussed at a very high-level meeting and finally was officially approved in 1978, forming the first officially adopted policy for wastewater reuse in Jordan (Haddadin and Shteiwi 2006).

In the early 1990s, the huge imbalance between Jordan's population and its available water resources continue widening increasingly. This has necessitated the government to revaluate the previous policies that were based on maximizing all supply resources. The result was issuing a policy statement in 1994, which was called "The Water Policy Framework", which summarized the water sector policies (World Bank 1997).

This Policy Framework was considered a step forward comparing to previous policies. It gave priority of water allocation first for the domestic sector, then to industry and tourism and the final priority was given to agricultural sector. The framework also called for institutional reforms.

Schiffler believed that the policy framework of 1994 has many advantages in comparison to the previous water policies in Jordan - that basically aimed to promote agricultural water use - and described it as a compromise between the different Jordanian stakeholders. Though, he also noticed that there was serious lack of enthusiasm and reluctance in the implementation of demand management instruments especially in the charges of groundwater abstraction in the agricultural sector. According to Schiffler, the main reason behind the unwillingness to increase water tariffs for municipal and agricultural sectors, were the riots that took place in 1989 and again in 1996 that were triggered by a rise in food and fuel prices (Schiffler 1998).

With the assistance and support from donors such as the World Bank and KfW (Haddadin 2006), the official water strategy has set long-term goals and developed different policies in order to achieve aimed goals gradually. The Water Strategy for Jordan was approved by the Council of Ministers in 1997 and adopted as the official water strategy of the government. Under this Strategy, it was agreed that a number of policies are needed to be formulated to achieve the Strategy's goals. Gradually, the MoWI and its two institutions, JVA and WAJ formulated four policies that were approved later on by the Jordanian government. These policies were:

- The "Water Utility Policy" was approved in July 1997.

- The second policy, the “Irrigation Water Policy” approved in February 1998.
- The third policy paper the “groundwater management policy”, which the Council of Ministers who approved it in February 1998.
- The fourth policy, “Wastewater Management Policy” was adopted by the Council of Ministers in June 1998 and since then has become the Government's policy on wastewater management and reuse.

The “Wastewater Management Policy” of Jordan was prepared in 1998 and consisted of 67 main points that were listed under 13 subtitles. The following key policy issues were included in the wastewater management policy:

- Wastewater shall not be treated as waste and therefore disposed. Wastewater shall be part of the national water budget.
- Adequate wastewater collection and treatment facilities should be available for all the major cities and towns in Jordan to protect the environment and public health.
- Priority of reuse of treated effluents should be directed as a source for irrigation.
- Treatment of wastewater shall be targeted towards producing an effluent fit for reuse in irrigation that complies with the WHO and FAO guidelines.
- A high importance should be given for the establishment of a section in the Water Authority to be responsible for the development and management of wastewater systems, wastewater treatment and reuse.
- A basin management approach shall be adopted where possible. The use of treated wastewater in irrigation shall be given the highest priority and pursued with care.
- Effluent quality standards shall be set based on the best attainable treatment technologies, and calibrated to support or improve ambient receiving conditions, and to meet public health standards for end users.
- Wastewater intended for irrigated agriculture shall be regulated based on the soil characteristics of the irrigated land, the type of crops grown, the irrigation methods, and whether other waters are mixed with the treated wastewater.
- Industries shall be encouraged to recycle part of its wastewater and to treat the remainder to meet standards set for ultimate wastewater reuse or disposal.

- Wastewater from industries with significant pollution should be treated separately to standards allowing its reuse for purposes other than irrigation or to allow its safe disposal.
- Consideration shall be given to isolating treated wastewater from surface and ground waters used for drinking purposes, and to the blending of treated effluent with relatively fresher water for suitable reuse.
- Priority shall be given to protecting public health and water resources from chemical and microbiological pollutants.
- The transfer of advanced wastewater treatment technologies shall be endorsed and encouraged. However, appropriate wastewater treatment technologies shall be selected with due consideration to operation and maintenance costs and energy savings, in addition to their efficiency in attaining and sustaining quality standards.
- Treated wastewater effluent is considered a water resource and is added to the water stock for reuse. Priority shall be given to agricultural reuse of treated effluent for unrestricted irrigation. Blending of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.
- Farmers shall be encouraged to use modern and efficient irrigation technologies. Protection of on farm workers and of crops against pollution with wastewater shall be ensured.
- Treated effluent quality should be monitored and users are alerted to any emergency causing deterioration of the quality so that they will not use such water unless corrective measures are taken.
- Sludge produced from the treatment process would be processed so it may be used as fertilizer and soil conditioner. Care shall be taken to conform to the regulations of public health and environment protection norms.
- Wastewater charges, connection fees, sewerage taxes and treatment fees shall be set to cover at least the operation and maintenance costs. It is also highly desirable that part of the capital cost of the services shall be recovered. The ultimate aim is for a full cost recovery.
- Appropriate criteria in order to apply the "polluter pays" principle shall be established.

- Treated effluent shall be priced and sold to end users at a price covering at least the operation and maintenance costs of delivery.
- All crops irrigated with treated or mixed waters shall be analyzed and monitored periodically.
- The role of the private sector will expand with management contracts, concessions and other forms of private sector participation in wastewater management such as BOO / BOT.
- The role of private sector in reuse of treated wastewater shall be expanded.

4.7. Wastewater Reuse and Management: Who Are the Actors Involved and How Do They Interact?

Similar to many other countries in the region, the management and reuse wastewater in Jordan engages many actors at the various levels of e.g. MoWI, MoA, MoH and MoE. Additionally there are the farming communities including water users associations and individual farmers. A successful wastewater reuse program requires substantial coordination among the different actors. The different responsibilities and the various activities in wastewater management and reuse are rarely and quite difficult to be integrated within a single institution.

In the Jordanian case, actors in wastewater reuse and management can be clearly divided into two major groups. The first group comprises governmental authorities, which are representing officially the Jordanian Government. The second group contains other actors.

4.7.1. Governmental Authorities

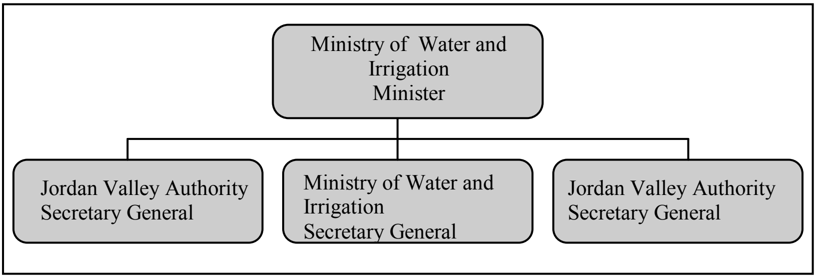
4.7.1.1. Ministry of Water and Irrigation (MoWI)

The MoWI was established in 1992 by a by law issued by the executive Branch of the Government under the Jordanian Constitution. The establishment of the MoWI aimed to achieve a more integrated approach to National water management, which has been supported by several donors that have assisted in the development of a national water strategy, water policy and water master planning.

MoWI incorporates both only institutions that deal with water in Jordan (Figure 4.7):[9]

- WAJ: In charge of water supply, sewerage systems and wastewater treatment plants in all parts of Jordan.
- JVA: Responsible for the socio-economic development of the Jordan Valley, including water development and distribution of irrigation.

Figure 4.7: Organizational Structure of MoWI Jordan



4.7.1.2. Water Authority Jordan (WAJ)

WAJ was established in 1983, according to the Water Authority Law No.34 of 1983 (temporary law), as an autonomous corporate body, with financial and administrative independence named the Water Authority. It was directly linked to the Prime Minister. The Water Authority taking over all responsibilities of the entities that were previously responsible for water and wastewater is the main aspect of the WAJ law. According to Article 23, WAJ became responsible for the public water supply and wastewater services, as well as for the overall water resources planning and monitoring.[10]

WAJ is headed by a secretary general who is responsible for 18 Directorates under the directive of eight Assistant Secretary Generals (Water Affairs, Sewerage Affairs, Technical Affairs, Regional Affairs (Southern, Middle and Northern Region), Financial Affairs, Administrative

[9] MoWI's website: http://www.mwi.gov.jo
[10] MoWI's website: http://www.mwi.gov.jo

Affairs), as well as five Units directly subordinated to the Secretary General fulfill the said functions. WAJ Program Management Unit (PMU) regulates water supply and wastewater utilities under private management. The structure of WAJ is strictly centralized. The regional branches of WAJ in the Governorates are fully dependant on WAJ headquarters with respect to human resources management, services and billing (Ibid.).

WAJ tasks with regard to wastewater reuse and management in Jordan can be summarized as follows:

- Construction, management, operation and maintenance of wastewater treatment plants.
- Collecting sanitation fees from municipal sector, which is added to the water bill.
- Monitor treated wastewater quality from treatment plants.
- Identify wastewater treatment plants that do not comply with treated wastewater standards and take necessary correction measures.
- Monitor groundwater quality
- Monitor soils in areas near treatment plants and areas where irrigation with treated wastewater is practiced
- Conduct theoretical and applied research and studies on issues related to wastewater reuse.

4.7.1.3. Jordan Valley Authority (JVA)

JVA was established in 1973 as the Jordan Valley Commission and was 1977 renamed in Jordan Valley Authority according to the Jordan Valley Development Law No. 18 of 1977. This law was adjusted by the Jordan Valley Development Law No. 19 of 1988 and its amendment in 2001. The area of JVA responsibility includes JV North, JV South, Southern Ghors and Wadi Araba. JVA is mainly responsible for the social and economic development of the Jordan Valley, including the development, utilization, protection and conservation of water resources in agricultural, municipal, industrial and tourist uses. JVA has about 1800 employees and its structure includes 21 Directorates and/or Departments subordinated to six Assistant Secretary Generals (Ghor Operation and Maintenance, Land and Development, Planning and Information, Administration and Financial Affairs, Irrigation and Drainage Affairs, Dams Affairs) together with five Units directly subordinated to the Secretary General.

The tasks of JVA with regard to wastewater reuse and management in Jordan can be summarized as follows:

- Distribution of treated wastewater for farmers after being diluted in water reservoirs.
- Collecting fees of diluted wastewater from farmers.
- Monitor treated wastewater quality for irrigation.
- Monitor groundwater quality (within JV area).
- Monitor soils in areas where irrigation with treated wastewater is practiced (within JV area).
- Conduct research and studies on issues related to wastewater reuse.

As mentioned before, the Government of Jordan's annual subsidies to both WAJ and JVA are estimated with about 60 million JD, of which three quarters are devoted to support WAJ. Only 50% of the total cost (O&M cost + depreciation + interest payments) of water sector operations are covered from tariffs and other related fees (MoWI/GTZ 2004).

4.7.1.4. Ministry of Health (MoH)

The Ministry of Health is empowered through the "General Health Law" No. 54 for the year 2002 to perform the following activities related to wastewater reuse and management in Jordan:

- Monitor treated wastewater quality in cooperation with other entitled institutions.
- Monitor sewer networks and their construction in cooperation with other entitled institutions.
- Monitor groundwater quality (for potable use).
- Check wastewater treatment plans and their conformity with health standards.
- Take all necessary measures -when needed- to stop hazards on the general health caused by wastewater, sewer networks and wastewater treatment plants.
- Monitor crops irrigated with treated wastewater.
- Destruction of crops that are irrigated illegally with untreated wastewater, a power that other ministries do not have.

4.7.1.5. Ministry of Agriculture (MoA)

The Ministry of Agriculture plays a central role in Jordan's water policy since irrigation is the largest sector that consumes water in Jordan. Water savings in irrigation are one of the important issues that the ministry is involved in. In relation to wastewater reuse and management in Jordan, the Ministry of Agriculture was empowered by The Agriculture Law of the year 2002 to perform the following activities:

- Define instructions and conditions for irrigation with treated wastewater and crops that can be irrigated with different qualities of treated wastewater.
- Supervise the destruction of crops that do not comply with instructions of treated wastewater irrigation.
- Monitor soils in areas where irrigation with treated wastewater is practiced.
- Monitor crops irrigated with treated wastewater.
- Provide extension services on needed protection measures for farmers using treated wastewater for irrigation.
- Provide extension services for farmers on best irrigation methods for wastewater irrigation.
- Conduct research and studies on issues related to wastewater reuse.

4.7.1.6. Ministry of Environment (MoE)

The Ministry of Environment is empowered to perform the following activities related to wastewater reuse and management in Jordan:

- Monitor treated wastewater quality.
- Monitor groundwater quality
- Monitor soils in areas that are irrigated with treated wastewater.

4.7.1.7. Institute of Standards and Metrology

This institute is responsible for preparing and updating standards in cooperation with experts from other governmental institutions. It issued *Reclaimed Domestic Wastewater (JS-893:2002)* for quality of wastewater discharged or reused in agriculture. *Industrial Wastewater (JS-202:1991)* that entails specification and qualities of industrial wastewater that might be disposed or reused for irrigation purposes. It has also published the standard *Uses of treated Sludge in Agriculture (JS-1145:1996)*.

4.7.2. Other Actors

4.7.2.1. Urban Water Users

Water demand of the municipal sector is rapidly increasing at about 7.4% per year. This is due to the high population growth and urbanization rates. According to WAJ estimations, about 97% of the total population of Jordan is served with piped water networks. However, it should be noted in this context that the water quantity billed by WAJ is only half of the quantity produced. About 52% of the supplied water is unaccounted for and is lost before reaching the consumers through leakages in the public water networks. In Amman, water is supplied only for a few hours per week and collected into water tanks to be used till the week after.

Households pay almost 55% of the total water charge for wastewater collection and treatment services. If treated wastewater will substitute freshwater used for irrigation, urban users will receive additional amounts of water.

4.7.2.2. Farmers

Irrigation water in Jordan is highly subsidized. The tariff charged does not cover O&M costs and it does not form an incentive to save in water irrigation. The MoWI still opposes a large increase in irrigation water tariffs. Reluctances are caused by the memories of riots that took place in 1989 and again in 1996 that were set off by a rise in food and fuel prices.

Large-scale farmers are benefiting much more than small farmers from subsidizing irrigation water. They also have better communication means to the responsible authorities and therefore they are against any reform in irrigation water tariff.

The diluted water tariff does not form an incentive for farmers to substitute freshwater for irrigation. As mentioned before, wastewater in Jordan has higher salinity than normal wastewater. Salinity might cause negative impacts on the soil and hinder farmers from planting some crops and prevent them from exporting. Therefore, when both are available, farmers still prefer to use freshwater for irrigation rather than diluted water.

4.7.2.3. Donors and Lenders

Since the early years after gaining the Jordanian independence in 1946, foreign donors have contributed in shaping the structure of Jordanian water sector through financing most of the water projects (Schiffler et al. 1994). The most important donors and lenders engaged in the water sector in Jordan are: United States Agency for International Development (USAID), The European Union (EU), Japan International Cooperation Agency (JICA) and The German Technical Cooperation (GTZ) and other countries like Canada, United Kingdom and France. The World Bank is considered the largest lender of Jordan, followed by the National Arab Fund and the KfW bank of Germany. The different donors and creditors have established a large number of water projects in Jordan that cannot be discussed here. Most of these projects have highly contributed in reducing the severity of Jordan's water shortage.

Parallel to that role, Schiffler believed that donors/lenders also have a huge influence on maintaining Jordan's domestic stability through providing aid and debt relief. Schiffler also argued that Donors can play a major role in helping Jordan in adopting a new system of water resources management (Schiffler 1998).

The role of donors and lenders in forming the institutional setting and the innovative policies in the water sector is extremely important. Donors and lenders had a vital role in the initiation of the official water strategy and the wastewater management policy, which incorporated wastewater as part of the national water budget. Same as for the Jordanian standards of treated wastewater and the formulation of committees for the coordination of wastewater reuse. All these factors assisted in putting wastewater reuse on the top of the policy agenda of the Jordanian government. This offered Jordan a good opportunity to obtain a leader position in wastewater management and reuse within the MENA region.

However, the amount of influence on the Jordanian water policy and the level of success differed from one project to another. In other situations, donors/lenders had different opinions or approaches in targeting the same problem in the water sector. A clear example of the lack of coordination and harmonization among the lenders aroused between the KfW and the World Bank in targeting the problem of increasing water tariff through the project "Agricultural Sector Adjustment Loan" (ASAL). The lesson learned from the project was summarized by a World Bank's report as follows:

> *"The Bank's credibility is harmed when it supports unrealistic targets linked to the wrong instruments. The Bank's analytical and advisory services formed the basis of a cross-sectoral and strategic framework for water and agriculture in Jordan that all stakeholders accepted-and increased water tariffs was a central objective. However, it became clear at the time the ASAL was approved that the second increase in water tariffs was politically unrealistic and would be jeopardized by the need for disbursement to meet balance of payment support. Rather than accepting this reality and working with government and KfW on alternatives to achieve the policy objective, perhaps on a longer schedule, the Bank remained silent. Release of the second tranche came as a surprise to KfW and undermined the partnership with them and other donors. It also sent the wrong signal to government that increased agricultural water tariffs were not as important as had been argued. Subsequently, the Bank's partnerships in the agricultural sector languished, reducing the Bank's effectiveness in the late 1990s."* (World Bank 2003).

In other examples more related to wastewater management and reuse, donors tried to apply their high technology and treatment standards without considering the appropriateness of adapting such technology for the local environment and climate in Jordan. The examples of the Ain Ghazal and later on As-Samra wastewater treatment plants in the city of Amman during the 1970s, were significantly analyzed by van Lier and Lettinga.

Both authors argue that the above mentioned treatment plants can be considered as a painful example of the mismanagement of wastewater treatment systems, because foreign donors implemented a conventional activated sludge plant for the treated wastewater. Many problems were faced in its operation. These problems were caused by the extreme high concentration rate of organic matter in the sewage as a result of the local climate conditions. The main operational problems were:

i) very high volumetric energy consumption for aeration;
ii) huge sludge production per m^3 treated sludge;
iii) operational problems in the activated sludge plant (bulking sludge);

iv) high consumption of polymers and clean water per time unit for drying the sludge after digestion.

Van Lier and Lettinga believed that most of the above mentioned problems have been caused on one hand by a too low design load of Ain Ghazal treatment plant. On the other hand, urbanization was not taken into consideration in transferring the Western technology because the extension of the plant at the same chosen site was impossible due to population growth (Van Lier and Lettinga 1999).

Later on, it was decided that the solution was the construction of one of the world's largest waste stabilization pond in As-Samra. The project was funded by western donors in a relatively short time. Due to population growth, the pond became overloaded, resulting in a poor effluent quality that nevertheless was transferred to the Jordan Valley for irrigation. At the end of the 1990s another donor country invested large amounts of money to upgrade the As-Samra stabilization pond. Despite the huge investments the quality of treated wastewater had hardly improved (Ibid).

Van Lier and Lettinga concluded their study with the following remarks:

> *"In the above example, none of the three investments can be considered as sustainable. It is hard to understand why and how established contractors and consultants came to the decision to use activated sludge in a country where both water and energy are extremely scarce. Also the decision to use lagoons in a (semi-) arid country like Jordan is hard to understand. Apart from difficulties in operation, the application of lagoons is accompanied with huge losses of costly water due to evaporation, and, especially for such concentrated types of sewage, tremendous malodour problems and a poor treatment efficiency. The latter can also be attributed to the poor pond design and to the fact that the design is not in agreement with the population growth and/or increase in sewage connections. Finally, the high evaporation losses are accompanied with a proportional increase in the salinity of the water, which makes application for irrigation doubtful"* (Ibid).

In other situations, several projects were very successful because the different donors and the MoWI coordinated the decision making process and the project activities. In the last years, donors felt that there was a lack of coordination among themselves - rather than a lack of coordination between donors/lenders and the Ministry.

Therefore, and in order to increase the benefit and to coordinate technical assistance efforts, donors and Jordanian governmental organizations formed a donor/lender committee, with regular monthly meetings, chaired by the United Nations Development Program. These meetings are used to ensure continuous coordination of efforts. In addition, it was agreed to establish six thematic sub-groups. One of them was formed to coordinate all activities in the water sector. The donor/lender sub-group for water established a technical committee for the reuse of treated wastewater. Within this framework, each of the donors/lenders provided their point of view on wastewater reuse in Jordan.

Since the first meeting was held in May 2004, it was clear that each donor/lender has its position on major issues in wastewater reuse such as standards and regulations, monitoring, health issues, treatment technologies, finances and private sector involvement.

It was clear - based on the minutes of the meeting - that each of the actors in this group had already a previously prepared policy paper that bound their position on the reuse of treated wastewater. For example:

- The MoWI Water Strategy and Wastewater Policy.
- Water Sector Review Update (2001) by the World Bank.
- Water Strategy Strategic Objectives: Enhanced Integrated Water Resources Management (2004) by USAID.
- EU: Water Strategy (2004).
- JICA: Country Study for Japan's Official Development Assistance to Jordan (1996).
- GTZ/KfW Joint Approach of Jordanian-German Co-operation in the Water Sector and Related Environmental Aspects, BMZ (2001).

Nevertheless, the Technical Committee on the "Reuse of Treated Wastewater" discussed the main issues to be tackled by both MoWI and the donors regarding its efficient, safe and sustainable use. These issues refer to effluent from wastewater treatment plants that are reused either un-mixed or blended with other water sources. Based on these discussions, the Technical Committee on "Reuse of Treated Wastewater" has adopted a position paper that included the following common positions on the reuse of treated wastewater in agriculture:[11]

- Wastewater shall form an integral part of renewable water resources and the national water budget.
- Wastewater shall be collected and treated to standards that allow its reuse in agriculture, industry and for other non-domestic purposes.
- Treated wastewater shall substitute freshwater in irrigated agriculture.
- Its application should not lead to an expansion of the irrigated area, except when conveyance to existing irrigated areas is economically not feasible.
- Agricultural use of treated wastewater should be done efficiently and in a sustainable manner.
- For each wastewater treatment facility the allowed use for its effluent has to be set by the concerned public authorities.
- National standards and regulations for treated wastewater have to set the requirements according to the different levels of end use. They should as a minimum fulfill the requirements of WHO and FAO guidelines.
- Periodically, these standards and regulations should be reviewed and modified if needed.
- Quality of treated wastewater should be closely monitored according to national standards. End users must be alerted to any emergency causing deterioration of its quality.
- The allowed end use of effluent from wastewater treatment facilities has to be monitored and enforced by the concerned public health authorities.
- All crops irrigated with pure or blended treated wastewater and the impacted soils and groundwater shall be analyzed and monitored periodically.
- Agricultural produce irrigated with treated wastewater should be part of the national marketing strategy including certification of product quality to promote public confidence in its safe consumption.
- Concern for public health and the health of farm workers have to be a focus in all programs for reuse of treated wastewater.
- Adverse effects on soil, groundwater, and other negative environmental impacts have to be avoided.

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[11] Technical Committee “Reuse of Treated wastewater” 24.05.2004.

- Programs for monitoring of public health (e.g. epidemiological studies) and environmental status have to be conducted in conjunction with stakeholders' awareness campaigns.
- The wastewater treatment technology and the level of treatment are to be determined by the final environmental discharge/reuse option.
- Farmers have to be addressed through awareness campaigns to promote the reuse of treated wastewater, appropriate methods of irrigation, safe application of treated wastewater and proper handling of irrigated agricultural produce.
- The public shall be informed about the value of treated wastewater for different end uses.
- Differential prices should be applied to treated wastewater to account for its quality and to encourage its use.
- Treated wastewater shall be priced and sold to end users at a price covering at least the operation and maintenance costs of delivery.
- The private sector role in reuse of treated wastewater shall be encouraged and expanded.

The above mentioned points adopted in the donor/lender position paper, clearly express greater interest in harmonizing the assistance of implementation of an effective partnerships for a successful wastewater management and reuse program.

As it has been discussed above, donors/lenders have not only supported Jordan with most of its water and wastewater infrastructure. Donors/lenders like the World Bank and KfW (Haddadin 2006), had also highly contributed in the formation of the official water strategy and the formulation of the four policies that were approved later on by the Jordanian government.

As discussed in chapter 1, there are different factors (such as social, political, cultural and economic) on how a problem moves from the systemic (public) agenda to the institutional (formal) agenda. Also, there are different arguments on how policies are initiated (Table 1.2). One of the most important factors is the nature of actors initiating the policy discussions and the way the government is involved in the policy initiation.

In that context, analysis shows that donors and lenders play a very important role in the water sector of Jordan. Donors and lenders financed a large part of Jordan's water and wastewater infrastructure in addition to the advance water data systems. In addition, donors - as outside initiators - have greatly promoted wastewater reuse policy in Jordan, which resulted in incorporating wastewater in the national water budget. But, donors and lenders were less successful in the initiation of crucial and unpopular policies within the water sector. For example, the World Bank's ASAL, faced strong objections from the Jordanian government and rejected a second increase in agricultural water tariffs.

4.7.2.4. Informal Interest Groups

In addition to the formal organizations, the role of the informal interest groups in Jordan should not be ignored. Jordan was able to establish several water laws and an appropriate institutional framework. But in any case, such a framework will not be supportive if the water users do not abide to.

The MoWI did not yet approach some of the most important reforms, because it is believed that they are politically untouchable. Many times, the main reason was that politically important groups have opposed the changes and worked hardly to stop them when they felt that their interests were at stake. Certain influential groups benefit from low irrigation water tariff or existing allocations of water and want to preserve these advantageous conditions. On the other hand, groups that would benefit from reforms (small farms and poor households) have minor influence and were not able to form effective lobby groups. Sometimes they are unaware about the level of the problem. In others cases, they lacked organization and communication channels with the responsible authorities (World Bank 2007). Schiffler argues that the informal groups in Jordan are mainly based on kinship (Schiffler 1998 and Schiffler et al. 1994).

4.8. WAJ and JVA: Competition or Cooperation in Wastewater Management?

The nature of WAJ tasks and the current water tariffs result in huge financial deficits that are about three times higher than income, generated by JVA. WAJ has no influence on the structure of the water tariff. WAJ Law 18 of 1988 & Amendments thereof Article 10 paragraph f states that WAJ:

> *"Recommend to the Council of Ministers tariffs for connections, subscriptions, price rates and deposit fees that*

> *should be collected for various water and public wastewater uses".*

In other words, WAJ has to provide water supply for the municipal sector, collect wastewater and treat it. However, WAJ can not fix the water or wastewater tariff. This forms a big obstacle for a full recovery of the O&M costs of the rendered services.

Concerning JVA, water for irrigation is heavily subsidized as a national policy. Problems really arouse in dry seasons when additional amounts of water are transferred to WAJ to be distributed for the municipal sector. A previous minister of Water and Irrigation summarized the relationship between WAJ and JVA as follows:

> *"WAJ and JVA disagreements on water allocation were frequent, and they were resolved by high-level meetings of the state officials chaired by the king"*(Haddadin et al. 2006).

In addition, WAJ is also responsible for the operation of wastewater treatment plants. As mentioned before, wastewater treatment standards in Jordan are relatively strict and some of the treatment plants are overloaded. Again, WAJ can take part in the preparation of treated wastewater standards but since the ownership and operation of the treatment plants rest within its responsibilities, it is the entity to be blamed if standards were not met.

Competition between WAJ and JVA did not only take place over freshwater resources but also over treated wastewater. During the early 1980s, Jordan witnessed a severe drought. As an owner and operator of As-Samra treatment plant, WAJ wanted to use part of the effluent to irrigate trees and the area next to the treatment plant instead of letting the effluent flow towards the Jordan Valley, which was part of JVA's irrigation budget. The Prime Minister had to interfere to settle the dispute. He supported the idea of WAJ and decided that treated wastewater should be used by farmers of the Jordan Valley (Ibid.).

Out of this and other examples, a strong need to improve coordination, not only between JVA and WAJ, but also among other engaged institutions became necessary. As a result, a water reuse unity was established at WAJ. At the national level, a water reuse committee was formed with representatives from MoWI, MoA, MoE and MoH. However, the ultimate goal should be in forming a wastewater reuse agency. Its responsibility lays in planning and executing wastewater reuse projects.

The analysis shows that there is no conflict between the MoH, MoA, MoE on one side and WAJ and JVA on the other side. Conflict between actors is merely based on water resources.

As discussed before, conflicts over water resources are mainly between the municipal sector, where the supply falls under the responsibility of WAJ, and the agricultural sector, where supply for irrigated agriculture (that is mainly practiced in the Jordan Valley) falls under JVA's responsibility. Therefore, other actors remain outside this conflict arena.

4.9. Phases of Wastewater Reuse in Agriculture and Related Policies in the Jordanian Experience

As discussed in chapter 1, and explained in Figure 1.1, successful wastewater reuse in agriculture is not merely depending on the existence of wastewater networks and wastewater treatment plants. It relies on appropriate policies, legislations, institutional frameworks and regulations. In addition, it depends on types of policy instruments for the implementation of wastewater policies.

In this section, the development of different policies that played a role in encouraging or discouraging wastewater reuse in agriculture in Jordan will be analyzed (see Figure 1.1). These policies and decisions are: sanitation policy, agricultural policy, water pricing policy and standards and health protection policies. The different policies are summarized chronologically at Figure 4.8.

The governmental policy to promote irrigated agriculture in Jordan began in the early 1950s when the major irrigation project, the construction of the King Abdallah Canal was initiated. The aim of this policy was to achieve self sufficiency and additional employment in the rural areas.

The unofficial reuse of wastewater in agriculture began near Amman in the end of the 1960s when the first technology for wastewater collection and treatment was established at Ain Ghazal area. Treated effluent was discharged into Amman stream that has been already dried up. Subsequently, farmers near Amman irrigated their plants with the effluent without governmental permission.

Due to the high population growth and urbanization rates, the demand of the municipal sector for water hugely increased during the 1970s. The government adopted the policy of pumping up freshwater that was used in the Jordan Valley for irrigation purposes to satisfy the demand of the municipal water sector in Amman. Freshwater was transferred from King Abdallah Canal (which was called East Ghor Canal at that time) in the Jordan Valley. As a result, irrigation water was rationed. In 1978, the official governmental policy to reuse wastewater in agriculture in the Jordan Valley was made in order to partly compensate farmers for the diverted freshwater to Amman (Haddadin 2006).

This reuse was done in an unplanned manner and the wastewater was not sufficiently treated, which resulted in the first cholera outbreak in the year 1978, the same year that the governmental policy of reusing wastewater in agriculture was adopted. As a result of the cholera outbreak, the government destroyed the fields planted with vegetables. Nevertheless, same farmers continued in the following years to irrigate with the inadequately treated wastewater simply because they had no other alternative. Therefore, it can be understood that the governmental policy at that time accepted wastewater irrigation as long as no outbreak of diseases occurred (Haddadin et al. 2006).

The growing share of water used by the municipal sector resulted in larger amounts of municipal wastewater, which needed to be collected and treated. During the United Nations International Drinking Water and Sanitation Decade (1980-1990), the Government of Jordan carried out comprehensive plans and investments in the infrastructure of wastewater collection and treatment. Also, the cholera outbreaks in 1978 and again in 1981 necessitated the expansion of wastewater networks and wastewater treatment.

One of the main decisions was the closure of the Ain Ghazal wastewater treatment plant. Its wastewater load was transferred to As-Samra treatment plant, which was constructed in 1985. As-Samra treatment plant, the largest in Jordan, was considered by the government as a short term solution before designing a more efficient one. This treatment plant became permanent and was overloaded in a short time with amounts of wastewater that are beyond its treatment capacity (Haddadin and Shteiwi 2006).

The reasons that led the government to consider As-Samra as a permanent solution for the wastewater management problem were based on demographic and geographic reasons. The high urban population concentration within the cities of Amman, Zarqa and other areas near the plant was about 70% of Jordan's population that generate about 76% of the total wastewater in Jordan.

The geographic reasons became especially favorable later on after the construction of King Talal Dam on the Zarqa River. Effluent of As-Samra treatment plant was discharged into the Zarqa River to flow into the dam's reservoir. This method assisted in raising the effluent quality. Then blended wastewater is transferred by piped distribution network to farmers in the Jordan Valley, the most cultivated area in Jordan.

The government adopted the policy of not imposing any crop restrictions for the use of diluted water in the Jordan Valley, since the effluent is firstly diluted in reservoirs to increase its quality before being distributed to farmers.

Since the construction of King Talal Dam, this approach of wastewater reuse was adopted by the government and treated wastewater has been considered as a resource for the agricultural sector - mainly after blending - and became part of the Jordanian water budget.

Few years after its construction in 1985, and due to the dramatic increase in wastewater amounts caused by the rapid population growth, As-Samra treatment plant became overloaded and the effluent quality deteriorated. As a result, the export market of Jordanian crops has suffered huge losses when the neighboring Gulf countries imposed restrictions and prohibitions on importing Jordanian crops and vegetables and thus avoiding products irrigated with inadequately treated wastewater.

In 1988, a more comprehensive law was developed, named Water Authority Law No. 18 of 1988. Under this law, WAJ was entitled to provide sewer systems and was tasked to formulate a Jordanian water and wastewater policy. Under the same law, the first standards for industrial wastewater disposal were developed.

During the 1990s, the water situation in Jordan continued to deteriorate. Agriculture consumed about 75% of Jordan's water for irrigation purposes and the water consumption was about 60% beyond sustainable levels. Additionally, the low water tariffs for irrigation provided few incentives for using water efficiently. Therefore, pricing irrigation was chosen as an instrument to reduce demand for water (World Bank 2003). The ASAL program recommended a huge increase in the irrigation tariff that reflects the real costs of water. The MoWI opposed a large increase in water tariffs. Since the World Bank and other donors insisted on the raise, the government agreed to heighten the tariff gradually. The water tariff was raised in 1995 for more than double. Still, the tariff charged did not cover O&M costs (Ibid.).

With the assistance and support from donors such as the World Bank and KfW (Haddadin 2006), the MoWI drafted an official water strategy with long-term goals. The Water Strategy for Jordan was approved by the Council of Ministers in 1997 and adopted as the official water strategy of the government. Under this Strategy, it was agreed that a number of policies are needed to be formulated to achieve the Strategy's goals. Gradually, the MoWI and its two institutions, JVA and WAJ formulated four policies that were approved later on by the Jordanian government. The "Wastewater Management Policy" of Jordan was prepared in 1998.

The first Jordanian standards for wastewater reuse (JS 893/1995) were developed in 1995. These standards contained specification for the following irrigation purposes: Irrigation of vegetables eaten cooked; Irrigation of fruit trees, industrial crop forests and grains; Irrigation of public parks and irrigation of fodder. In the same time, the (JS 893/1995) standards prohibited irrigation of crops eaten raw (i.e. tomato, cucumber, lettuce, …); and prohibited irrigation during a period of two weeks before harvest and sprinkler irrigation (McCornick et al. 2004).

According to the MoWI, amounts of collected wastewater are increasing annually by about 2.5% due to the construction of new wastewater networks, maintenance of existing ones and the connection of new households to the sewers network. In addition, the increased sewage amounts pumped by tanks and dumped into the As-Samra wastewater pond have resulted into the overload of the treatment plant. It became a major source for environmental pollution, due to the insufficiently treated effluent that was discharged into the Zarqa River and the odor that was produced by the plant.

The MoWI considered several possibilities for funding the upgrade of the treatment plant and decided in cooperation with the USAID that the upgrading will be constructed, operated and maintained according to a 25-year (BOT) agreement. The final agreements were signed at the end of 2003, with a total of US$169 million. Almost half of the amount (US$ 78.1

million) was financed by USAID. The project was officially opened in August 2008.

To achieve cost recovery, the government raised the wastewater tariffs in the cities of Amman and Zarqa almost 9% in 2001. Households pay almost 55% of the total water bill for wastewater collection and treatment services. The treatment and collection costs are only paid for water supplied by water networks.

A detailed review of the reuse standards resulted in the new standards JS893/2002 that were enacted in 2003. McCornick et al. considered the main reason behind revising the JS 893/1995 standards was the prohibition imposed on importing fruits and vegetable grown in Jordan by the Gulf countries.

As mentioned before, the new As-Samra treatment plant project was officially opened in 2008. Till the time of writing these pages, there has not been a single scientific study published on the performance of the new treatment plant or even on the evidence of improvement in effluent quality. The only information available was a press report published on September 5th, 2009 at the Al-Arab Al-Yawm daily Jordanian newspaper.

The report indicated according to sources at MoWI and an interview with the director of the Project Management Unit that the new treatment plant is encountering several operating obstacles and part of the received wastewater was transferred to the old treatment plant. Another major problem of the treatment plant is the accumulation of sludge. (Al-Arab Al-Yawm 05.09.2009 p.2).

Figure 4.8: Timeline of Main Policies and Events that Promoted or Hampered Wastewater Reuse in Jordan.

encouragement of irrigated agriculture **1950s**		policy to pump freshwater from Jordan Valley to Amman **1970s**	Cholera outbreak (also1981) fields destruction **1978**	Increase in wastewater collection rates **1980-1990**	As-Samra overloaded effluent deteriorated policy of effluent dilution in dam reservoir **end of 1980s**	
	1960s beginning of unofficial wastewater reuse near Amman		**1978** Adopting officially policy of compensating farmers with treated wastewater	**1985** need for treatment As-Samra construction	**end of 1980s** Gulf countries banned import of Jordanian crops	
WAJ establishment **1988**		ASAL raise irrigation tariff 150 % **1997**		raise wastewater tariffs in Amman and Zarqa 9% **2001**		official operation of As-Samra project **2008**
	1995 first Jordanian standards for wastewater reuse		**1998** formulation of wastewater management policy		**2003** agreement As-Samra upgrade BOT USAID US$ 78.1 million	

4.10. Other Water Policy Alternatives

The limited water resources in Jordan combined with the population pressure had led the Jordanian government to the implementation of supply side management projects. This policy worsened the problem of water shortage and harmed the environment, especially the groundwater resources. The water policy of the government considered wastewater as a resource for irrigation. This was highly influenced by the following factors:

- The environmental damage that was caused by the overexploitation of the groundwater resources.
- The possibilities for the development of new freshwater resources are extremely limited.
- The few existing possibilities for new water resources are expensive and include high operating costs.
- The fact that Jordan is not oil producing country makes sea water desalinization, using fuel produced energy, unfeasible.

At the time being, Jordanian policy-makers try to focus on huge water projects in order to increase water supply. The most important projects are thoroughly discussed among policy-makers and donors are the Disi fossil aquifer project and the Red Sea-Dead Sea conveyance project for seawater desalination.

4.10.1. Disi Aquifer Project

Currently, the Disi Project is of high priority and has the full attention and support of the policy-makers in Jordan. It aims to pump fossil groundwater from an aquifer that is non-renewable, in the Disi-Mudawarra area in the south of Jordan - near the border to Saudi Arabia. The second step is to convey the water over a distance of approximately 325 km to the capital of Amman. The conveyance system shall have a capacity of transporting 100 MCM water per year that will be used for municipal purposes. It is planned to construct the project with the participation of the private sector under BOT basis.[12]

This project entails huge costs, because the expenditure to deliver water to Amman over such a long distance is very expensive. For example, Salman et al. estimated the conveyance costs at US$ 1/m^3. Also, they have

[12] MoWI's Website.

estimated the capital costs of the pipeline to be about US$ 600 million. Salman et al. argue if the government would invest in water supply networks and reduce leakage down to about 15% this will have more immediate impact on the country's social welfare. Also larger parts of the country would benefit from the maintenance, while the Disi project aims only to supply the area of Amman (Salman et al. 2006).

In addition, the project entails also environmental concerns. The water that will be transferred to the Amman area is non-renewable. According to experts, groundwater can be extracted between 30 to 50 years. Moreover, the water quality might deteriorate with time to brackish water. Since the aquifer is situated near the borders of Saudi Arabia, the government there may also decide to pump certain amounts of water, which may cause faster depletion.

4.10.2. The Red Sea - Dead Sea Conveyance Project

The concept of this regional project was initiated between Jordan, Israel and the USA for an integrated development of the Jordan Valley. The project plan is to link the Red Sea with the Dead Sea, the lowest point on earth, by transferring about 1,800 MCM of salt water from the Red Sea to raise the level of the Dead Sea. In the last 35 years the surface of the lake shrank about one third. Until the year 2020 a decline from now -418 meter is predicted.

Desalinated water is a main aim of the project, when water from the Red Sea will be lifted about 220 meter above sea level, and then flow by gravity to the Dead Sea about -418 meter below sea level. The difference in elevation will be used to generate power for operating desalination plants. From there the desalinated water will be pumped to large cities in the area (Haddadin 2006).

The length of the project area is estimated with about 200 km. It is also expected that the project will produce 851 MCM of freshwater annually. Two-thirds will be delivered to Jordan and one third to Israel and the Palestinian Authority. According to the MoWI, other objectives of the project are:

- provision of sustainable source of freshwater to Jordan, Israel and the Palestinian Authority;
- stimulation of the economic development in the Jordan Valley;

- promotion of the peace process in the region;
- stabilization of the level of the Dead Sea and
- provision of additional water to mitigate environmental damages.[13]

At the time being, a feasibility study is conducted. The estimated cost for this study is about US$ 5 million. Since the project will have very high costs, several actors and donors in the water sector have restraints on it. The National Water Master Plan pointed out that - if implemented - the project may have several negative environmental impacts like endangering the coral reefs in the Gulf of Aqaba or the fear that the mix of a ten times higher salt concentration lake water with salt water might create gypsum in the Dead Sea. Another problem is seen in the high energy required to transfer water from the Dead Sea to recipient areas in Amman (MoWI/GTZ 2004).

[13] MoWI's Website.

5. Findings and Conclusions

The extreme aridity the MENA region is experiencing and the high population growth impose huge challenges of water resource management in the region that received different policy responses by governments. Wastewater reuse in agriculture is a common practice and is increasingly becoming recognized as a main source for irrigation.

Despite the perceived advantages of wastewater reuse, large amounts of treated or insufficiently treated wastewater are disposed into the environment or seas, instead of being reused. This is mainly due to the fact that most of the MENA countries lack clear policies that encourage and promote wastewater reuse in agriculture.

Other obstacles that hamper the promotion of wastewater reuse are the incomplete economic analysis of the wastewater treatment and reuse projects; the high costs of developing wastewater collection networks and wastewater treatment plants with the lack of wastewater recovery mechanisms; the low demand for treated wastewater; and the cheap prices of freshwater as discussed in chapter 3.

Experiences in wastewater reuse differ within the MENA countries. Despite these obstacles, some countries were able to promote wastewater reuse by adopting appropriate policies. In countries like Jordan and Tunisia treated wastewater became a vital aspect and a strategic component within the national water budgets (Hypothesis 2).

The Tunisian experience proves that the country was able to overcome the problem of institutional fragmentation in wastewater reuse by forming an independent wastewater agency that many of the tasks of a number of different institutions were assigned to. One of the important results is the high wastewater treatment collection and treatment rates. Additionally, a committee with representatives from the different ministries and agencies, the municipalities and representatives of the farmers was formed on national and regional levels to improve coordination. In 2002 the Ministries of Agriculture, Environment and Water resources were consolidated into one single ministry to oversee integrated water resources management and wastewater reuse. These reasons explain why Tunisia is a pioneer country in the field of planned wastewater reuse in the MENA region.

The Tunisian example shows that the strong institutional setting and governmental support are major prerequisites for practicing planned and safe wastewater reuse. However, this can never guarantee high demand for treated wastewater by the agricultural sector. Tunisian regulations do not allow the use of treated wastewater for irrigating vegetables, which generate high income for farmers. Since farmers in Tunisia have alternative water sources, they prefer using freshwater to wastewater although the price of treated wastewater is cheaper.

In the Jordanian context, farmers have no other alternative and therefore demand for treated wastewater is so high that almost the whole amount of wastewater treated is reused. This is consistent with the first hypothesis of this research, which assumed that the extent of conflict over freshwater resources between the water sectors can foster wastewater reuse in agriculture.

Jordan (the case study of this research) is also considered one of the advanced countries in MENA region in the field of wastewater reuse in agriculture. In the country, wastewater has been considered more as a valuable resource rather than a source of pollution and for that reason wastewater has been included as part of the national water budget. In Jordan, the reuse of wastewater in agriculture has been adopted as a tool for water demand management. This process has replaced amounts of freshwater resources, which were previously used for irrigation, to be used in the municipal sector where higher quality water is needed for potable use.

With the current competition between the different water sectors on available freshwater resources, the share of agricultural sector is increasingly dropping (see Chapter 4). As a result, agricultural sector's dependence on treated wastewater for irrigation purposes is increasing. The projections of MoWI indicate that the coming years will bring an increase in the amounts of wastewater reused for irrigation purposes. (Hypothesis 1, research question 1.1, research question 1.2).

Jordan was able to establish an acceptable institutional and legal framework including a wastewater management policy and wastewater standards. The development of these frameworks and standards came as a result of an experimental and flexible approach by adopting different policies related to wastewater reuse such as policies on sanitation, water pricing, standards and health protection (see Figure 1.1). These policies were analyzed in chapter 4.9 and summarized in (Figure 4.8). The implementation of wastewater reuse projects has resulted in various positive impacts on the environment and the general human health of the society.

Nevertheless, within the Jordanian setting, wastewater reuse in agriculture aims mainly to substitute the high quality freshwater that was used for irrigation with the diluted water that is suitable for irrigation. Freshwater has been transferred to the municipal sector, where higher water quality is needed for drinking purposes (research question 1.2). The extent of benefits and advantages that were gained from this process were not equal for the main actors involved in wastewater reuse projects.

Consequently, some actors have to bear a number of negative aspects as a result of the process. The different roles of the main actors in wastewater reuse in Jordan and the way they interact were analyzed in chapter 4.7 (research question 2.4). Table 5.1 analyzes the advantages and disadvantages for those actors who are directly affected with freshwater reallocation and its replacement with diluted water in agriculture.

Table 5.1: Advantages and Disadvantages for Actors Affected by Water Reallocation through Wastewater Reuse in Agriculture in Jordan

Actor	Advantages	Disadvantages
Urban Users	• Urban users receive additional amounts of water, which were withdrawn from farmers	• Urban users pay already 55% of the water bill for wastewater collection and treatment. If the quality of treated wastewater shall be improved, urban users might bear the highest share of the additional treatment costs.
WAJ	• Disposing treated wastewater by gravity into wadis, and storing it later on in reservoirs is a low cost method, especially because Jordan lacks water bodies where treated wastewater can be safely discharged. • WAJ delivers additional amounts of water to the urban users that were withdrawn from farmers and charge fees from urban users for delivered water.	• Does not charge fees from JVA for discharged treated wastewater into reservoirs
JVA	• Receive treated effluent from WAJ treatment plants without paying for it. However, JVA receive fees from farmers for distributing the diluted water.	• The price that is paid by farmers for diluted water is relatively cheap and JVA has no direct influence on setting the water tariff

Table 5.1 (continued)

Actor	Advantages	Disadvantages
Farmers	• Diluted water contains nutrients that can replace the mineral fertilizers that farmers use.	• Farmers were compensated for the amounts of freshwater that are transferred to urban users with diluted water that has lower quality. The higher salinity of diluted water may have negative impacts on soil and crops. • There is no price incentive for using diluted water. Farmers pay for diluted water the same price as for freshwater. • Farmers who use diluted water are unable to export their crops to neighboring countries
Consumers		• Consumers are unaware if the crops they buy are irrigated with blended water or freshwater

5.1. Grounds of Success for Wastewater Reuse in Jordan

Several factors have enabled Jordan to achieve an acceptable program for the wastewater reuse in agriculture among the MENA countries. Most of these factors have less to do with the expensive treatment technologies rather than the existing wastewater management policy and the enabling institutional setting (Hypothesis 2 and research question 2.3). These factors are:

- Jordan falls among few other countries within the category of absolute water scarcity. The huge water shortage and the competition between the different water sectors left only limited amounts of water for the agricultural sector. The population growth and increasing urbanization rates resulted in a constant raise in the amounts of generated wastewater. The government of Jordan set wastewater reuse in agriculture on the policy agenda after taking the decision to pump up freshwater used in the Jordan Valley for irrigation purposes to the urban users in Amman (research question 2.2). The official governmental decision was made in order to partly compensate farmers at the Jordan Valley for the amounts of freshwater that have been pumped to Amman. Therefore, wastewater became an important resource for irrigation when freshwater became unattainable.

- Donors and lenders played an important role in supporting most of Jordan's water projects and wastewater treatment plants. However, their role in developing a suitable institutional setting for wastewater reuse has much higher importance. Donors and lenders contribution as outside initiator in forming the official water strategy, the wastewater management policy, the Jordanian standards of treated wastewater and the establishment of committees for the coordination of wastewater reuse, assisted in putting wastewater reuse on the top of the policy agenda (research question 2.2). This offered Jordan a good opportunity to obtain a leading position in wastewater reuse within the MENA region.

- The Jordanian wastewater management policy called for expanding the role of the private sector in wastewater management and reuse. This policy enabled Jordan to solve the problem of the country's largest wastewater treatment plant. As-Samra treatment plant, that receives more than 75 % of the country's wastewater, has been lately upgraded and modernized with the participation of the private sector. Replacement of existing wastewater treatment plant, to be constructed, operated and maintained according to a 25-year BOT agreement that is the first in MENA region.

- The physical conditions of Jordan and the population distribution are very favorable for wastewater reuse. Areas with dense population are located on the mountains upper the Jordan Valley. The As-Samra treatment plant that receives about 75% of the countries wastewater and other treatment plants flow their effluents into dams. This process has two main advantages; first: mixing the effluent with water in the dam reservoirs improves its quality. Second: discharging the effluent into the reservoirs serves as a storage method in winter, when the need for irrigation water is less than it is in the dry summer months. After being blended, the diluted water flows from the reservoir down to the Jordan Valley by the use of gravity conveyance through wadis and at a later stage into pipes and canals to farms. This physical characteristic saves high energy costs for pumping the diluted water to farmers in the Jordan Valley.

5.2. Bottlenecks in Wastewater Reuse and Management

Although Jordan, as pointed out previously, is considered advanced in wastewater reuse and management, the country still faces some challenges that should be dealt with wisely and through adopting new policies. The main bottlenecks are:

- The national water policy in Jordan needs to change some of the adverse incentives on wastewater reuse in agriculture. Till now, tariffs of freshwater and groundwater charges for irrigation purposes are low. The pricing policy of freshwater and groundwater in the agricultural sector is merely based on political factors that aim to achieve social stability rather than creating opportunities for recovering the full water costs including operation and maintenance. Lifting subsidies gradually is necessary to resolve ideal pricing patterns that will not harm small farmers. A series of tariff increases will raise revenues that can be used for the construction of new wastewater treatment plants and upgrading the overloaded ones. Additionally, the current tariff structure has no price incentive for farmers using diluted water for irrigation. Without adopting a pricing policy that permits farmers to pay for diluted water less than freshwater, equity will not be achieved.

- Although the institutional setting in Jordan offers opportunities to wastewater reuse, there are potentials for improvement to achieve more benefits and provide sustainability. For example, the large number of actors involved such as the MoWI, WAJ, JVA, MoA, MoH and MoE causes a lack of coordination and overlapping responsibilities. Main improvements in the institutional setting should be directed to handover the responsibilities of wastewater management and reuse to one agency. This also will enhance the implementation and enforcement of the standards and regulations that already existed and were partly neglected.

- Effluent quality remains one of the main obstacles for wastewater reuse in agriculture. A number of wastewater treatment plants in Jordan are operating beyond their design capacity, which results in deterioration of the treated wastewater quality. In some cases it does not even reach the Jordanian standards. The policy of effluent dilution with freshwater solved the problem partly. However, the illegal irrigation practices nearby wadis where low quality effluent is discharged, before being diluted in reservoirs, still poses a major threat for the general health. Relying on donors for the construction or upgrading new treatment plants cannot be a soulution. The problem of As-Samra treatment plant began since the end 1980s and the BOT solution was implemented 18 years later in cooperation with the USAID, who financed the project with US$ 78.1 million.

- Jordanian standards for treated wastewater are quite strict and therefore sometimes are not met. The government should share information on water quality with transparency and promote public awareness. This will enable farmers to take protection measures against possible health risks for themselves and the consumers of agricultural products (see Hyderabad Declaration Box 2.2). Enhancement of Jordanian standards and improving the effluent quality will also form a first step for reopening the export market for irrigated crops.

- Under the current Jordanian water strategy and water policies, water should be first allocated to satisfy the demand of the municipal sector, then the industrial sector and finally the agricultural sector, the largest water consumer in Jordan (see chapter 4.3.2). However, the water policy is inconsistent with the agricultural policy. The low water prices encourage the irrigation of several water intensive crops, like Banana and citrus trees, despite the huge water shortage the country faces. Thus, wastewater reuse in Jordan will not achieve its ultimate goals unless water pricing and agricultural policies become consistent with the Jordanian water strategy and its different policies.

6. References

Aalbers, H. and Sietzema, M. J. (1999): Present Technological Options for Water Use and Treatment in the Context of the Ecological Integrity Approach, Urban Waste Expertise Programme (UWEP) Occasional Paper, Netherlands.

Abedel Khaleq, R. and Dziegielewski, B. (2006): A National Water Demand Management Policy in Jordan, Management of Environmental Quality, Vol. 17 No. 2 pp. 216-225.

Abu Madi, M., Braadbaart, O., Al-Sa'ed, R. and Alaerts, G. (2003): Willingness of Farmers to Pay for Reclaimed Wastewater in Jordan and Tunisia. Water Science and Technology: Water Supply, Vol. 3 No. 4. pp. 115-122. IWA Publishing.

Abu-Sharar, T.M. and Battikhi, A.M. (2002): Water Resources Management under Competitive Sectoral Demand, A case study from Jordan. International Water Resources Association. Water International, Vol. 27 No.3.

Abu-Sharar, T.M., Hussein, I.A. and Al-Jayyousi, O.R. (2003): The Use of Treated Sewage for Irrigation in Jordan: Opportunities and Constraints. The Journal, Vol. 17 No. 4.

Al Atiri, R., Rezgui, F. and Aniba, B. (2002): Wastewater Reuse: The Case of Tunisia. Water Demand Management Forum. Rabat, Morocco.

Al Salem, S.S. and Abouzaid, H. (2006): Wastewater Reuse for Agriculture: Regional Health Perspective. Eastern Mediterranean Health Journal, Vol. 12, Nos. 3/4.

Al-Arab Al-Yawm Daily Newspaper, Issue Dated 05.09.2009. Amman, Jordan.

Al-Hadidi, K. (2002): Valuation of Irrigation Water The Case of Jordan, Water Demand Management Forum, Beirut, Lebanon - June 2002.

Alkhaddar, R.M., Sheely, W.J.S. and Al-Ansari, N. (2005): Jordan's Water Resources Supply and Future Demand, Water International, Vol. 30 No. 3, pp. 294-303, International Water Resources Association.

Al-Kharabsheh, A. (1999): Ground-Water Quality Deterioration in Arid Areas: A Case Study of the Zerqa River Basin as Influenced by Khirbet Es-

Samra Waste Water (Jordan). Journal of Arid Environments 1999, Vol. 43 pp. 227-239.

Al-Nakshabandi, G.A., Sqqar, M.M., Shatanawi, M.R., Fayyad, M. and Al-Horani, H. (1997): Some Environmental Problems Associated with the Use of Treated Wastewater for Irrigation in Jordan. Agricultural Water Management 34 (1997) pp. 81-94.

Al-Zboon, K. and Al-Ananzeh, N. (2008): Performance of Wastewater Treatment Plants in Jordan and Suitability for Reuse. African Journal of Biotechnology, Vol. 7 No. 15 pp 2621-2629.

Ammary, B.Y. (2007): Wastewater Reuse in Jordan: Present Status and Future Plans. Desalination 211 (2007) pp. 164-176.

Arar, A. (1989): The Future Role of Sewage Effluent for Irrigation in the Near East. In: Bouchet, R. (ed.): Reuse of low Quality Water for Irrigation. Bari, Italy.

Asano, T and Levine, A.D.(1996): Wastewater Reclamation, Recycling and Reuse: Past, Present, and Future. Water Science and Technology Vol. 33 No. 10-11, Elsevier Science Ltd.

Asano, T. (1998): Wastewater Reclamation and Reuse. Water Quality Management Library, Volume 10, CRC Press, Boca Raton, FL.

Asano, T. (2002): Water from (Waste)Water - the Dependable Water Resource. Water Science and Technology. Vol. 45 No. 8.

Asano, T. (2005): Urban Water Recycling. Water Science and Technology Vol. 51 No.8. IWA Publishing.

Awad, M. (1997): Environmental Study of the Amman-Zerqa Basin Jordan. Environmental Geology, Vol. 33 (1).

Bahri, A. (2009): Managing the Other Side of the Water Cycle: Making Wastewater an Asset. Global Water Partnership Technical Committee, TEC Background Papers No. 13, Mölnlycke, Sweden.

Bahri, A. and Brissaud, F. (1996): Wastewater Reuse in Tunisia: assessing a national policy. Water Science and Technology Vol. 33 No. 10-11. IWA Publishing.

Bakir, H. (2000): Water Demand Management and Pollution Control: Key to Securing and Safeguarding the Water Supplies of MENA in the 21st

Century, WHO/ Regional Center for Environmental Health Activities (CEHA), Amman, Jordan.

Bakir, H. (2001): Guiding Principles and Options for Accelerated Extension of Wastewater Management Services to Small Communities in East Mediterranean Region Countries, WHO/ Regional Center for Environmental Health Activities (CEHA), Amman, Jordan.

Bannayan, H. (1991): The Inadequacy of Stabilization Ponds Treatment as Manifested by the Effects of Khirbet es-Samra Effluent on the Groundwater Quality of the Surrounding Area. In: Water Pollution in Jordan, Causes and Effects. Proceedings of the Second Environmental Pollution Syposium. 29th September 1990.

Bartram, J., Fewtrell, L., and Stenström, T. (2001): Harmonised Assessment of Risk and Risk Management for Water-Related Infectious Disease: An Overview. In. Fewttrell, L. and Bartram, J. (eds.): Water Quality: Guidelines, Standards and Health. WHO. IWA Publishing, London, UK.

Bataineh, F., Najjar, M. and Malkawi, S. (2002): Wastewater Reuse in Jordan, Water Demand Management Forum.

Bazza, M. (2003): Wastewater Recycling and Reuse in the Near East Region: Experience and Issues. Water Science and Technology: Water Supply Vol. 3 No.4.

Bilbeisi, M. (1992): Jordan’s Water Resources and the Expected Domestic Demand by the Years 2000 and 2010, Detailed According to Area. In: Jordan’s Water Resources and their Future Potentials. Friedrich Ebert Stiftung, Amman- Jordan.

Blumenthal, U., Peasey, A., Ruiz-Palacios, G. and Mara, D.D. (2000): Guidelines for Wastewater Reuse in Agriculture and Aquaculture: Recommended Revisions Based on New Research Evidence. London School of Hygiene & Tropical Medicine, UK and WEDC, Loughborough University, UK.

Brooks, D.B., Thompson, L. and El Fattal, L. (2007): Water Demand Management in the Middle East and North Africa: Observations from the IDRC Forums and Lessons for the Future. Water International, Vol. 32 No. 2 pp. 193-204.

Bruvold, W.H., Olson, B.H., Rigby, M. (1981): Public Policy for the Use of Reclaimed Water. Environmental Management Vol. 5 No. 2 pp. 95-107.

Cairncross, S. (1992): Sanitation and Water Supply: Practical Lessons from the Decade. World Bank, Washington, D.C.

Carr, R.M., Blumenthal, U.J. and Mara, D.D (2004): Health Guidelines for the Use of Wastewater in Agriculture: Developing Realistic Guidelines. In: Scott, C.A., Faruqui, N.I and Raschid-Sally, 'L. (eds.): Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities. CABI/IWMI/IDRC.

Choukr-Allah, R. and Hamdy, A. (2003): Wastewater Recycling and Reuse in Mediterranean Region as a Potential Resource for Water Saving. Options Méditerranéennes: Série B. Etudes et Recherches No. 44.

Chu, J., Chen, J., Wang, C. and Fu, P. (2004): Wastewater Reuse Potential Analysis: Implications for China's Water Resources Management. Water Research 38 (2004) 2746-2756.

Cobb, R. W. and. Edler, C. D (1972): Participation in the American Politics: The Dynamics of Agenda-Building, Boston. Cited in: Howlett, M. and Ramesh, M. (1995).

Darghouth, S. Bisaz, A. (2001) Foreword. In: World Bank and Swiss Development Cooperation Agency.

DeLeon, P. (1999): The Stages Approach to the Policy Process: What Has It Done? Where Is It Going? In: Sabatier, Paul A. (ed.). (1999): Theories of Policy Process. Westview Press.

Donor Lender Sub-Group Water/Technical Committee 'Reuse of Treated Wastewater'. Position Paper, Amman, 24.05.2004.

Duqqah, M.M., Shatanawi, M.R., Mazahrih, N., Fardous, A. and Mazahreh, S. (2005): Reclaimed Wastewater Treatment and Reuse in Jordan: Policy and Practices. In: Hamdy, A., El Gamal, F., Lamaddalena, N., Bogliotti, C. and Guelloubi, R. (eds.): Non-conventional Water Use: WASAMED project, Bari, Italy.

EMENA Technical Infrastructure (1990): Wastewater Reuse in the Middle East and North Africa, Regional Study, Final Report.

Engineering-Science (1987): Monetary Wastewater Reclamation Study for Agriculture. Prepared for Monetary Regional Water Pollution Control Agency, Pacific Grove, California.

Faruqui, N. (2000): Wastewater Treatment and Reuse for Food and Water Security, International Development Research Center, Ottawa, Canada.

Faruqui, N. I., Scott, C.A. and Raschid-Sally, 'L. (2004): Confronting the Realities of Wastewater Use in Irrigated Agriculture: Lessons Learned and Recommendations. In: Scott, C.A., Faruqui, N.I and Raschid-Sally, 'L. (eds.): Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities. CABI/IWMI/IDRC.

Feachem, R. G., Bradley, D. J., Garelick, H. and Mara, D.D. (1983): Sanitation and disease : health aspects of excreta and wastewater management. World Bank Studies in Water Supply and Sanitation No. 3. The Johns Hopkins University Press.

Fewttrell, L. and Bartram, J. (eds.): Water Quality: Guidelines, Standards and Health. WHO. IWA Publishing, London, UK.

Food and Agriculture Organization of the United Nations (FAO) - Regional Office for the Near East and World Health Organization (WHO), Regional Office for the Eastern Mediterranean (2003): Proceedings of Expert Consultation for Launching the Regional Network on Wastewater Re-use in the Near East.

Food and Agriculture Organization of the United Nations (FAO), Regional Office for the Near East (2001): Experience of FAO on wastewater reuse in the Near East region. Regional workshop on water reuse in the Middle East and North Africa organized by World Bank Middle East and North Africa region, Cairo, Egypt, 2-5 July 2001.

Friedler, E. (2001): Water Reuse - An Integral Part of Water Resources Management: Israel as a Case Study, Water Policy Journal, Vol.3 No.1, Elsevier Science pp. 81 – 99.

Haddadin, M. (2006): Evolution of Water Administration and Legislation. In: Haddadin, M. (ed.): Water Resources in Jordan: Evolving Policies for Development, the Environment, and Conflict Resolution. RFF Press, Washington, DC.

Haddadin, M. and Shteiwi, M. (2006): Linkages with Social and Cultural Issues. In: Haddadin, M. (ed.): Water Resources in Jordan: Evolving Policies for Development, the Environment, and Conflict Resolution. RFF Press, Washington, DC.

Haddadin, M., Sunna', S. and Alrashid, H. (2006): Development of Water Resources and Irrigation. In: Haddadin, M. (ed.): Water Resources in

Jordan: Evolving Policies for Development, the Environment, and Conflict Resolution. RFF Press, Washington, DC.

Hamoda, M.F. (2004): Water Straegies and Potential of Water Reuse in the South Mediterranean Countries. Desalination 165 pp. 31-41.

Havelaar, A. Blumenthal, U.J., Strauss, M., Kay, D. and Bartram, J. (2001): Guidelines: the Current Position. In: In. Fewttrell, L. and Bartram, J. (eds.): Water Quality: Guidelines, Standards and Health. WHO. IWA Publishing, London, UK.

Howlett, Michael and Ramesh, M. (1995): Studying Public Policy: Policy Cycles and Policy Subsystems. Oxford University Press.

Jamrah, A.I. (1999): Assessment of Characteristics and Biological Treatment Technologies of Jordanian Wastewater. Bioprocess Engineering, Vol. 21 (1999) pp 331-340.

Johnson, B.B. (1980): Federal Wastewater Reuse Policy: Institutional and Attitudinal Obstacles to National Progress. Resource Recovery and Conservation 5 pp. 179-193.

Karaa, K., Karam, F. and Tarabey, N. (2005): Wastewater Treatment and Reuse in Lebanon: Key Factors for Future Agricultural Uses. In Hamdy, A., El Gamal, F., Lamaddalena, N., Bogliotti, C. and Guelloubi, R. (eds.): Non-conventional Water Use: WASAMED project, Bari, Italy.

Keraita, B., Drechsel, P. and Amoh, P. (2003): Influence of Urban Wastewater on Stream Water Quality and Agriculture in and around Kumasi, Ghana. Environment & Urbanization, Vol. 15 No. 2 October 2003.

Kfouri, C., Mantovani, P. and Jeuland, M. (2009): Water Reuse in the MNA Region: Constraints, Experiences, and Policy Recommendations. In: Jagannathan et al (eds.): Water in the Arab World: Management Perspectives and Innovations. The World Bank, Washington, USA.

Khouri, N., Kalbermatten, J.M. and Bartone, C.R. (1994): The Reuse of Wastewater in Agriculture: A Guide for Planners. UNDP-World Bank Water and Sanitation Program. The World Bank, Washington, DC.

Lenton, R., Wright, A. M. and Lewis, K. (2005): Health, Dignity, and Development: What Will It Take? UN Millennium Project, Task Force on Water and Sanitation, Earthscan London, Sterling, Va.

Matouq, M. (2008): The Potential for Reusing Treated Municipal Wastewater for Irrigation in the Hashemite Kingdom of Jordan. Int. J. Water, Vol. 4, Nos. 1/2, pp. 105-120.

McCornick, P.G., Hijazi, A. and Sheikh, B. (2004): From Wastewater Reuse to Water Reclamation: Progression of Water Reuse Standards in Jordan. In: Scott, C., Faruqui N.I. and Raschid, L. (eds.): Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities, CABI/IWMI/IDRC.

Ministry of Water and Irrigation (2007): Water Budget for the Year 2007. (in Arabic).

Ministry of Water and Irrigation of Jordan (1998): Jordan's Water Strategy and Water Policies in Jordan. MoWI, Amman, Jordan.

Ministry of Water and Irrigation of Jordan / GTZ (2004): National water master plan, Amman, Jordan.

Ministry of Water and Irrigation Website: http://www.mwi.gov.jo

Mohsen, M.S. (2007): Water Strategies and Potential of Desalination in Jordan. Desalination 203 (2007), p.p. 27 - 46.

Mougeot, L.J.A. (2006): Growing Better Cities: Urban Agriculture for Sustainable Development. International Development Research Centre.

Mrayyan, B. (2005): Optimal Utilization of Reclaimed Wastewater for Irrigation Purposes: Case of As-Samra Wastewater Treatment Plant. Journal of Environmental Assessment Policy and Management Vol. 7 No. 4 pp. 735-750.

Mubarak, J.A. (1998): Middle East and North Africa: Development Policy in View of a Narrow Agricultural Natural Resource Base, World Development, Vol. 26, No. 5, pp. 877-895, Elsevier Science Limited.

National Research Council (1996): Use of Reclaimed Water and Sludge in Food Crop Production. National Academy Press. Washington, D.C.

Nazzal, Y.K. Mansour, M. Najjar, M. and McCornick, P. (2000): Wastewater Reuse Law and Standards in the Kingdom of Jordan, Ministry of Water and Irrigation. Amman, Jordan.

Neubert, S. (2002): Wastewater Reuse in Agriculture- a Challenge for Administrative Coordination and Implementation. In: Neubert, S., Scheumann, W. and van Edig, A. Reforming Institutions for Sustainable Water Management. German Development Institute, Bonn.

Neubert, S. (2009): Wastewater Reuse: How “Integrated” and Sustainable is the Strategy?. Water Policy 11, pp. 37-53.

Parkinson, J. and Tayler, K. (2003): Decentralized Wastewater Management in Peri-urban Areas in Low-income Countries. Environment & Urbanization, Vol. 15 No. 1 April 2003.

Pescod, M.B. (1992): Wastewater treatment and Use in Agriculture, FAO, Rome.

Qadir, M., Bahri, A., Sato, T. and Al-Karadsheh, E. (2009): Wastewater Production, Treatment, and Irrigation in Middle East and North Africa. Irrigation Drainage Systems. Published online 17 November 2009.

Qadir, M.,Wichelns, D., Raschid-Sally, L.,McCornick, P.G., Drechsel, P., Bahri, A. and Minhas, P.S. (2010): The Challenges of Wastewater Irrigation in Developing Countries. Agricultural Water Management 79 (2010). pp. 561-568.

Queensland Government (2000): Draft Queensland Water Recycling Strategy. Department of Natural Resources, Brisbane, Australia. Cited in: Asano, T. (2005): Urban Water Recycling. Water Science and Technology Vol. 51 No.8. IWA Publishing.

Raschid-Sally et al. (2001): Rethinking Urban Wastewater Re-use: Opportunities and Challenges, In: Proceedings of Frontiers in Urban Water Management: Deadlock or Hope? Symposium of UNESCO International Hydrological Program, 18-20 June 2001 Marseille, France.

Raschid-Sally, L., Bradford, A.M. and Endamana, D. (2004): Productive use of wastewater by poor urban and peri-urban farmers: Asian and African case studies in the context of the Hyderabad Declaration on Wastewater Use. In: Moriarty, P., Butterworth, J. and van Koppen, B.: Beyond Domestic: Case studies on poverty and productive uses of water at the household level. Delft, the Netherlands, IRC International Water and Sanitation Centre. (Technical Paper Series; no. 41).

Redwood, M. (2004): Wastewater Use in Urban Agriculture: Assessing Current Research and Options for National and Local Governments. Cities Feeding People Program Initiative. International Development Research Centre.

Rijsberman, F. R. and Lebel, J. (2004):Foreword. In: Scott, C.A., Faruqui, N.I and Raschid-Sally, ‘L. (eds.): Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities. CABI/IWMI/IDRC.

Rose, G.D. (1999): Community-Based Technologies for Domestic Wastewater Treatment and Reuse: Options for Urban Agriculture. CFP Report Series, Report 27. IDRC.

Sabatier, Paul A. (1999): The Need for Better Theories. In: Sabatier, Paul A. (ed.): Theories of Policy Process. Westview Press.

Sadeq, H.T. (1999): A Rare and Precious Resource. The UNESCO.

Saghir, J. Schiffler, M., and Woldu, M. (2000): Urban Water and Sanitation in the Middle East and North Africa Region: The Way Forward, World Bank.

Salman, A. et al. (2006): The Economics of Water in Jordan. In: Haddadin, M. (ed.): Water Resources in Jordan: Evolving Policies for Development, the Environment, and Conflict Resolution. RFF Press, Washington, DC.

Sammis, T., Stewart, B. and Zachritz, B. (2001): Sewage Effluent Discharge Regulations for Irrigation Development in the Middle East Region, Middle East Countries Standards Site for Sewage Treatment and Water Reuse.

Scharpf, F. (1997): Games Policy Actors Play. Boulder: Westview Press.

Schiffler, M. (1998): The Economics of Groundwater Management in Arid Countries: Theory, International Experience and a Case Study of Jordan, Frank Cass Publishers in association with German Development Institute.

Schiffler, M. et al. (1994): Water Demand Management in an Arid Country The Case of Jordan with Special Reference to Industry, German Development Institute, Reports and Working Papers 10/1994, Berlin.

Scott, C.A., Faruqui, N.I and Raschid-Sally, ‘L. (eds.): Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities. CABI/IWMI/IDRC.

Scott, C.A., Faruqui, N.I. and Raschid-Sally, ‘L. (2004) Wastewater Use in Irrigated Agriculture: Management Challenges in Developing Countries. In: Scott, C.A., Faruqui, N.I and Raschid-Sally, ‘L. (eds.): Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities. CABI/IWMI/IDRC.

Shatanawi, M. and Fayyad, M. (1996): Effect of Khirbit As-Samra Treated Effluent on the Quality of Irrigation Water in the Central Jordan Valley. Water Resources, Vol. 30 No. 12 pp. 2915-2920.

Shelef, G. (1991): Wastewater Reclamation and Water Resources Management. Water Science and Technology Vol. 24 No. 9.

Shetty, S. (2004): Treated Wastewater Use in Tunisia: Lessons Learned and the Road Ahead. In: Scott, C., Faruqui N.I. and Raschid, L (eds.): Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities, CABI/IWMI/IDRC.

Shuval, H. (1992): Wastewater Recycling and Reuse as a Water Source for Mediterranean Countries: Hygienic and Technological Aspects, Presentation at the 2nd Water Mediterranean Conference, Rome.

Shuval, H.I. (1990): Wastewater Irrigation in Developing Countries: Health Effects and Technical Solutions. Summary of World Bank Technical Paper Number 51. World Bank, Washington, D.C.

Shuval, H.I., Adin, A., Fattal, B., Rawitz, E. and Yekutiel, P. (1986): Wastewater Irrigation in Developing Countries: Health Effects and Technical Solutions. World Bank Technical Paper Number 51. The World Bank. Washington, D.C.

Taha, S. and Bataineh, F. (2002): Water Valuation: The Case of Jordan, Valuation of the Water for Domestic Use, Water Demand Management Forum, Beirut, Lebanon - June 2002.

Task Force on Water and Sanitation Millennium Project (2004).

Toubkiss, J. (2006): Costing MDG Target 10 on Water Supply and Sanitation: Comparative Analysis, Obstacles and Recommendations. World Water Council, World Water Forum.

Tutundjian, S. (2001). Water Resources in Jordan, USAID Amman, Jordan.

Uleimat, A.A. (2004): Quality Aspects of Reclaimed Domestic Wastewater in Jordan. In: Practices and Experiences of Water and Wastewater Technology. Proceedings of the Seminar Organized by the Regional Centre on Urban Water Management. Muscat, Oman 5-7 October 2004. UNESCO.

UNESCO (2001): Proceedings of Frontiers in Urban Water Management: Deadlock or Hope? Symposium of UNESCO International Hydrological Program, 18-20 June 2001 Marseille, France.

United States Agency for International Development (USAID) and Associates in Rural Development Inc. (ARD) (2001):Standards, Regulations and Legislation for Water Reuse in Jordan. Water Policy Support Project.

van Lier, J.B. and Lettinga, J. (1999): Appropriate Technologies for Effective Management of Industrial and Domestic Waste Waters: The Decentralised Approach; Water Science and Technology Vol. 40 No. 7 pp 171-183; IWA Publishing.

Varis, O. and Somlyódy, L. (1997): Global Urbanization and Urban Water: Can Sustainability Be Afforded? Water Science and Technology Vol. 35. No. 9, Elsevier.

Védry, B., Gousailles, M., Affholder, M., Lefaux, A. and Bontoux, J. (2001): From Sewage Water Treatment to Wastewater Reuse. One Century of Paris Sewage Farms History. Water Science and Technology Vol. 43. No. 10, IWA.

Water Authority Jordan (2006): Annual Report, Ministry of Water and Irrigation, Amman Jordan.

WHO (1989): Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture. Report of WHO Scientific Group. WHO Technical Report Series 778. WHO, Geneva.

WHO (2003): Looking Back: Looking Ahead: Five Decades of Challenges and Achievements in Environmental Sanitation and Health. WHO.

WHO (2006): WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater. 4 Volumes. World Health Organization Press, Geneva.

World Bank (1992): World Development Report 1992: Development and Environment. Oxford University Press.

World Bank (1994a): A Strategy for Managing Water in the Middle East and North Africa. The World Bank, Washington D.C.

World Bank (1994b): From Scarcity to Security, Averting Water Crisis in the Middle East and North Africa, World Bank, Washington D.C.

World Bank (1997): The Hashemite Kingdom of Jordan, Water Sector Review, World Bank.

World Bank (2003): Performance Assessment Report: Jordan, Agricultural Sector Adjustment and Agricultural Sector Technical Support Project, World Bank.

World Bank (2007): Making the Most of Scarcity: Accountability for Better Water Management Results in the Middle East and North Africa. MENA Development Reports, The World Bank, Washington D.C.

World Bank and Swiss Development Cooperation Agency (2001): Water Reuse in the Middle East and North Africa, Summary Report of MENA Regional Workshop on Water Ruse, 2-5 July 2001 Cairo, Egypt.

World Bank and World Water Council (2003). Middle East and North Africa Regional Water Initiative, "Middle East and Mediterranean Regional Day: Moving from Scarcity to Security through Policy Reform," Kyoto, Japan: World Bank, 2003. Summary Report.

World Development Report 1992: Development and Environment on Clean Water and Sanitation World Bank 1992.

World Health Organization (WHO), Regional Office for the Eastern Mediterranean, Regional Centre for Environmental Health activities (CEHA) (2005): A Regional Overview of Wastewater Management and Reuse in the Eastern Mediterranean Region.

World Water Forum (2006): Middle East and North Africa Regional Document. Mexico.

World Water Forum (2006): Presentation The Middle East Water Report to the 4th World Water Forum in Mexico.