NATO Science for Peace and Security Series - C:
Environmental Security

The Jordan River and Dead Sea Basin

Cooperation Amid Conflict

Edited by
Clive Lipchin
Deborah Sandler
Emily Cushman

Springer

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The Jordan River and Dead Sea Basin

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PREFACE

The 21st century will present unprecedented challenges. Already in its first decade we have seen the dramatic impact of two systemic risks, that of climate change and that of the financial crisis. The cause but also the solution to these crises lies in a deeper understanding of the underlying factors and interdependencies. New ways must be found to overcome deep obstacles and find common solutions to seemingly intractable problems.

The water crisis in the Middle East is a central challenge of the 21st century. The future of the people of the region depends on finding lasting solutions. Due to the exhaustion and pollution of available sources, compounded by climate change, demographic change and economic development, the pressures of water resource management will grow. New solutions must urgently be found as business as usual is not sustainable.

This book provides vital new insights into possible elements of a sustainable future in one key area, that of the Jordan River and Dead Sea Basin. The future development of the Jordanian, Palestinian and Israeli people depends on finding a just and sustainable system of water resource management in this Basin. Given the potential for regional and other conflicts arising out of tensions over water, the ramifications are wider and even global in significance.

This volume provides fresh regional and international perspectives which greatly assist in our understanding of the issues and their possible resolution. The papers arise out of a highly productive workshop held in November 2007 at Kibbutz Ein Gedi on the shore of the Dead Sea in Israel. The workshop brought together regional and international experts in the field of water resources governance and management. The workshop contributed substantially in building a shared expertise and common identification of the challenges facing the Basin and the means to address them.

The workshop and book demonstrate that despite the political tensions and instability in the region, expert dialogue is possible and can help to build a common understanding when it comes to shared water resources. A major outcome of the workshop was the establishment of the Jordan River–Dead Sea Basin Forum. The purpose of the Forum is to create a much needed venue and safe space for dialogue among the riparians of the Basin. The transparent and expert nature of the dialogue and the atmosphere of mutual respect that was evident at the workshop and reflected by the contributing authors of this book provided a source for optimism regarding the potential to move forward the discussion on shared water resources. The diversity of the authors and participants in the Forum, not least from the region, reflects the possibility of on-going cooperation in this key area.

The NATO Science for Peace and Security Program which funded the workshop has contributed to a concrete and useful collaboration the benefits of which may be expected to ripple beyond the workshop and this book. The initiative and organizational skills of Dr. Deborah Sandler, from the University of Oxford and Dr. Clive Lipchin of the Arava Institute made the workshop possible and ensured its wider resonance through this book and the establishment of the Forum. Thanks are due to them and to Mr. Danny Shachaf of the Dead Sea and Tamar Regional Council for this achievement.

Finally, this book draws on the presentations at the workshop and provides a valuable contribution on cross-border water governance in areas of immense water scarcity and considerable conflict. It is my hope that the book will be read by a wide audience in the region and beyond, and provide a source of inspiration for all those who are committed to the resolution of the enormous challenge of water resource management in the Middle East.

Dr. Ian Goldin
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February 2009.

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INTRODUCTION

THE JORDAN RIVER AND DEAD SEA BASIN: COOPERATION AMID CONFLICT?

The Jordan River and Dead Sea Basin is one of the world's most spectacular and unique ecosystems. It is unmatched in the intensity of attention it draws, serving as an ancient and modern cradle of history, culture and spirituality. Legendary times of war and peace have dominated the landscape, as some of the oldest continually inhabited communities in the world are nestled within its base. Today, however, the land itself is under siege as the Jordan River has dwindled down to a muddy and polluted stream, and the Dead Sea is receding at the alarming rate of approximately 1 m every year. All riparian parties – Jordan, Israel, the Palestinian Authority, Lebanon and Syria – have the heavy responsibility to safeguard this shared and threatened region. The international community is also obligated to protect, foster and ensure its sustainable development.

The Jordan River and Dead Sea Basin lies at the northern end of the Great Rift Valley, formed approximately 3 million years ago, through tectonic movements in the earths crust. The Jordan River flows for 251 km, its southern end terminating at the Dead Sea. The Dead Sea Region, at 417.5 m below sea level, is the lowest point on earth. The sea itself has a tenfold increase in salinity over the ocean and its mineral content is dramatically different; it is the saltiest large body of water on the planet. Despite the popular notion that the Dead Sea is devoid of life, the region was long considered one of the most fertile, and still thrives with an extraordinary range of plants and animals, including the endangered hyrax, ibex and leopard. Camels, jackals, and fox make their homes in the mountains and plateaus above the Dead Sea, and millions of birds use the surrounding wetlands as resting and breeding grounds on their annual migration from Europe to Africa.

In this book: *The Jordan River and Dead Sea Basin: Cooperation Amid Conflict*, Middle Eastern and international experts have gathered to examine the crisis of the Jordan River and Dead Sea Basin, and look at the challenges, risks and opportunities that are inherent in safeguarding and sustaining its resources. This book reflects a dialogue that began at a NATO funded Advanced Research Workshop, held at Kibbutz Ein Gedi, on the shores of the Dead Sea, from the 19th to the 21st of November 2007. The newly formed Science for Peace and Security (SPS) NATO Committee, which supported the endeavour, was established with the aim of contributing to security, stability and solidarity among nations, by applying the best technical expertise in bridging environmental studies with security studies. The Ein Gedi workshop reflected the best available expertise regards water governance for the Jordan River and Dead Sea basin.

ECONOMIC AND STRATEGIC VALUE OF THE JORDAN RIVER AND DEAD SEA BASIN

The Jordan River and Dead Sea Basin has profound economic and strategic value for each of the riparian parties. The Middle East is one of the driest regions in the world; currently 70–90% of the waters are used for human consumption. By all reckoning, there is not enough water to meet demand. Add to this the absence of a regional management approach to water use and allocation between countries, along with the mismanagement of water within countries, and the potential for economic, environmental and human catastrophe are evident.

The agricultural sector in Israel, Jordan and Syria extracts water from the Jordan River and other sources that feed into the Dead Sea. In 1953, Israel commenced redirecting waters to the National Water Carrier, and in 1964 began operating a dam that diverts water from the Sea of Galilee, a major source of the Jordan River. Today, the Jordan River receives no water from the Sea of Galilee. Also in 1964, the Jordanian government began siphoning water from the Yarmouk River, the largest tributary to the lower Jordan River, and Syria has also built reservoirs to capture water from the Yarmouk. This, along with the dumping of sewage by these countries and the Palestinian Authority, has turned the Jordan River into the dwindling and damaged river that it is today. The resulting impact can now be observed in each party's chronic depletion of the groundwater systems, lowered water tables and deteriorating water quality.

The severity of the situation is reflected in Jordan, where water is the central factor in the country's ability to sustain its population. A high rate of population growth has dramatically outdistanced the supply of available water. This has been exacerbated in recent years by the large influx of refugees from the Iraq conflict. Pumped water is available sometimes only for 1 day a week for the city of Amman, home to over a million people. Today, on a per capita basis, Jordan has one of the lowest levels of water resources in the world, ranking the Kingdom at 20% of the world's water poverty level.

In the West Bank, the overexploitation of aquifers by Israel and the Palestinian Authority has led to receding water tables and a decline in water quality. The Israeli–Palestinian conflict makes joint water management exceedingly difficult with each party seeking to maximise its share of the resource. Investment in wastewater treatment infrastructure has been desperately lacking due to the inability of the parties to agree on a workable approach. The result is free-flowing sewage that percolates into the aquifers and that flows into the lower Jordan River and Dead Sea. Further, the unresolved issue of water allocations and rights between Israel and the Palestinians regarding the shared aquifers of the West Bank has retarded Palestinian economic development, especially in the agricultural sector, which is a vital source of employment for Palestinians. In fact, it is water that will underpin any successful agreement reached by the parties. Ensuring and quantifying Palestinian water rights to both the aquifers and the Jordan and the Dead Sea is a non-negotiable element from a Palestinian perspective. By contrast, Israel views the issue as one of needs over rights and is willing to transfer desalinated water to the West Bank provided Israel can remain in control of the many wells it currently operates in the West Bank. For a final agreement to be reached, the dissonance between a "needs-based" approach and a "rights-based" approach must be resolved.

The economic consequences are particularly difficult for those whose life and livelihood is centred around the Basin. Hotels and industry have been adversely affected, and operators scramble to maintain evaporation ponds, salt-water pools and health spas, as the Dead Sea's shoreline recedes. Kibbutz Ein Gedi, on the shore of the Dead Sea, has lost more than $25 million in revenue since 1995, when large sinkholes began forming in response to the rapid sea level decline. The kibbutz was forced to tear down large stretches of date palms, close its seaside resort and abandon plans for expansion due to shifting ground and environmental degradation.

The Dead Sea has long been famous as being a venue for medical and health treatments due to the rich, unpolluted air, mud pools and thermal springs. Mineral extraction companies such as the Dead Sea Works in Israel and the Arab Potash Company in Jordan, evaporate millions of cubic metres of water each year in large evaporation ponds in order to glean profitable minerals that produce lucrative exports such as magnesium chloride and potash. While these operations are financially valuable to Jordan and Israel, the resulting balance and overall sustainability of industrial policy has not been comprehensively addressed. It is estimated that without a major change in water policy, the Dead Sea will continue to shrink, until it reaches equilibrium at over 600 m below sea level, in approximately 100 to 200 years.

PRESSURE FOR SOLUTIONS

In response to growing pressure for long-term solutions to the water crisis, representatives from the riparian parties, scientists, concerned citizens, international and national politicians and World Bank officials are today addressing the environmental imperative facing the Jordan River and Dead Sea Basin. Central proposals to have emerged include large-scale water transfers from outside the basin to replenish the Dead Sea and to provide fresh water for domestic use via desalination. The altitude difference between the Dead Sea and either the Mediterranean or Red Seas will make hydropower and desalination possible.

Two of the main ideas include restoring the flow of water to the Jordan River and thus the Dead Sea and the construction of a conduit that would transport seawater from the Red Sea or the Mediterranean Sea to the Dead Sea. These ideas are twofold: (1) to produce energy for desalination due to the altitude differences between the coast and the Dead Sea and (2) to divert water into the Dead Sea for its rehabilitation. The first proposal envisions a conduit piping water from the Mediterranean through Israel to the Jordan River via the Sea of Galilee in the northern part of the basin. This would be supplemented by desalination on Israel's northern coast to both increase domestic water supply and to restore the Jordan River. A central route that would connect the Mediterranean Sea to the Dead Sea would include desalination at the Dead Sea. Due to Jordanian resistance to the proposal of having to rely on Israel for access to the water, these options seem improbable at this time. The other main proposal is the construction of a conduit carrying seawater from the Red Sea at the Gulf of Aqaba to the Dead Sea. The conduit would run through Jordanian territory, with desalinisation plants providing water for Amman, the West Bank and Israel. This proposal, supported by the World Bank, has drawn sustained controversy from environmentalists across the region due to both its environmental impact and exorbitant cost, and is at present in the early stages of environmental assessment. The viewpoints of experts, proponents and detractors of these and other options are presented in this book.

Such large-scale infrastructure projects are unprecedented for the region and they offer both opportunity and challenges. The fractious political situation requires that governance of these proposed projects be central to their assessment and planning. Currently, the water crisis is driving the countries to consider these options without fully considering how these projects are to be managed in a regional setting that meets economic needs for water in a sustainable fashion. It is our contention that these projects must be considered from a regional and ecosystem-based perspective. The entire basin's riparians should be engaged in the process and agreements need to be reached on project management and allocation of the water.

Whatever the solution, it cannot be imposed from outside the region. There must be a combined and coherent effort to link the global, regional and local initiatives to create a cohesive regional water policy, taking into account water allocation between countries, as well as water management within countries. This approach must also move from the bi-lateral to the multi-lateral stage. Use of creative, efficient and diverse technology such as desalinisation and recycling are best combined with good management policies for agriculture rationalisation, sustainable development and responsible water use. Transparent and well formulated administrative systems for information sharing and data collection are present in every regime that successfully mediates its water crisis. These systems must be incorporated in the Jordan River and Dead Sea Basin as well. This is a central theme in the book and perspectives from the international community and from the region are represented here.

CONFLICT OR COOPERATION: INTERNATIONAL MODELS

Historically, the governments of the Jordan River and Dead Sea Basin have blamed each other for the lack of sustainable domestic policies, as well as the absence of regional collaboration on safeguarding these resources. Yet, in this region where mistrust is too often the norm, there is also an interesting history of cooperation on environmental issues. Environmental peacemaking has proven itself to be a cornerstone for the building of cross cultural communities, and the pooling of common professional and personal efforts. The most robust elements of the Israeli–Jordanian peace treaty and the various Israeli and Palestinian agreements have been about water and the environment. Indeed, this is the platform upon which thornier issues like borders, refugees and the fate of Jerusalem may be debated.

The crisis facing the Jordan River and Dead Sea Basin represents one of the major challenges of the 21st century. The need for vision, sustainable management and realistic infrastructure in water allocation and use is not unique to the Middle East. In arid and water scarce regions, human activity often can develop without regard for environmental impact or social consequences, and in extreme conditions, conflicts between riparian parties are more likely to erupt. In taking a long-term view, it is instructive to draw lessons from other regions, and to apply their successes and failures to the unique conditions of the Jordan River and Dead Sea Basin. Discussed in this book are salient examples from the Euphrates–Tigris Basin of Turkey, Syria and Iraq; Africa (where over 62% of the continent's land area consists of transboundary water resources); and North America where tensions on transboundary waters between the United States and Mexico are on-going. The inclusion of these case studies in the book reflects first, the global nature of transboundary water management and second, the importance of sharing experiences in cooperative water governance and whether transferability of governance systems from other transboundary basins to the Jordan River and Dead Sea basin is an option.

AGREEMENTS ON WATER USAGE

The agreements reached between Israel and the Palestinians and between Israel and Jordan both regulate the management of transboundary waters. The Oslo II agreement signed in 1995 between Israel and the Palestinian Authority deals specifically with the shared groundwater of the West Bank. A significant achievement of the Oslo II talks was Israel's recognition of Palestinian water rights; yet these rights were never quantified. The agreement also lead to the establishment of the Palestinian Water Authority and the Joint Water Committee, which was tasked with approving and overseeing joint water management projects in the West Bank and Gaza Strip. Although the Oslo accords have since collapsed, the agreements reached on water still stand. These agreements are by no means perfect and many flaws still abound. There is, for example, a hardship placed on the Palestinians to establish sewage and wastewater projects without Israeli security approval. Yet, even with such challenges, the dialogue on water issues remains on-going between the parties, and despite all the political upheavals, many joint research projects have been implemented.

Similarly, in 1994, the Israel–Jordan peace treaty reached agreement on the allocation of the upper Jordan and Yarmouk rivers and the groundwater in the Arava valley. Issues such as flows, reservoir storage and the development of joint projects for increasing water supply for the two countries are all dealt with in the treaty, and since its signing, all major agreements have been upheld.

Both these examples show a precedent for cooperation over water in a region of conflict. The contributions offered in this book go beyond bi-lateral agreements and argue for a regional multi-lateral approach to water management. Ultimately, for sustainable management of the Jordan River and Dead Sea Basin, *all* riparians must be involved. This includes Syria and Lebanon, along with the revision of bi-lateral agreements into multi-lateral agreements. The chapters in this book offer options for consideration in this regard, specifically with regards to resolving the ecological degradation of the Jordan River and Dead Sea basin.

THE MEDITERRANEAN ACTION PLAN

An example of multi-lateralism for water management already exists for the region and may also provide a useful guide for that of the Jordan and the Dead Sea. In 1975, 16 Mediterranean countries and the European Community adopted the Mediterranean Action Plan (MAP). MAP was defined as a wide-ranging scientific, political, legal and social program aimed at "preventing, controlling and abating pollution in the Mediterranean Sea". The legal component of MAP was established in February, 1976 when the parties met again in Barcelona to adopt the Convention for the Protection of the Mediterranean Sea Against Pollution (the Barcelona Convention), the Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft (the Dumping Protocol) and the Protocol Concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency (Emergency Response Protocol). Shortly thereafter two more protocols – on Land-Based Sources and Specially Protected Areas – were adopted.

MAP was a watershed for regional environmental cooperation, and the first of 13 Regional Seas Programs established around the world under the auspices of UNEP; today there are more than 140 countries engaged in such programmes. This achievement is particularly striking when we are reminded that not long ago, regulation of the oceans reflected mainly individual state interests of navigation and fishing. It was within this context that Israel and her Arab neighbours led the way, and participated in an international forum, signed agreements and worked together in numerous committees for their common good. This demanded vision and political commitment from all parties, a number of whom were still in a formal state of war. Political scepticism was accompanied by difficult realities on the ground. The situation in Israel reflected how domestic interests were at odds with a regional environmental initiative. Seventy percent of the population lived within 15 km of the Mediterranean, and was dependent on the coastal area for economic and recreational activities; almost all of the country's commercial and industrial activities were situated along the coast. The Israeli stretch of Mediterranean was the frequent depository of waste and treated sewage from industrial and commercial activity, as well as raw domestic sewage. The beaches were tar-filled, and the sea was frequently unsafe for swimming. Land-based sources of pollution flowed into the sea from up rivers and streams and the regulation of these sources was minimal.

In 1995, 20 years after the adoption of MAP, the Contracting Parties returned to Barcelona and adopted the Action Plan for the Protection of the Marine Environment and the Sustainable Development of Coastal Areas of the Mediterranean, to replace the 1975 Action Plan. In addition, the Parties amended and updated the protocols and adopted new protocols (Biodiversity; Hazardous Waste and Offshore). A significant shift in focus was observed as the Parties began working from pollution prevention to sustainable development. This is reflected in the development of coastal zone and planning management initiatives through the MED POL programme, various resolutions, local activities and the establishment of the Mediterranean Commission on Sustainable Development (MCSD).

The MCSD can offer instruction in grappling with the crisis in the Jordan River and Dead Sea Basin. Although the issues are different, the process of cooperative thinking and planning is necessarily similar. Today, the MCSD is comprised of 46 members; the 22 permanent members represent the Contracting Parties to the Barcelona Convention. Significantly, there are also 24 rotating representatives from the wider Mediterranean community, including the scientific community, the business community, local authorities, NGOs and experts, as well as 14 alternative members. The MCSD aims to assess major sustainable development issues that are of common concern to the Member States and make proposals and recommendations. This takes place through biannual meetings and the continuity of working groups comprised from representatives of a wide range of member states. International institutions and NGOs are important partners in fostering forward movement and cooperation.

Through this process, the MCSD continues to build a broad epistemic community, defined as "knowledge-based groups of experts and specialists who share common beliefs about cause and effect relationships in the world and some political values concerning the ends to which policies should be addressed" (P Hass Saving the Mediterranean). This community, created and fostered along professional and value based understandings and aims, is instrumental in exerting important influence in persuading the Mediterranean States to adopt and support initiatives that are represented in international and regional agendas. It does this through functioning as a forum for communication and action across national, regional and international lines.

THE JORDAN RIVER AND DEAD SEA WATER FORUM

A significant outcome of the NATO conference in November 2007 reflected in this book is the recognition by regional actors that on-going communication and sharing of knowledge is central to any solution in the region. In early 2008, drawing on other successful environmental initiatives, such as the Mediterranean Commission on Sustainable Development, professionals from Jordan, Israel and Palestine, supported by international experts, established the Jordan River and Dead Sea Water Forum. The Forum is a focal point for facilitating momentum for sustainable resources policy for the entire Basin through the building of professional partnerships and networks between Israeli, Jordanian and Palestinian academics, scientists, water policy officials, water managers, local authorities, business interests, NGOs and interested individuals. Aimed at fostering an understanding of the importance of the regional and international importance of the Jordan River and Dead Sea Basin, the Forum seeks to empower groups of experts from the riparian parties to contribute individually and collectively to the development and promotion of national and regional sustainable development projects and policies. This is being done through the organisation of local, regional and international activities and cross-boundary projects and reports. It is hoped that with time, Lebanon and Syria will agree to participate in the Forum.

It is our hope that the Forum will contribute to the eventual establishment of a regional and multi-lateral agreement on the sustainable management of the Jordan River and Dead Sea Basin. The diversity of authors represented by this book and their agreement to work together makes us optimistic for the future.

Of course no project of this size and scope can be achieved without the hard work and commitment of very special people. We are indebted to the following individuals for the realization of this book. Ms. Emily Cushman of the Arava Institute for her editorial prowess, dedication and attention to detail. Mr. Danny Shachaf from the Dead Sea Research Institute and the Tamar Regional Council for his support and dedication to the conference, the book and the establishment of the Forum. Ms. Abby Lutman and the staff of the Arava Institute for their logistical support. The authors themselves for the hard work invested in their contributions. Finally, we are thankful for the financial support of the NATO Science for Peace and Security program for making both the conference and the book a reality.

In closing, we would like to dedicate this book to Dr. Fadia Daibes-Murad, a key speaker at the conference and the author of one of the chapters of this book. Dr. Daibes-Murad was tragically killed in a car accident in March 2009. She was a keen and enthusiastic colleague and will be sadly missed. Our thoughts and prayers are with her family.

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SECTION I

WATER UNDER FIRE: AN INTERNATIONAL CHALLENGE

A LONG-TERM VIEW OF WATER AND SECURITY: INTERNATIONAL WATERS, NATIONAL ISSUES AND REGIONAL TENSIONS

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Abstract: Water management is, by definition, conflict management. It is a resource on which we all depend, it fluctuates in time and space and its management is usually fragmented. That said, there is no such thing as managing water for a single purpose – *all* water management is multi-objective and based on navigating competing interests. Nevertheless, conflict is not a given. While it may be the focus of press reports of international waters, there is clear evidence from around the world that water issues also induce cooperation. This is even the case in "hostile" basins where disputes rage over other issues, such as the Jordan River basin. There is certainly a long history of tensions over, or related to, shared freshwater resources, but there is also a lengthy, and in many ways deeper, history of water-related cooperation. Despite empirical research that finds that water-related cooperation overwhelms conflict over the last 50 years (see, most recently, Wolf et al., 2003), prevailing theories fail to explain this phenomenon. *Why* do countries that share a basin cooperate on water, even when they will not cooperate over other issues? By any quantitative measure, water should be the most *conflictive* of resources, not an elixir that drives enemies to craft functioning and resilient institutional arrangements. We examine these questions historically, yet, recognizing that history-based indicators may lose validity over time in a rapidly changing world, we focus on future issues that may look nothing like the past. Five critical areas related to water resources will change dramatically in coming years:

1. New technologies for negotiation and management are being implemented, changing the face of both.
2. Globalization, privatization and the WTO are impacting our valuation of water, and its place in relation to rights and responsibilities.

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3. Global climate change may shift precipitation patterns, dramatically impacting water resources management.
4. The geopolitics of desalination is shifting, as cost becomes viable at a larger scale.
5. The nature of conflict and cooperation are changing in both scope and scale.

Keywords: Shared waters; transboundary waters; hydropolitics; desalination; WTO

1. Introduction

Water management is, by definition, conflict management. Postel (1999) describes the roots of the problem: Water, unlike other scarce, consumable resources, is used to fuel *all* facets of society, from human life to ecosystems to economies to aesthetics and spiritual practice. Moreover, it fluctuates wildly in space and time, its management is usually fragmented, and it is often subject to vague, arcane, and/or contradictory legal principles. There is no such thing as managing water for a single purpose – *all* water management is multi-objective and based on navigating competing interests. Within a nation these interests might include domestic use, agriculture, hydropower generation, recreation, and environmental concerns – any two of which are regularly at odds – and the chances of finding mutually acceptable solutions decrease exponentially as more stakeholders are involved. Add international boundaries, and the chances drop yet again.

Surface and groundwater that cross sovereign borders can present significant challenges to regional stability when basic hydrologic needs are overwhelmed by political considerations. While the potential for paralyzing disputes is especially high in these basins, history shows that water can also catalyze dialogue and cooperation, even between especially contentious riparians. There are 263 rivers around the world that cross the boundaries of two or more nations, and an untold number of international groundwater aquifers. The catchment areas that contribute to these bodies comprise approximately 47% of the land surface of the earth, include 40% of the world's population, and contribute almost 80% of freshwater flow. In Asia and the Middle East, there are 40 such basins, comprising 65% of the region's land surface (Wolf et al., 1999). While most of these rivers are shared by two to four countries, some cross through many more. For example, the Ganges Brahmaputra, the Mekong and the Tarim rivers flow through six nations, and the Nile through ten.

Within each international basin, demands from environmental, domestic, and economic users increase annually, while the amount of freshwater in the world remains roughly the same. Given the scope of the problems and the resources available to address them, avoiding water conflict is vital. Conflict is expensive, disruptive, and interferes with efforts to meet human needs, reduce environmental degradation, and achieve economic growth. Developing the capacity to monitor, predict, and preempt transboundary water conflicts, particularly in developing countries, is key to promoting human and environmental security in international river basins, regardless of the scale at which they occur.

In order to understand the long term implications of transboundary water management and the potential for future conflict and cooperation, it is critical to assess what the indicators and triggers are of such processes currently, and then evaluate their prospects for the future.

2. Hydropolitical Resilience and Vulnerability[1]

In general, the concepts of "resilience" and "vulnerability" as related to water resources are often assessed within the framework of "sustainability," and relate to the ability of bio-physical systems to adapt to change (e.g. Gunderson and Pritchard 2002). As the sustainability discourse has broadened to include human systems in recent years, so too has research been increasingly geared towards identifying indicators of resilience and vulnerability within this broader context (Bolte et al., 2004; Lonergan et al., 2000; Turner, 2003). In parallel, dialog on "security" has migrated from traditional issues of war and peace to also begin incorporating the human-environment relationship in the relatively new field of "environmental security" (see UNEP, 2004; Vogel and O'Brien, 2004).

As the potential for conflict and violence to erupt over international waters became increasingly apparent, the term "hydropolitics" (coined by Waterbury, 1979), emerged as a way to describe the ability of geopolitical institutions to manage shared water resources in a politically sustainable manner, meaning without tensions or conflict between political entities. "Hydropolitical resilience" then, is defined as the complex human-environmental system's ability to adapt to permutations and change within these systems, and "hydropolitical vulnerability" is defined by the risk of political dispute over shared water systems. Wolf et al. (2003) suggested the following relationship between change, institutions, and hydropolitical vulnerability: "*The likelihood of conflict rises as the rate of change within the basin exceeds the institutional capacity to absorb that change.*"

This suggests that there are two sides to the dispute setting: the rate of change in the system and the institutional capacity. In general, most of the parameters commonly identified as indicators of water conflict are only weakly linked to dispute in reality. Institutional capacity within a basin – whether defined as water management bodies or treaties, or generally positive international relations – is as important, if not more so, than the physical aspects of a system. That said, rapid changes in either institutions or the physical system, when they

[1] The next sections draw from Wolf et al. (2005).

outpace the institutional capacity to absorb those changes, are at the root of most water conflict. For example, the rapid institutional change in "internationalized" basins – basins that include the management structures of newly independent states – has resulted in disputes in areas formerly under British administration (e.g., the Nile, Jordan, Tigris–Euphrates, Indus, and Ganges–Brahmaputra), as well as in the former Soviet Union (e.g., the Aral tributaries and the Kura–Araks). On the physical side, rapid change most outpaces institutional capacity in basins that include unilateral development projects *and* the absence of cooperative regimes, such as treaties, river basin organizations (RBOs), or technical working groups, or when relations are especially tenuous over other issues (Wolf et al., 2003).

The general assumption of this relationship then, is that rapid change tends to indicate vulnerability while institutional capacity tends to indicate resilience, *and* that the two sides need to be assessed in conjunction with each other for a more accurate gage of hydropolitical sustainability. Building on these relationships, the characteristics of a basin that would tend to enhance resilience to change include:

- International agreements and institutions, such as RBOs
- A history of collaborative projects
- Generally positive political relations
- Higher levels of economic development

In contrast, facets that tend towards vulnerability would include:

- Rapid environmental change
- Rapid population growth or asymmetric economic growth
- Major unilateral development projects
- The absence of institutional capacity
- The potential for "internationalization" of a basin
- Generally hostile relations

3. Water and Security

Water disputes revolve around one or more of three areas where the rate of change may exceed the institutional capacity to absorb that change: quantity, quality, and timing. The dynamics of these three issues play out very differently within various scales related to water and security, whether internationally, intranationally, or regionally and indirectly. Each setting might be characterized as follows:

International waters

- Very little violence, but long processes from tension to cooperation, resulting in exacerbated political relations, inefficient water management, and ecosystem neglect.
- Long, rich record of conflict resolution and development of resilient institutions.
- Institutional capacity is at the heart of whether environmental stresses lead to conflict or cooperation.
- Long-term prospect likewise has low conflict potential.

Intranational waters (between sub-national political units, including states/ provinces, ethnic/religious groups, and/or economic sectors)

- Violence potential higher than in international setting.
- Rationale for international involvement more difficult, given greater issues of national sovereignty.
- Long-term prospect has moderate conflict potential.

Regional instability (indirect – political dynamics of loss of irrigation water)

- Potential for politically destabilizing processes of mass migrations to cities and/or neighboring countries when water supplies for broadly irrigated regions are threatened due to drop in quantity (including lowering of groundwater levels) or quality.
- Issues of poverty alleviation and distribution of wealth are tied directly to amelioration of security concerns.
- Has highest potential for long-term violence.

3.1. INTERNATIONAL WATERS

Water is a unique and vital resource for which there is no substitute. It ignores political boundaries, fluctuates in both space and time, and has multiple and conflicting demands on its use – problems compounded in the international realm by the fact that the international law that governs it is poorly developed, contradictory, and unenforceable. It is no wonder, then, that water is perpetually suspect – not only as a cause of historic armed conflict, but as the resource that will bring combatants to the battlefield in the 21st century. That said, what is the likelihood that "the wars of the next century will be about water," as some have predicted?[2]

[2] World Bank vice-president Ismail Serageldin, quoted in the New York Times, 10 August 1995. His statement is probably most often quoted.

In order to cut through the prevailing anecdotal approach to the history of water conflicts, researchers at Oregon State University undertook a 3-year empirical study on the issue. They compiled a dataset of *every* reported interaction between two or more nations, whether conflictive or cooperative, that involved water as a scarce and/or consumable resource or as a quantity to be managed – essentially, where water was the *driver* of the events[3] (Wolf et al., 2003). The study documented a total of 1,831 interactions over the past 50 years, and found the following:

First, despite the assumed potential for dispute in international basins, the record of acute conflict involving violence over transboundary water resources is overwhelmed by the record of cooperation. The last 50 years have seen only 37 acute disputes. Of those, 30 were between Israel and one or more of its neighbors, and the violence ended in 1970. During the same period, however, 157 water-related treaties were negotiated and signed. Overall, the total number of international water-related events of any magnitude is likewise weighted towards cooperation: 507 conflict-related events, versus 1,228 cooperative events, implying that violence over water is neither strategically rational, hydrographically effective, nor economically viable.

Second, despite the occasional fiery political rhetoric – perhaps aimed more often at constituents than at the enemy – the majority of actions taken over water are mild. Of all the events, 43% fell between mild verbal support and mild verbal hostility. Counting the *official* verbal support and hostility, the share of verbal events reaches 62% of the total. Thus, almost two thirds of all events were only verbal and more than two thirds of those had no official sanction (Wolf et al., 2003).

Third, there were more areas of cooperation than of conflict. The distribution of cooperative events covered a broad spectrum, addressing everything from water quantity, quality, and economic development, to hydropower and joint management. In contrast, almost 90% of the conflicts related to quantity and infrastructure. Furthermore, almost all extensive military acts in the most extreme cases of conflict fell within these two categories.

Fourth, despite the lack of physical violence, water served as both an irritant and a unifier. As an irritant, water can make good relations bad and bad relations worse. On the other hand, international waters can act as a unifier in basins with relatively strong institutions, however complex the system.

This historical record suggests that international water disputes do get resolved, even among enemies, and even as conflicts erupt over other issues. Some of the most deep-seated enemies have negotiated water agreements or are in the process of doing so, creating resilient institutions that persist even when

[3] Excluded are events where water is incidental to the dispute, such as those concerning fishing rights, access to ports, transportation, or river boundaries. Also excluded are events where water is not the driver, such as those where water is a tool, target, or victim of armed conflict.

relations are strained. The Mekong Committee, for example, established by the governments of Cambodia, Laos, Thailand, and Vietnam as an intergovernmental agency in 1957, exchanged data and information on water resources development throughout the Vietnam War. Israel and Jordan have held secret "picnic table" talks on managing the Jordan River since the unsuccessful Johnston negotiations of 1953–1955, even though they were technically at war from Israel's independence in 1948 until the 1994 treaty. The Indus River Commission survived two major wars between India and Pakistan. All ten Nile Basin riparian countries are currently involved in senior government-level negotiations to develop the basin cooperatively, despite "water war" rhetoric between upstream and downstream states.

3.1.1. Tensions and time lags: causes for concern

While history may suggest that violence is unlikely to erupt over water disputes between nations, the security concerns are far from absent. Problems arising out of timing, quantity, and quality issues can create or exacerbate other tensions and challenges that are equally threatening.

The first complicating factor is the time lag between when nations first start to impinge on each other's water planning and when agreements are finally, arduously, reached. A general pattern has emerged for international basins over time. Riparians of an international basin implement water development projects unilaterally – first on water within their own territory, in attempts to avoid the political intricacies of the shared resource. At some point, one of the riparians, generally the regional power, will implement a project that impacts at least one of its neighbors. In the absence of relations or institutions conducive to conflict resolution, the project can become a flashpoint, heightening tensions and regional instability, and requiring years or, more commonly, decades, to resolve – the Indus treaty took 10 years of negotiations, the Ganges 30, and the Jordan 40 – and, all the while, water quality and quantity degrades to where the health of dependent populations and ecosystems are damaged or destroyed. This problem gets worse as the dispute gains in intensity; one rarely hears talk about the ecosystems of the lower Nile, the lower Jordan, or the tributaries of the Aral Sea – they have effectively been written off to the vagaries of human intractability. During such periods, threats and disputes rage across boundaries with relations as diverse as those between Indians and Pakistanis and between Americans and Canadians. Water was the last and most contentious issue resolved in negotiations over a 1994 peace treaty between Israel and Jordan, and was relegated to "final status" negotiations – along with other of the most difficult issues such as Jerusalem and refugees – between Israel and the Palestinians.

The timing of water flow is also important; thus, the operation of dams is also contested. For example, upstream users might release water from reservoirs in the winter for hydropower production, while downstream users might need it for irrigation in the summer. In addition, water quantity and water flow patterns are crucial to maintaining freshwater ecosystems that depend on seasonal flooding. Freshwater ecosystems perform a variety of ecological and economical functions and often play an important role in sustaining livelihoods, especially in developing countries. As awareness of environmental issues and the economic value of ecosystems increases, claims for the environment's water requirements are growing. For example, in the Okavango Basin, Botswana's claims for water to sustain the Okavango Delta and its lucrative ecotourism industry have contributed to a dispute with upstream Namibia, which wants to use the water passing through the Caprivi Strip on its way to the delta for irrigation.

Water quality problems include excessive levels of salt, nutrients, or suspended solids. Salt intrusion can be caused by groundwater overuse or insufficient freshwater flows into estuaries. For example, dams in the South African part of the Incomati River basin reduced freshwater flows into the Incomati estuary in Mozambique and led to increased salt levels. This altered the estuary's ecosystem and led to the disappearance of salt-intolerant flora and fauna important for people's livelihoods (the links between loss of livelihoods and the threat of conflict are described below).

Excessive amounts of nutrients or suspended solids can result from unsustainable agricultural practices, eventually leading to erosion. Nutrients and suspended solids pose a threat to freshwater ecosystems and their use by downstream riparians, as they can cause eutrophication and siltation, respectively, which, in turn, can lead to loss of fishing grounds or arable land. Suspended solids can also cause the siltation of reservoirs and harbors: for example, Rotterdam's harbor had to be dredged frequently to remove contaminated sludge deposited by the Rhine River. The cost was enormous, and consequently led to conflict over compensation and responsibility among the river's users. Although negotiations led to a peaceful solution in this case, without such a framework for dispute resolution, siltation problems can lead to upstream/downstream disputes such as those in the Lempa River basin in Central America (Lopez, 2004).

3.1.2. Prognosis for the future

As we move into the future, it stands to reason that each of these exacerbating factors – quantity, quality, and timing – will only become more difficult to manage. Nevertheless, there is little reason to anticipate violence at the international level. If one were to launch a war over water, what would be the goal? Presumably, the aggressor would have to be both downstream and the regional hegemon – an upstream riparian would have no cause to launch an attack and a weaker state would be foolhardy to do so. An upstream riparian, then, would have to launch a project which decreases either water quantity or quality. If it is a developing country, it would have to find international funding for that project in contravention of the rules of all development banks, knowing that it will antagonize a stronger downstream neighbor.

The downstream power would then have to decide whether to launch an attack. If the project were a dam, destroying it would result in a wall of water rushing back on downstream territory. Were it a quality-related project, either industrial or waste treatment, destroying it would probably result in even worse quality than before. Furthermore, the hegemon would have to weigh not only an invasion, but an occupation and depopulation of the entire watershed in order to forestall any retribution – otherwise, it would be extremely simple to pollute the water source of the invading power. Both countries could not be democracies, since the political scientists tell us that democracies do not go to war against each other. The international community would also have to refuse to become involved, yet it rarely stands idle when two countries go to war with each other. All of this effort would be expended for a resource which costs at most about $\$1/m^3$ to create from seawater, the cost of which is dropping every year. Finally, there are 263 international watersheds, only a handful in which the above scenario is even applicable. The Nile, Plata, and Mekong come to mind, and yet they either have existing treaties or ongoing negotiations towards a treaty. Finding a site for a "water war" turns out to be as difficult as accepting the rationale for launching one.

The Jordan River Basin is often seen as a worst case scenario, given the tremendous hostility both across and within borders and the fact that it "ran out" of water, meaning demand reached supply, in 1968. Nevertheless, while all the riparian nations will still not even sit in the same room, the last shot fired across international boundaries over water was in 1970. This means that in this arid and hostile setting, *all* economic and population growth over the last 40 years has come through greater efficiencies, and through dialog and collaboration (or at least through unwritten coordination, when integration has proved impossible), and *not* through violence at the official level.

All of this is not to deny that people will continue to suffer and die in increasing numbers for lack of safe drinking water and sanitation or that eco-systems will see unprecedented destruction as water systems are mismanaged. It is important to note, however, that the politics which lead up to warfare rarely have to do with suffering. Furthermore, water will likely remain a diffuse resource with little relative contribution to most economies, and from which the elite who make decisions related to war and peace rarely benefit.

3.2. INTRANATIONAL WATERS

The second set of security issues occur at the sub-national level. Much literature on transboundary waters treats political entities as homogeneous monoliths – "Canada feels ..." or "Jordan wants ..." Analysts are only recently highlighting the pitfalls of this approach, often by showing how different subsets of actors relate very different "meanings" to water. In reality, water is often treated as a security issue, a gift of nature, or a focal point for local society, rather than a basic environmental input. That said, disputes must be understood as more than simply over quantity, but also over conflicting attitudes, meanings, and contexts. Throughout the world, local water issues revolve around core values and traditions that often date back generations. Irrigators, indigenous populations, and environmentalists, for example, might see water as integral to their very ways of life, and increasingly threatened by newer uses for cities and hydropower. Moreover, the local setting strongly influences international dynamics and vice versa.

While water disputes at the international level remained relatively peaceful, those at the sub-national – between tribes, water-use sectors, or states/provinces – have a more violent history. In fact, the OSU study suggests that, as the scale drops, the likelihood and intensity of violence rises (Giordano et al., 2002). There are many examples of internal water conflicts, from interstate violence along the India's Cauvery River, to California farmers blowing up a pipeline bound for Los Angeles, to inter-tribal bloodshed between Maasai herdsmen and Kikuyu farmers in Kenya. The desert state of Arizona even commissioned a small navy and sent its state militia to stop a dam and diversion along the Colorado River in 1934.

Another common point of contention at the intrastate level is water quality – an issue that is inextricably linked to water quantity. Firstly, when water is rendered inappropriate for certain uses, scarcity increases. A decrease in water quantity might also concentrate pollution, or a sudden boost in quantity, such as a flood, might lead to contamination by sewage. Disputes over water quality usually emerge between those who cause degradation, and those affected by it. As pollution poses growing threats to human health, livelihoods and the environment, water quality issues often lead to substantial public outcry.

One of the main causes of declining water quality is pollution, through industrial and domestic wastewater or agricultural pesticides. In Tajikistan, for example, where environmental stress has been linked to civil war (1992–1997), high levels of water pollution have been identified as one of the key environmental issues threatening human development and security. Water pollution from the tanning industry in the Palar Basin of the Indian state of Tamil Nadu makes the water within the basin unfit for irrigation and consumption. The pollution contributed to an acute drinking water crisis, leading to protests by the local community and activist organizations, as well as to disputes and court cases between tanners and farmers (Carius et al., 2004).

3.2.1. Prognosis for the future

One might anticipate a moderate likelihood of tensions over intranational waters in coming years. Clearly, this aspect has been seeing more violence in recent years, from South Asia to eastern Africa. Disenfranchised peoples within nations without the infrastructure or economy to mitigate water scarcity or degradation may well find their needs driving conflict with competing populations.

3.3. REGIONAL INSTABILITY: POLITICAL DYNAMICS OF LOSS OF IRRIGATION WATER

As water quality degrades – or quantity diminishes – over time, the effect on the stability of a region can be unsettling. For example, during the first 30 years of Israeli occupation of the Gaza Strip, water quality deteriorated steadily, saltwater intrusion degraded local wells, and water-related diseases took a rising toll on residents. In 1987, the Intifada, or Palestinian uprising, first broke out in the Gaza Strip, then spread rapidly throughout the West Bank. Was water quality the cause? It would be simplistic to claim direct causality. Was it an irritant exacerbating an already tenuous situation? Undoubtedly, yes.

An examination of relations between India and Bangladesh reveals how these internal instabilities can be both caused and exacerbated by international water disputes. In the 1960s, India built a barrage at Farakka in an effort to flush silt away from Calcutta's seaport some 100 mi south, diverting a portion of the Ganges flow away from its course into Bangladesh in the process. In Bangladesh, the reduced upstream flow resulted in a number of adverse effects: degraded surface and groundwater, impeded navigation, increased salinity, degraded fisheries, and endangered water supplies and public health. Migration from affected areas further compounded the problem. Ironically, many of those displaced in Bangladesh have found refuge in India.

Given that two thirds of the world's water is used in agriculture, threatened access to irrigation water can have massive impacts. A common result is mass-migration country-side to the cities – an invariable recipe for political instability. In pioneering work, Sandra Postel identified those countries that rely heavily on irrigation, and whose agricultural water supplies are threatened either by a decline in quality or quantity. The list coincides precisely with current international security "hot spots", where instability can have profound effects: India, China, Pakistan, Iran, Uzbekistan, Bangladesh, Iraq, and Egypt (Postel and Wolf, 2001).

Water management in many countries is also characterized by overlapping and competing responsibilities among government bodies. Disaggregated decision-making often produces divergent management approaches that serve contradictory objectives and lead to competing claims from different sectors. Such claims are even more likely to contribute to disputes in countries where there is no formal system of water-use permits, or where enforcement and monitoring are inadequate.

Controversy also often arises when management decisions are formulated without sufficient participation by local communities and water users, thus failing to take into account local rights and practices. Protests are especially likely when the public suspects that water allocations are diverting public resources for private gain or when water use rights are assigned in a secretive and possibly corrupt manner, as demonstrated by the violent confrontations in 2000 following the privatization of Cochabamba, Bolivia's water utility (Postel and Wolf, 2001).

Finally, there is the human security issue of water-related disease. It is estimated that between 2.2 and 5 million people die each year from water-related diseases or inadequate sanitation. More than half the people in the world lack adequate sanitation. Eighty percent of disease in the developing world is related to water (Gleick, 1999). This is a crisis of epidemic proportions, and the threats to human security are self-evident.

3.3.1. Prognosis for the future

These more subtle connections between water and security are the most likely to drive human suffering, violence, and ecosystem degradation into the future. The global community has simply not shown the political will to alleviate the harm caused by the lack of a safe, stable supply of water resources, and there is little indication that these trends will do anything but continue to intensify.

4. Long-Term Sustainability: Why Might the Future Look Nothing Like the Past?

Some aspects of the future will probably look very similar to the present, especially the disparity between the world's wealthy and its poor in the ability to adapt to climate change. For example, both the Netherlands and Bangladesh are low-lying countries facing serious flooding challenges which are only likely to intensify with rising sea levels and stronger storms. However, while multi-million dollar sea walls are built to protect the Netherlands and render flood-related deaths and damages negligible, thousands die every year amid widespread devastation in Bangladesh. Similarly, while few suffer from the effects of water scarcity or contamination in the developed world, 2.2 to 5 million people die every year in the developing world from water-related causes. There is no evidence to suggest that any of this will improve in the future.

Nevertheless, the entire basis of this study rests on the assumption that we can tell something about the future by looking at the past. It is worth stopping at this point, then, to challenge the very foundation of that assumption: Why might the future look nothing like the past? What new approaches or technologies are on the horizon to ameliorate the risk to the basins we have identified, or even to change the whole approach to basins at risk?

By definition, a discussion of the future can not have the same empirical backing as a historical study – the data just aren't yet available. Yet, there are cutting edge developments and emergent trends which, if examined within the context of this study, might suggest some possible changes in the way we approach transboundary waters in the future.

4.1. NEW TECHNOLOGIES FOR NEGOTIATION AND MANAGEMENT

The OSU dataset of political conflict and cooperation mentioned earlier goes back to 1948. While water management still retains many characteristics of the past, some fundamental aspects are profoundly different. Institutions are getting better and more resilient, management and understanding are improving, and water-related issues are increasingly pressing matters for global and local decision makers. Most importantly, however, the 21st century has access to vast new technologies which could not be dreamed of in 1948, contributing substantially to the ability both to negotiate and to manage transboundary waters more effectively. These include:

- Major advances are being made regularly in water technologies designed either to increase supply – e.g., desalination, wastewater reclamation – or decrease demand – e.g., drip irrigation, plant genetics, low-flow utilities. As a country's economy grows, its per capita water use initially grows as well. Eventually, however, it can drop in water stressed regions, as new wealth allows them to afford these technologies (as has been the case in Israel and California).
- Modular modeling systems (MMS's) such as STELLA, Waterware, and Riverware can now be used for comprehensive modeling of hydrologic and human systems. Because of their modular design, they can also act as a facilitation tool by allowing managers/negotiators to build the model in cooperation, increasing the joint knowledge base and communications. Graphical User Interfaces (GUI's) allow for each component to be brought together into an intuitive, user-friendly setting.
- Geographic Information Systems (GIS) allow several spatial data layers, encompassing biophysical, socioeconomic and geopolitical parameters, to be viewed and analyzed graphically. Advances in remote sensing also allow for flow data to be collected from basins that are not gauged, reducing the options for holding data secret.
- Real time monitoring tools, such as radio-controlled gauging stations, add new options for real time management, and allocations based on existing hydrologic settings rather than fixed quantities.

New technologies and data cannot replace the political will necessary for creative solutions, nor are they widely available outside the developed world. Nevertheless, if appropriately deployed, they can contribute to more robust negotiations and greater flexibility in joint management.

4.2. GLOBAL CLIMATE CHANGE

It is clear that the likelihood of political tension is related in part to the rate of change within a basin. It is also clear from most climate studies that it is *precisely* the rate of change of the global and regional hydrologic cycles which are most likely to be exacerbated by global climate change. While some areas will become wetter and others drier, the *variability* of extreme events is likely to increase throughout much of the world. Since the potential for violence increases when change exceeds the rate of institutional capacity to absorb the change, increased variability will put greater stresses on the hydropolitical system. For example, the entire water rights and distribution network of many parts of the world rely on the natural storage of much water resources in the snowpacks of mountain ranges, many of which are projected to shrink dramatically in coming years. Water allocations in the dry months will become increasingly threatened, while wet months will become increasingly devastating. The result is dangerous stress to agriculture, industry, and generally on regional natural and human resources.

Unilateral implementation of massive development projects, such as dams and diversions, has proven an equally strong instigator of political tension (Postel and Wolf, 2001). As global climate change reduces the world's "free" storage in mountain snowpacks, the need for new conversations over these sensitive projects is unavoidable, even in the developed world where the age of dam-building was long thought to be over. For example, the environmentally- and energy-conscious Pacific Northwestern US states of California, Oregon, and Washington have reopened the possibilities of new storage programs in recent years, in order to adapt to new flow regimes.

4.3. GLOBALIZATION: PRIVATE CAPITAL, WTO AND CIRCUMVENTED ETHICS

Despite the growing attention paid to globalization and the World Trade Organization (WTO), discussion rarely centers around how emerging trends create new dynamics in the realm of water resources. One of the most profound is the shift of development funds from global and regional development banks such as the World Bank and the Asia Development Bank to private multi-nationals, such as Bechtel, Vivendi and Ondeo (formerly Lyonnaise des Eaux). Development banks are susceptible to public pressures and ethics norms, which have forced them to develop procedures for evaluating social and environmental impacts of projects, and to incorporate them in decision-making. On international waters, guidelines which generally prohibit development unless all riparians agree to the project have promoted successful negotiations over the years. Private enterprises, however, have no such restrictions, so nations eager to develop controversial projects have been increasingly turning to private capital to circumvent public ethics. The most controversial projects of the day – Turkey's GAP project, India's Narmada River project, and China's Three Gorges Dam – are all proceeding through the studied avoidance of development banks and their mores.

Another, more subtle, effect of globalization is the WTO's emphasis on privatization and full cost recovery of investments. Local and national governments have traditionally implemented and subsidized water development systems to keep water prices down, but are now under globalization's increasing pressure to develop these systems through private companies. These large multinational water companies in turn manage for profit and, if they use development capital, both push and are pushed to recover the full cost of their investment. This can translate not only into immediate and substantial rises in the cost of water which disproportionately affect the poor, but also into the eradication of local and indigenous management systems and cultures. If water-related violence is to erupt in the future, it is much more liable to resemble the "water riots" against a Bechtel development in Bolivia in 1999, in which eight people were killed, than "water wars" across national boundaries.

As WTO rules are elaborated and negotiated, real questions remain as to how much of this process will be *required* of nations in the future, simply to retain membership in the organization. The "commodification" of water as a result of these forces is a case in point. Over the last 20 years, no global water policy meeting has neglected to pass a resolution which defined water as an "economic good," setting the stage at the 2000 World Water Forum for an unresolved show-down against those who would define water as a human or ecosystem *right*. The debate looms large over the future of water resources – if water is a commodity, and if WTO rules prohibit obstacles to the trade of commodities, will nations be forced to sell their water? While it may seem far-fetched now, the globalization debate between market forces and social forces with regard to water resources continues to play out in microcosms. A California company, for example, is challenging British Columbia over precisely such an issue under NAFTA rules.

4.4. THE GEOPOLITICS OF DESALINATION

Twice in the last 50 years – during the 1960s nuclear energy fervor, and in the late 1980s, with "discoveries" in cold fusion – much of the world briefly thought it was on the verge of having access to virtually free energy supplies. "Too cheap to meter" was the phrase during the Atoms for Peace Conference, but ultimately neither the economics nor the technology supported these claims. On the other hand, it is not far fetched to picture similar developments which could profoundly change the economics of desalination.

Today's marginal cost of desalinated water (between $0.40/m^3 and $0.80/m^3) renders it only cost-effective in the developed world where: (1) the water will be used for drinking water; and (2) the population to whom the water will be delivered lives along a coast and at low elevations; and (3) there are no alternatives. The only places that do not face such restrictions are those where energy costs are especially low, notably the Arabian Peninsula. A fundamental shift in either energy prices or membrane technology could bring costs down substantially. If either happened to the extent that the marginal cost allowed for agricultural irrigation with sea water (around $0.08/m^3 on average), a large proportion of the world's water supplies would shift from rivers and shallow aquifers to the sea – an unlikely, but plausible, scenario.[4]

In addition to these fundamental economic changes, geopolitical thinking surrounding water systems would also need to shift. Currently, there is inherent political power in being an upstream riparian who controls the headwaters. In the scenario for cheap desalination, that spatial position of power would shift from the mountains to the valleys and from the headwaters to the sea. Many nations who are currently dependent on upstream neighbors for their water supply, such as Israel, Egypt, and Iraq, would suddenly find roles reversed by virtue of their coastlines.

4.5. THE CHANGING SOURCES OF WATER AND THE CHANGING NATURE OF CONFLICT

Both the realms of water and of conflict are undergoing slow but steady changes which may obviate much of the thinking in this report. As the world's surface water supplies and easy groundwater sources become increasingly scarce, two major changes are emerging: quality is steadily becoming a more serious issue to many than quantity, and water use is shifting to less traditional sources. Many of these sources – such as deep fossil aquifers, wastewater reclamation, and interbasin transfers – are not restricted by the confines of watershed boundaries, our fundamental unit of analysis in this study. Moreover, population-driven food demand will grow exponentially in coming years, putting unprecedented pressures on water demand.

[4] While the shifts described here are very dramatic, current trends suggest that desalinated water is becoming more attractive in the developing world as well. It should also be noted that desalinated drinking water also becomes available as wastewater, which can be treated for agricultural and industrial uses (Asit Biswas, personal communications, 2000).

Conflict, too, is becoming less traditional, increasingly being driven by internal or local pressures, or more subtle issues of poverty and stability. The combination of these changes in water resources and in conflict suggests that tomorrow's water disputes may look very different from today's.

References

Bolte, J.P., Hulse, D.W., Gregory, S.V., and Smith, C., 2004. Modeling Biocomplexity – Actors, Landscapes and Alternative Futures. Keynote speech, Proceedings from the International Environmental Modeling and Software Society. 14–17 June 2004, University of Osnabrück, Germany.

Carius, A., Dabelko, G.D., and Wolf, A.T., 2004. *Water, Conflict, and Cooperation. Policy*. Briefing Paper for the United Nations & Global Security Initiative of the United Nations Foundation, http://www.un-globalsecurity.org/pdf/Carius_Dabelko_Wolf.pdf.

Giordano, M., Giordano, M., and Wolf, A.T., 2002. The Geography of Water Conflict and Cooperation: Internal Pressures and International Manifestations, *Geographical Journal*, 168(4): 293–312.

Gleick, P., 1999. *The World's Water 1998–1999: The Biennial Report on Freshwater Resources*, Island Press.

Gunderson, L.H. and Pritchard, L., 2002. *Resilience and the Behavior of Large-Scale Systems*, Island Press, Washington, DC, 287 pp.

Lonergan, S., Gustavson, K., and Carter, B., 2000. The Index of Human Insecurity, AVISO Bulletin #6: 1–11, GECHS, Ottawa, ON.

Lopez, A., 2004. *Environmental Conflicts and Regional Cooperation in the Lempa River Basin*: The role of the Trifinio Plan as a regional institution, EDSP Working Paper No. 2, Environment, Development, and Sustainable Peace Initiative.

Postel, S., 1999. *Pillar of Sand: Can the Irrigation Miracle Last?* Norton, New York.

Postel, S. and Wolf, A., 2001. Dehydrating Conflict, *Foreign Policy*. September/October 2001: 60–67.

Turner, B.L. et al., 2003. *A Framework for Vulnerability Analysis in Sustainability Science*, Proceedings of the National Academy of Sciences. Vol. 100 #14, pp. 8074–8079, 8 July.

UNEP, 2004. *Understanding Environmental Conflict and Cooperation*, UNEP–DEWA, Nairobi.

Vogel, C. and O'Brien, K., 2004. Vulnerability and Global Environmental Change: Rhetoric and Reality. AVISO Bulletin #13: 1–8 March. GECHS, Ottawa, ON.

Waterbury, J., 1979. *Hydropolitics of the Nile Valley*, Syracuse University Press, New York.

Wolf, A.T., Natharius, J., Danielson, J., Ward, B.S., and Pender, J.K., 1999. International River Basins of the World, *International Journal of Water Resources Development*, 15(4): 387–427.

Wolf, A.T., Yoffe, S.B., and Giordano, M., 2003: International waters: Identifying basins at risk, *Water Policy*, 5: 29–60.

Wolf, A.T., Kramer, A., Carius, A., and Dabelko, G.D., 2005. Managing Water Conflict and Cooperation, Chapter 5 in: *Worldwatch Institute State of the World 2005: Redefining Global Security*, Worldwatch Institute, Washington, DC.

INVESTIGATING INCENTIVES TO EXAGGERATE THE RISKS OF WATER WARS

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Abstract: Predictions and warnings of inevitable and imminent wars over scarce water are increasingly common. These statements continue to be made despite relatively weak empirical evidence to support them. This study presents the sets of incentives to stress and even exaggerate the probability of war over water facing five sets of actors: policy-makers, academics, the media, non-governmental organizations (NGOs), and the private sector. The study argues that this confluence of such an array of incentives has likely contributed to an overemphasis of the likelihood of war over water in public discourse.

Keywords: Conflict; environmental security; media; NGOs; political economy; war; water management

1. Introduction: The Prevalence of Warnings vs. The Paucity of Evidence

Over the past 25 years, warnings of future wars over water have become commonplace in statements by political officials, research studies by academics, popular journalistic sources, and reports by environmental and development-oriented non-governmental organizations. Commonly cited figures include former Egyptian Foreign Minister and former Secretary General of the United Nations Boutrous Ghali, who purportedly claimed that "The next war in the Middle East will be fought over water, not politics" or the vice president of the World Bank,

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Ismail Serageldin, who is purported to have stated that “the wars of the next century will be over water.”[1]

The typical premise of what has come to be known as “the water wars hypothesis” is that increasing competition among nations with growing populations for fixed or even dwindling water resources will lead to the outbreak of violent conflict. Claims range from those who present water wars as a possibility which can be avoided with cooperation and proper planning (e.g., Frey and Naff, 1984; Postel and Wolf, 2001), to those who predict that such wars are likely (e.g., Cooley, 1984; Naff and Matson, 1984; Starr, 1991; Bulloch and Darwish, 1993; De Villiers, 1999; Ward, 2002), to those who confidently predict that they are “certain” (e.g., Myers, 1993: 47).

Despite its popularity, both the theoretical and the empirical foundations of such a water war hypothesis have increasingly been challenged (Lonergan, 2001; Dolatyar, 2002; Wolf, 2007). Critics note, for instance, that relatively little systematic empirical evidence exists of past violent conflicts over water and there is little sign that such conflicts are occurring more frequently (e.g., Yoffe et al., 2003). Furthermore, they note that proponents of the water war hypothesis often rely on a very limited number of cases and statements by officials (Dinar, 2002). Given the relative paucity of supporting evidence of past water-motivated conflict, it is perhaps surprising that proclamations that water wars are imminent remain so prevalent. While much of the literature on the topic has attempted either to promulgate or refute the water war hypothesis, little if any has addressed what incentives different key actors have for emphasizing, and even exaggerating, the risks of such wars. This chapter provides just such an analysis. The confluence of such incentives is likely to have led to the continued popularity of such warnings, despite relatively little supporting evidence.

2. Evidence for and Against the Water War Hypothesis

The overwhelming support for the water war hypothesis comes from statements about the potential for such wars by prominent political figures, and evidence of past events such as Israel’s bombing of Syrian efforts to divert the Jordan headwaters and the Palestinian Liberation Organization’s (PLO) attempt to blow up Israel’s National Water Carrier (e.g., Naff and Matson, 1984; Starr, 1991; Gleick, 1993). While the Middle East is the most cited example, other regions have also been cited as having experienced violent conflict over water. Most recently, skirmishes in Sri Lanka have been described as water-related (Bajpaee, 2006; The Economist, 2006), and several commentators, including U.N. Secretary General Ban Ki Moon, have characterized the violence in the

[1] These quotes have been reproduced in numerous books and articles. See, for instance, De Villiers (1999).

Darfur region of Sudan as stemming, at least in part, from struggles over scarce water resources (Ban Ki Moon, 2007).

Recently, some statistical evidence has lent support to the claim that water scarcity may increase the odds of violent conflict, especially at the intra-national level (e.g., Hauge and Ellingsen, 1998; Miguel et al., 2004; Levy et al., 2005; Gleditsch et al., 2006). The research is far from conclusive, however.

Warnings of violence are not tantamount to actual outbreak of violence. Leng (1980), for instance, found no correlation between frequency of threats of war by policy-makers and the onset of war. In a study specifically looking at conflict and cooperation over water resources between 1948 and 1992, Yoffe et al. (2003) noted over 400 incidents of verbal exchanges by political figures between 1948 and 1999 that were conflictive in nature, but only 37 instances of violent conflict of varying levels of intensity (most from the Middle East and prior to 1970), and no all-out wars.

The water war hypothesis has faced theoretical challenges as well. For instance, many argue that the economic value of water, used mostly for non-essential agriculture, does not justify the high economic and personal costs of war, especially when international trade allows importation of virtual water (e.g., Allan, 2002; Fisher and Huber-Lee, 2005). Others have noted that the declining costs of desalination and other technologies may actually be decreasing practical scarcity, and therefore the risk of conflict (e.g., Lomborg, 2001).

The empirical and theoretical critiques of the water war hypothesis have led some leading scholars on the topic to tone down or qualify their statements about the likelihood of future water wars. Homer-Dixon, for instance, declared that “the renewable resource most likely to stimulate interstate resource war is river water” (1994: 19), but later qualified it saying that “wars over river water between upstream and downstream neighbors are likely only in a narrow set of circumstances…[and] there are, in fact, very few river basins around the world where all these conditions hold” (1999: 208).

3. Previous Work on Incentives for Stressing the Environmental Conflict

Many commentators have noted that various actors may have incentives for stressing or even exaggerating the risks of water wars. Lonergan stated that in “many cases, the comments are little more than media hype; in others, statements have been made for political reasons” (2001: 110). Little research, however, has moved beyond merely acknowledging the possibility of such incentives. An understanding of the motivations of various groups of actors to stress the possibility of water wars can help explain the continued popularity of such warnings and help to evaluate them more critically.

Of the little research that does exist addressing incentives, Simon (1980) suggests four possible reasons that researchers offer what he claims are overly gloomy scenarios regarding possible implications of resource scarcity: (a) international funding organizations eager to fund research dealing with crises; (b) newspapers and books eager to sell sensationalist headlines; (c) a psychological predisposition to focus on bad news or worst case scenarios, and (d) a belief that sounding alarm bells can mobilize action. Haas (2002) claims that "exaggerated beliefs about resource scarcity and their possible threats to environmental security persist" due to the interdisciplinary nature of the problems, which allows multiple approaches, with few common methods of analysis or methods to refute such claims. Trottier (2003) suggests that certain private sector actors in the water industry have an incentive to stress or exaggerate the risks of water wars in order to promote additional water-related infrastructure.

Explanations such as "blood sells" or the promotion of private sector interests may have some merit, but ultimately are unsatisfying, in that they are not relevant for several actors, they oversimplify a multifaceted picture, and they ignore other possible motives. Such simplistic explanations also may imply that those offering such statements were intentionally misleading the public, which is not the case for many such actors. In sum, even taken collectively, the above arguments provide only a partial picture of existing incentives.

4. Multiple Incentives for Multiple Actors to Stress Risks of Water Wars

This study analyzes incentives of five different groups of actors who have contributed to the popularity of the water war hypothesis. These are: (a) political leaders and policy-makers, (b) academic scholars, (c) the news media, (d) non-governmental organizations (NGOs) and (e) the private sector.[2] For each group, possible incentives at work for stressing a water war scenario are offered. These are summarized in Table 1. The first entry for most groups is the straightforward case in which they simply believe that water wars are imminent. As can be seen from the table, however, each group has several other possible incentives to stress the water war hypothesis, some unique to it, and some that overlap with those of other actors. Some examples are given in which such incentives seem likely to have played a role, though no attempt is made in this study to verify that these incentives did in fact play a role in the specific decisions by particular actors.

[2] An additional group, intergovernmental organizations, shares many of the incentives of some of the five listed, and it will be discussed along with those throughout the article.

TABLE 1. Incentives to Stress or Exaggerate Risk of Water Wars

Actor	Incentives to stress or exaggerate risk of water wars
Political leaders and policy-makers	• Signal an actual risk of violence • Signal to riparian that water is considered high level politics • Signal to domestic population that water policy is taken seriously • Signal to third country desire for mediation • Serve as a negotiating tactic or intentional obstacle to negotiations • Raise profile of water-related development or environmental needs
Academic scholars	• Assessment that water wars are actually imminent or likely • Serve as null hypothesis of research into water and conflict • Claim that political statements and/or media publications are worthy of study in their own right • Raise profile of research and expand the pools of funding • Raise profile of water-related development or environmental needs
Journalists/popular press	• Assessment that water wars are actually imminent or likely • Reporting of statements by "experts" • Need for gripping headlines • Need to shorten analysis into sound-bites • Practice of giving equal coverage to opposing views • Practice of focusing on aspect of most interest to target audience • Raise profile of water-related development or environmental needs
Non-governmental organizations	• Assessment that water wars are actually imminent or likely • Raise profile of water-related development or environmental needs • Gain media coverage for organization • Expand pools of available funding
Private sector	• Assessment that such wars are actually imminent or likely • Desire to promote water-related infrastructure to alleviate scarcity

4.1. POLITICAL LEADERS AND POLICY-MAKERS

4.1.1. Signal an actual risk of violence

The most straightforward reason that political leaders might warn of the dangers of a war over water is, of course, their belief that such a risk is actually imminent and/or to issue a meaningful threat to riparian countries that they are prepared to engage in warfare if actions are taken to deprive it of water resources. Such threats appear to be the case, for instance, in statements in the 1950s and 1960s by Israeli leaders regarding the Jordan headwaters (Gat, 2005; Shemesh, 2004), and perhaps for statements by Sadat that Egypt would go to war to prevent Ethiopia from building dams along the Nile (Dinar and Wolf, 1994). Political leaders may have several other possible reasons for voicing water war risks other than to offer credible threats. Indeed, given that research has shown that public threats seem more often to be met with defiance rather than compliance (e.g., Leng, 1980), other reasons may in fact be primary ones.

4.1.2. Signal to riparian that water is considered high level politics

Issues of water management are often considered technical or bureaucratic issues far from the realm of "high politics", which traditionally has focused on security and economic development. Warning of risks of war over water can be a way to signal to a riparian country that their actions are being taken seriously at high levels of government. This may be done to convince a country to refrain from or redesign a planned action or to induce them to engage in negotiations. Güner (1998) describes the use of threats of war as signaling tactics by Turkey and Syria in their dispute over the waters of the Euphrates. Such use of threats of war may be an important signaling device, even if the likelihood of the threat being realized is limited.

4.1.3. Signal to domestic population that water policy is taken seriously

Political leaders may wish to signal to domestic constituencies as well. Putnam (1988) and others noted that political leaders are often engaged in two-level decision-making in which they attempt to balance both domestic and international political demands. A public statement of willingness to fight for water rights is likely to send a signal to domestic constituencies, such as agricultural lobbies, that water rights are being taken seriously by the national government or by a particular political party. In analyzing the "bellicose statements, even at the highest levels" of the Indian and Pakistani governments in the 1950s and 1960s, Alam suggests that "though the statements made by key decision makers in public may suggest a move towards war, the statements are used to generate domestic support for a political position. As seen in the Indus basin, the political rhetoric did not match the governments' actions which sought to resolve an international water dispute through cooperation… The experience from the Indus basin, therefore, throws into question whether public statements made for a domestic audience are truly indicative of a country's intent to go to war over shared waters" (2000: 349).

4.1.4. Signal to third party

Another possibility is that threats or warnings of war are meant to influence third parties, who often play a role in mediating disputes between nations and in financing water development projects. Israeli Prime Minister Ariel Sharon's warnings that continued diversions Lebanese diversions of waters of the Wazzani River, a tributary of the Jordan, could spur military conflict (Amery, 2002), for instance, may have been meant to engage a third party to mediate between Israel and Lebanon, with whom Israel has no direct diplomatic relations. Indeed, soon after the statements were made, U.S. officials became involved in negotiating an agreement between the sides, and requested that future messages over water disputes be transmitted through them and not by threats of military action (Walla!, 2001). Similarly, Iraqi threats against Syria in the 1970s spurred intervention by the Soviet Union and Saudi Arabia, who helped negotiate a settlement.

Threats of war may also be intended as signals to third parties from the financial sector. Political leaders may issue warnings or threats in order to deter institutions from offering finance or to encourage them to change lending terms for projects being considered. Threats of violent conflict were important in motivating World Bank efforts to help negotiate an agreement between India and Pakistan on the Indus River in the 1960s (Ward, 2002); and at least one analyst has suggested that the risk of regional instability is at least partly a factor in dissuading international agencies and governments from financing dams in Ethiopia (Collins, cited in Ward, 2002: 185–186). Iraqi threats against Turkey, a stronger upstream neighbor, may have been intended for the World Bank, which was contemplating funding of Turkish dams at the time (Kibaroglu and Ünver, 2000).

4.1.5. Serve as negotiating tactic or intentional obstacle to negotiations

Policy-makers may issue threats or warnings of war over water as negotiating tactics for issues not directly related to water resources. Güner (1998) claims that threats of military and terrorist acts between Syria and Turkey, while ostensibly over shared water resources, were, in reality, attempts to impact issues such as territorial disputes and separatist movements. He states that in 1993, Turkish Prime Minister Tansu Çiller sent a message to Syrian President Hafez al-Assad stating that there would be no solution to water disputes between the nations unless Syria prevented the Kurdish separatist group PKK from acting within its territory.

Rather than serve to induce action in negotiations over issues other than water, it is also possible that threats or warnings of war by political officials are meant to prevent negotiations or concessions on such issues. Many figures have used the risk of future war over water as a justification for not relinquishing control of territory, for instance, such as is the case with many Israeli arguments against ceding control over the West Bank or Golan Heights (Sherman, 2002).

4.1.6. Raise profile of water related development or environmental needs

One reason to stress the risks of war over water that is common to all groups of actors looked at in this study is to bring attention to aspects of water management that may otherwise be deemed by policy-makers as less deserving of attention and/or funding, such as pollution, sanitation, or other environmental or development matters that may not otherwise be high on many people's political agendas. British diplomat John Ashton, the United Kingdom's "Climate Ambassador", reportedly commented that global warming should be recast as a security issue to help mobilize support for cuts in global greenhouse gas emissions (Doyle, 2007). Such a rationale seems reasonable in explaining declarations concerning water wars made by other officials in governments and at bodies such as the World Bank or UNESCO (e.g., UN, 2006), which are formally charged with development and educational issues, not conflict resolution.

4.2. ACADEMIC SCHOLARS

4.2.1. Assessment that such wars are actually imminent or likely

Academic scholars of course may assess that water wars are genuine risks. This straightforward explanation is supported by past violent conflict over water as detailed in case studies and some systematic empirical studies, as well as by plausible theoretical models.

4.2.2. Serve as null hypothesis of research

Many scholars have come to the conclusion that risks of water wars are small, and present the issue only as a worst case scenario. Still, such work serves to keep the issue alive in the public consciousness and in academic debates. Moreover, these researchers implicitly give the water wars hypothesis a modicum of credibility in that they deem it worthy of study. Furthermore, because empirical studies in this field are still limited in number, and theories remain speculative, publications both supporting and refuting the risks of conflict invite further work.

4.2.3. Political statements and/or media publications as fields of study

Researchers may focus on the *threats* of water wars as topics of interest in their own right, even if they are not concerned with the probability of *actual risks* of conflict. Many focus on some aspect of the water war topic without needing to address the credibility of the threats. Statements by public figures, media coverage of risks, and the economic rationale for or against resource wars are all legitimate subjects of study. Furthermore, as Haas (2002) points out, the interdisciplinary nature of the topic allows researchers from a multitude of fields to apply their own theoretical framework to the issue and offers them a wide range of journals in which to potentially publish their results. While these studies need not necessarily promote the water war hypothesis, they do keep the issue alive in public affairs and academic circles.

4.2.4. Raise profile of research and expand the pools of available funding

By connecting issues of water to those of security, researchers can raise the profile of their work, promote their own name, and better gain access to policy-makers. Furthermore, because the topic is interdisciplinary, researchers connecting water and security expand the number and types of journals in which they can publish, and gain exposure to audiences outside their particular field of expertise, which offers possibilities for further research collaboration.

Water policy is interdisciplinary in nature, and thus research on these topics is open to a range of fields from both the natural and social sciences, each with its respective sources of funding. Security studies too have their own pool of funding, which can be large given the importance attached to security in policy. Thus, researchers connecting the issues of resource scarcity and security open up large new pools of possible funding. This does not ensure that researchers will promote such linkage, but it does represent a financial incentive to do so.

4.2.5. Raise profile of water related development or environmental needs

As in the case of political figures, researchers may attach the risk of water war in order to draw attention to and increase understanding of water management issues, or in order, as Simon (1980) stated, to mobilize action on particular environmental or development issues. Several books, for example, have the phrase “water war” in the title, although actual discussion of violent conflict over water represents a relatively minor portion of the book, with the bulk being dedicated to various water management issues (e.g., De Villiers, 1999; Ward, 2002; Shiva, 2002; Olivera and Lewis, 2004). The primary intent of these books is an effort to raise attention to some aspect of water management. The risk of violent conflict serves simply to highlight a potential danger of inaction.

4.3. JOURNALISTS AND THE POPULAR PRESS

4.3.1. Assessment that water wars are actually imminent or likely

Media reports of risks of water wars may be a sincere reflection of research and analysis. However, the press primarily merely relays information and analysis. Therefore, this explanation is really a statement that the press takes seriously the assessments of others who stress the risks of violence over water resources.

4.3.2. Reporting of statements by "experts"

Many observers note that media often considers elites inherently worthy of coverage, with several claiming that the media even gives them a preferred status (e.g., Becker, 1967; Herman and Chomsky, 1988; Cottle, 2003). Davis (2003) claims that journalists are drawn to sources in official positions of power, expect them to provide expert knowledge, and grant them 'primary definer' status. He also notes that because of concerns over costs, journalists increasingly rely on outside sources considered credible for information and analysis. The prospect of imminent water wars was first presented by official figures of authority or power and was duly covered by the media. Once established, it has remained a popular theme in the popular press, despite subsequent evidence suggesting the risks of an actual occurrence of water wars are low. Furthermore, continued reference to the risks of water wars by those in positions of power will further media coverage.

4.3.3. Need for gripping headlines

Simon's (1980) observation that "bad news sells" more than good news has ample empirical support. Cottle (2003) provides numerous examples that the press tends to focus on exceptional or violent behavior. Disagreements over water allocations may be considered mundane and not newsworthy, whereas violence over such allocations is. Thus, the media will favor coverage of a position presenting the possibility of water wars over positions suggesting that such conflicts are not likely. An article on water in the Middle East written by Freid (2007) and published in the *San Francisco Chronicle*, for instance, was titled "*Future of war will go with the flow*" with the byline *"Water promises to be flash point*"; this, despite the fact that experts quoted in the article itself actually stated that they felt water was unlikely to lead to violence.

4.3.4. Need to shorten analysis into sound-bites

Because the media is increasingly structured around presenting brief sound-bites or catchy headlines (Davis, 2003), they frequently reduce complex issues into memorable catchphrases and simplistic storylines, at the expense of nuanced explanation, and often at the expense of accuracy. Bird and Dardenne contend that "news stories, like myths, do not 'tell it like it is', but rather, 'tell it like it means'" (1988: 337), or what the media feels should be the story, rather than what the facts actually depict. Aubin (1998) noted how pressures to provide pithy coverage of complex security issues have resulted in inaccurate media coverage, and how, once established, this misinformation has managed to persist in subsequent coverage.

4.3.5. Giving equal coverage to opposing views

The quest for "balanced coverage" may itself be a contributor to the amount of media exposure granted to the risk of water wars. When confronted with differing expert opinions regarding highly specialized or technical issues that journalists themselves are incapable of evaluating, the press often attempts to provide equal coverage, irrespective of where the weight of expert opinion lies (Dearing, 1995). Dunwoody and Peters refer to such a strategy of balance as "a surrogate for validity checks" (1992: 210). While this provision of equal coverage is ostensibly done with a goal of balancing perspectives, it can result in disproportionate coverage of a minority viewpoint. Press coverage of climate change is a well documented example in which the overwhelmingly minority viewpoint among climate scientists that climate change is not occurring has been given prominent media coverage (Boykoff and Boykoff, 2004). No content analysis of media coverage of conflict over war was undertaken for this study; however, given the lack of consensus on the water wars issue, such journalistic protocol is likely to produce a similar outcome in which the prospect that water wars are likely is given more coverage than the viewpoint that they are not.

4.3.6. Focus on aspect of most interest to target audience

Singer and Endreny (1987) found a "lack of congruence between the size of the risk and the amount of media coverage it receives." Combs and Slovic (1979: 841) found, for instance, that relative to actual objective risks, "disease appeared to be greatly underreported while violent, often catastrophic events… stood out as being overreported". Water-related illnesses kill between 5 and 10 million people a year (UNDP, 2006), several times the combined number of casualties from all the wars in the world each year. These deaths, however, are less newsworthy than the prospect of war, precisely because they are long-standing, chronic problems. Moreover, they generally afflict the poorer classes in developing countries, but not the target audience of the media. Wars may be more likely to have some kind of spillover effect that could impact or interest the typical reader of the media, especially the Western media.

4.3.7. Raise profile of water-related development or environmental needs

Journalists, like the other actors examined, may reference water wars in order to draw attention to development or environmental issues related to water that, on their own, would likely not be deemed newsworthy. Thus, for instance, the risk of water wars in often mentioned prominently in articles in which it is not the primary topic. For example, the Boston Globe published an editorial entitled, "The next world war will be over water", although the text of the article concentrated almost solely on the health impacts of such scarcity (Rothfeder, 2002).

4.4. NON-GOVERNMENTAL ORGANIZATIONS

Over the last few years, a number of NGOs have adopted environmental security issues as a field of concern, many of which have addressed the issue of water wars. Several NGOs have played a leading role in framing perceptions of policymakers and influencing parties regarding transboundary water management (Dinar, 2002).

4.4.1. Assessment that water wars are actually imminent or likely

As with other actors NGOs may promote a genuine belief that violent conflict over water is imminent.

4.4.2. Raise profile of water related development or environmental needs

From among the actors evaluated in this study, NGOs face perhaps the strongest incentive to use the specter of water wars in order to raise the profile of water-related development or environmental goals they happen to be championing. By tying their main issue to conflict over water, they offer those that sympathize with their mission an additional reason to offer support and/or take action. For instance, the British-based World Development Movement offers the elimination of the underlying causes of poverty as its primary objective. Its website lists water among its numerous and wide-ranging current and past campaign topics, which also include: international trade, climate change, tobacco, asbestos, genetically modified organisms, transnational corporations, international debt relief, and toys. It provocatively named its water campaign "Stop Water Wars", though the primary goals of the campaign are advocacy in support of provision of basic water and sanitation services to the poor and opposition to privatization of the water industry. Similarly, a warning on the risks of war over water figures prominently on the homepage of the website, www.worldwaterwars.com, though relatively little on the website relates to the potential for water-related violence.

4.4.3. Gain media coverage for organization

NGOs are often eager to access media outlets to spread their messages. Anderson (2003) notes that the media constitute a primary public arena in which their claims "compete for access and public legitimacy". Media exposure can increase visibility of the organization as well as its causes. In so doing, it can also increase the pool of potential members and donors. In addition, many NGOs use press coverage as a measure of their effectiveness when reporting to funders. Press coverage can also serve as a channel through which advocacy-oriented NGOs can communicate to and exert influence on policymakers. Given the lack of media attention to chronic issues such as sanitation and pollution, NGOs have an incentive either to link such subjects to that of wars or security.

4.4.4. Expand pools of available funding

As in the case of academic scholars, combining issues can open up new pools of funding. NGOs with either an environmental or a security/peace advocacy focus face an economic incentive to expand their focus to include some aspect of environmental security, such as water wars. Several NGOs have combined some aspect of conflict resolution and environmental protection. Conca et al. (2005) and others have noted the increased role of NGOs in environmental peacemaking. Again, even if the organizations are not explicitly promoting or supporting the water war hypothesis, by addressing the issue, they help to keep it in the public consciousness.

4.5. PRIVATE SECTOR

The private sector, like the other actors considered, may issue warnings about the risks of violent conflict over water because it considers such risks credible. Conflict can affect possibilities for and terms of investment, and as such, the private sector tends to be a keen analyst of information regarding political and military risks. As Trottier (2003) notes, however, certain private industry actors have an incentive to promote the risks of war in order to encourage policy-makers to invest in water infrastructure that would reduce scarcity. Water industry leaders promoting such technological and supply-side fixes have an incentive to stress that their projects may reduce the risks of war over scarce water resources. This potential benefit of decreasing scarcity through additional infrastructure may be important in gaining an advantage over demand reduction policies, which are often economically more efficient options. Examples include desalination, inter-basin pipelines, and international water shipping.

A representative of a desalination facility under construction in Israel commented, for instance, that “unfortunately water is one of the reasons that create war. If you compare the cost of one F-16, it is more or less the cost of this desalination plant. I believe at the end of the day it will be much cheaper to solve conflict based on this type of plant than through buying new F-16s” (Leyne, 2004). The website of a developer of large bags that can be filled with water and towed to facilitate international shipping of water quotes the World Bank’s Serageldin’s statement that the next century’s wars will be over water, and then claims that "Waterbag technology will have a direct impact on the Peace Process in the Middle East."[3]

5. Conclusions

Water has been and continues to be a source of political conflict, at times even violent conflict. Given both the relatively limited empirical evidence and the theoretical critiques of the water war hypothesis, however, the prospect of wars over water resources seems markedly over-represented in political, academic, and journalistic discourse. Understanding incentives various actors face to stress or even exaggerate the possibility of such conflict can help explain the significant exposure and tractability that such warnings have received to date.

Some of the incentives discussed above are relevant to multiple actors, such as the use of the threat of war to highlight other water-related issues. This overlap in interests can serve to strengthen the incentive if parties understand that other actors will be receptive to such actions. Also, actions by different actors are mutually reinforcing. Policy-makers are not only covered by the media, but also react to it. NGOs may seek access to policy-makers via the media, or seek to use the media to mobilize action to pressure policy-makers, and, in turn the media may seek out NGOs for sources of information. Academics too may covet media coverage in order to publicize their findings, and may be sought out by the media as credible sources of information. Similarly, policy-makers often rely on academics for credible information on which to base policies, and academics often treat the behavior and statements of policy-makers as subjects of their studies. Furthermore, political motives are not limited to policy-makers, but may be shared by other actors who seek to influence public policy. Politicians are influenced by and influence private sector representatives. This mutually-reinforcing web of interactions and common incentives to stress the risks of water wars may well contribute to the continued prominence of the issue of water wars.

Exaggerating or overemphasizing the prospects of conflict over water resources entails its own set of risks. For example, using the specter of war to raise attention or mobilize action on related environmental or development issues may ultimately reduce attention to such causes, as resources may be redirected towards conflict prevention. Similarly, by focusing on water as a cause of conflict, attention may be drawn away from more important or proximate causes.

This study was also meant to be suggestive, rather than conclusive. It did not attempt to estimate or quantify the actual influence of the various incentives laid out above in motivating the behavior of the set of actors described. Rather, it simply provided examples in which it seems reasonable that the incentives

[3] The website of the company "Waterbag", http://www.waterbag.com/, accessed on 14 June 2008.

were relevant. Nor did it suggest methods for identifying when such incentives are in fact responsible for actions by a given party. Furthermore, because this analysis generates plausible hypotheses based on real world decision-making but supported by anecdotal evidence, it is subject to much of the same critiques leveled against much of the environmental security literature, including the water war hypothesis. Finally, it must be noted that although past incidences of water-related violent conflict have been relatively rare, as populations grow, economies develop, and climatic conditions change, past trends may not be indicative of future scenarios.

Actors also face a set of possible incentives to underestimate or deemphasize the risks of water wars; for instance, a desire not to undermine investment opportunities or ongoing negotiations. This study did not address such incentives; however, it is the feeling of this author that the list of such incentives is smaller, and less likely to have influenced the public debate on the topic.

Such limitations noted, this study does provide analysts with a conceptual framework with which to start evaluating various claims regarding the prospects of violent conflict over water and other natural resources.

The specific topic of this study was conflict over water, however, much of the analysis is relevant to discussions of conflict over other natural resources and to broader discussions of environmental security in general. Analysts of this topic acknowledge “that one cannot dismiss the political motives of those who wished to elevate – or prevent the elevation – of environmental concerns to the same status as military ones” (Diehl and Gleditsch, 2001: 3). This study attempted to provide a clearer picture of these motives, with the hope that a better understanding of the various incentives to stress the risks of violent conflict over scarce resources will assist analysts in better evaluating the credibility of the diverse pronouncements on this topic.

References

Alam, U.Z., 2002. Questioning the water wars rationale: a case study of the Indus Waters Treaty, *The Geographical Journal*, 168(4): 341–353.

Allan, J.A., 2002. Hydro-Peace in the Middle East: Why No Water Wars? A Case Study of the Jordan River Basin, *SAIS Review*, XXII: 255–272.

Amery, H.A., 2002. Water wars in the Middle East: a looming threat, *The Geographical Journal*, 168(4): 313–323.

Anderson, A., 2003. Environmental activism and news media, in: *News, public relations and power*, S. Cottle, ed., Sage, London/Thousand Oaks, CA, pp. 117–132.

Aubin, S.P., 1998. *Distorting defense: network news and national security*, Praeger, Westport, CT.

Bajpaee, C., 2006. Asia’s Coming Water Wars, *The Power and Interest News Report*.

Ban Ki Moon, 2007. A Climate Culprit in Darfur, Washington, DC, June 16.

Becker, H.S., 1967. Whose Side Are We On? *Social Problems*, 14(Winter): 239–247.

Bird, S.E. and Dardenne, R.W., 1988. Myth, chronicle and story: Exploring the narrative qualities of news, in: *Media, myths, and narratives: Television and the press*, J.W. Carey, ed., Sage, Beverly Hills, CA, pp. 67–88.

Boykoff, M.T. and Boykoff, J.M., 2004. Balance as bias: global warming and the US prestige press, *Global Environmental Change*, 14(2): 125–136.

Bulloch, J. and Darwish, A., 1993. *Water wars: coming conflicts in the Middle East*, Gollancz, London.

Combs, B. and Slovic, P., 1979. Newspaper coverage of causes of death, *Journalism Quarterly*, 56: 837–849.

Conca, K. et al., 2005. Building peace through environmental cooperation, in: *State of the world 2005: redefining global security*, World Resources Institute, W.W. Norton, New York/London, pp. 144–157.

Cooley, J.K., 1984. The war over water, *Foreign Policy*, 54: 3–26.

Cottle, S., ed., 2003. *News, public relations and power*, Media in focus, Sage, London/Thousand Oaks, CA.

Davis, A., 2003. Public relations and news sources, in: *News, public relations and power*, S. Cottle, ed., Sage, London/Thousand Oaks, CA, pp. 27–42.

De Villiers, M., 1999. *Water wars: is the world's water running out?* Weidenfeld & Nicolson, London.

Dearing, J.W., 1995. Newspaper coverage of maverick science: creating controversy through balancing, *Public Understanding of Science*, 4(4): 341–361.

Diehl, P.F. and Gleditsch, N.P., 2001. Controversies and questions, in: *Environmental conflict*, P.F. Diehl and N.P. Gleditsch, eds., Westview, Boulder, CO/Oxford, pp. 1–12.

Dinar, A. and Wolf, A.T., 1994. International markets for water and the potential for regional cooperation: economic and political perspectives in the Western Middle East, *Economic Development and Cultural Change*, 43(1): 43–66.

Dinar, S., 2002. Water, security, conflict, and cooperation, *SAIS Review*, XXII(2): 229–253.

Dolatyar, M., 2002. Hydropolitics: challenging the water-war thesis, *Conflict, Security and Development*, 2(2): 115–124.

Doyle, A., 2007. Climate Change Called Security Issue Like Cold War, *Reuters News Service*, 22 August.

Dunwoody, S. and Peters, H.P., 1992. Mass media coverage of technological and environmental risks: a survey of research in the United States and Germany, *Public Understanding of Science*, 1: 199–230.

Fisher, F.M. and Huber-Lee, A., 2005. *Liquid assets: an economic approach for water management and conflict resolution in the Middle East and beyond*, Resources for the Future, Washington, DC.

Freid, S.L., 2007. Future of war will go with the flow: water promises to be flash point, *San Francisco Chronicle*, 10 June.

Frey, F.W. and Naff, T., 1985. Water: an emerging issue in the Middle East? *Annals of the American Academy of Political and Social Science*, 482: 65–84.

Gat, M., 2005. The great powers and the water dispute in the Middle East: a prelude to the six day war, *Middle Eastern Studies*, 41(6): 911–935.

Gleditsch, N.P., Furlong, K., Havard, H., Lacina, B., and Owen, T., 2006. Conflicts over shared rivers: resource scarcity or fuzzy boundaries? *Political Geography*, 25(4): 361–382.

Gleick, P., 1993. Water and conflict: fresh water resources and international security, *International Security*, 18(1): 79–112.

Güner, S., 1998. Signalling in the Turkish–Syrian water conflict, *Conflict Management and Peace Science*, 16(2): 185–206.

Haas, P.M., 2002. Constructing environmental conflicts from resource scarcity, *Global Environmental Politics*, 2(1): 1–11.

Hauge, W. and Ellingsen, T., 1998. Beyond environmental scarcity: causal pathways to conflict, *Journal of Peace Research*, 35(3): 299–317.

Herman, E.S. and Chomsky, N., 1988. *Manufacturing consent: the political economy of the mass media*, Pantheon, New York.

Homer-Dixon, T., 1994. Environmental scarcities and violent conflict: evidence from the cases, *International Security*, 19(1): 5–40.

Homer-Dixon, T., 1999. *Environment, scarcity and violence*, Princeton University Press, Princeton, NJ.

Kibaroglu, A. and Unver, I.H.O., 2000. An institutional framework for facilitating cooperation in the Euphrates–Tigris River Basin, *International Negotiation*, 5(2): 311–330.

Leng, R.J., 1980. Influence strategies and interstate conflict, in: *The correlates of War II: testing some realpolitik models*, J.D. Singer, ed., Free Press, New York, pp. 124–157.

Levy, M.A., Thorkelson, C., Vörösmarty, C., Douglas, E., and Humphreys, M., 2005. *Freshwater Availability Anomalies and Outbreak of Internal War: Results from a Global Spatial Time Series Analysis*, Paper presented at the Human Security and Climate Change Workshop, 21–23 June 2005, Asker, Norway.

Leyne, J., 2004. 'Water factory' aims to filter tensions, *BBC News*, 7 September 2004. (January 27, 2008); http://news.bbc.co.uk/go/pr/fr/-/2/hi/middle_east/3631964.stm.

Lomborg, B., 2001. Resource constraints or abundance, in: *Environmental conflict*, P.F. Diehl and N.P. Gleditsch, eds., Westview, Boulder, CO/Oxford, pp. 125–154.

Lonergan, S.C., 2001. Water and conflict: rhetoric and reality, in: *Environmental conflict*, P.F. Diehl and N.P. Gleditsch, eds., Westview, Boulder, CO/Oxford, pp. 109–124.

Miguel, E., Satyanath, S., and Sergenti, E., 2004. Economic shocks and civil conflict: an instrumental variables approach, *Journal of Political Economy*, 112(4): 725–753.

Myers, N., 1993. *Ultimate security: the environmental basis of political stability*, Norton, New York.

Naff, T. and Matson, R.C., 1984. *Water in the Middle East: conflict or cooperation?* Westview, Boulder, CO.

Olivera, O. and Lewis, T., 2004. *Cochabamba! Water War in Bolivia*, South End Press, Cambridge, MA.

Postel, S.L. and Wolf, A.T., 2001. Dehydrating conflict, *Foreign Policy*, 126: 60–67.

Putnam, R.D., 1988. Diplomacy and domestic politics: the logic of two-level games, *International Organization*, 42(3): 427–460.

Rothfeder, J., 2002. The next world war will be over water, *Boston Globe*, 6 January.

Shemesh, M., 2004. Prelude to the six-day war: The Arab–Israeli struggle over water resources, *Israel Journal*, 9(3): 1–45.

Sherman, M., 2002. The hydro-political implications of the Oslo Agreements: An Israeli perspective, in: *Conflict management of water resources*, M. Chatterji, S. Arlosoroff, and G. Guha, eds., Ashgate, Burlington, VT.

Shiva, V., 2002. *Water wars: privatization, pollution and profit*, South End Press, Cambridge, MA.

Simon, J.L., 1980. Resources, population, environment: an oversupply of false bad news, *Science*, 208(4451): 1431–1437.

Singer, E. and Endreny, P., 1987. Reporting hazards: their benefits and costs, *Journal of Communication*, 37: 10–26.

Starr, J., 1991. Water wars, *Foreign Policy*, 82: 17–36.

The Economist, 2006. Asia: Beyond euphemism; Sri Lanka at war, *The Economist*, 380(8491): 51, 19 August.

Trottier, J., 2003. Water wars: the rise of a hegemonic concept exploring the making of the water war and water peace belief within the Israeli–Palestinian conflict, *History and Future of Shared Water Resources*. PCCP. Paris, UNESCO. 6.

United Nations (UN), 2006. From water wars to bridges of cooperation: exploring the peacebuilding potential of a shared resource, *UN Chronicle*, 43(2): 63.

United Nations Development Programme (UNDP), 2006. Human Development Report 2006 – Beyond scarcity: Power, poverty and the global water crisis, *Human Development Report*, UNDP, New York.

Walla!, 2001. U.S. Supports Pumping Hasbani Waters by Lebanon, *Walla! News Services* (18 March, 2001); http://news.walla.co.il (in Hebrew).

Ward, D.R., 2002. *Water wars: drought, flood, folly, and the politics of thirst*, Riverhead Books, New York.

Wolf, A.T., 2007. Shared waters: conflict and cooperation, *Annual Review of Environment and Resources*, 32(1): 241–269.

Yoffe, S., Wolf, A., and Giordano, M., 2003. Conflict and cooperation over international freshwater resources: indicators of basins at risk. *Journal of the American Water Resources Association*, 39(5): 1109–1126.

SECTION II

WATER GOVERNANCE FOR SUSTAINABILITY IN THE JORDAN RIVER–DEAD SEA BASIN: PERSPECTIVES FROM JORDAN AND THE PALESTINIAN AUTHORITY

A JORDANIAN SOCIO-LEGAL PERSPECTIVE ON WATER MANAGEMENT IN THE JORDAN RIVER–DEAD SEA BASIN

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Abstract: The recession of the Dead Sea level is caused by the diversion of the surface water inflow into it and the excessive evaporation brought about by the industries extracting minerals from it. Sharing of the Jordan River waters was the subject of an American developed plan in collaboration with the riparian parties. The consumptive uses by the riparian parties of the Jordan River waters have denied the Dead Sea of much of its renewable water resource. This chapter addresses the history of planning for the use of the Jordan River waters and the intervention by the United States to work out a Unified Plan for the development of the Jordan Valley. The implementation of water use plans is also discussed. The concessions granted to companies to utilize Jordan River water to generate power, and to have the Hula marshes dried up are alluded to. The concessions granted for the Dead Sea works to Jewish and Arab companies is narrated. The possible alternatives to mitigate the negative impact on the Jordan River and the Dead Sea imparted by the consumptive use of the basin's water are listed and discussed.

Keywords: Jordan River; Dead Sea; side wadis; Lake Tiberias; Jordan Valley; irrigated agriculture; water sharing; sinkholes

1. Introduction

The Dead Sea is the terminus of the Jordan River, whose catchment straddles territories in Lebanon, Syria, Israel, Palestine and Jordan. The Dead Sea basin further includes catchments of wadis that discharge directly into it from the east and west and a catchment in Wadi Araba south to the Gharandal Divide that separates it from the Red Sea catchment. The Wadi Araba catchment drains

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territories in Jordan, Israel and some wadis even drain small territories in Sinai of Egypt. The catchment of Wadi Araba is of no important significance in its contribution to the water inflow into the Dead Sea.

The average historic annual surface flow into the Dead Sea is about 1.4 billion cubic meters (BCM) per year, of which the Jordan River contributes about 1.2 BCM. The remaining flows originate primarily in Jordan to the east and flow in side wadis (Zarqa Maien, Zara, Mujib, Ibn Hammad, Isal, Numeira, Hasa, Feifa and Khneizeera) that discharge directly into the Dead Sea and contribute about 200 million cubic meters (MCM) annually. Inflows from the western escarpment are not significant.

Jordan's population centers are located primarily in the Jordan River and Dead Sea basin. The capital city of Amman, as well as Zarqa, Irbid, Jerash, Ajloun, Madaba, Karak and Tafila are examples of such centers. Major cities and towns in the West Bank are located in the Jordan River basin. In Israel, several population centers are located in the Jordan River basin and so are some Syrian and Lebanese towns. However, among all these riparian parties, Jordan has the highest percentage of population residing in the Jordan River and Dead Sea basin exceeding 90% of its total population.

Agriculture dominated Jordan's economy until the early 1960s. The country experienced a massive influx of refugee population in the aftermath of the exodus of Palestinians from their homeland (1947–1948), causing per capita income to dip and unemployment to soar. The per capita income shrank to about $250 in 1953. Around this time, the government made a concerted effort to build up the economy and boost the Gross Domestic Product (GDP) through intensive job creation. Both the indigenous segment of the population and the incoming wave of Palestinian refugees (who became citizens in 1950) had agricultural skills carried down from generation to generation. It was therefore natural to target agriculture as the potential employer and a catalyst in the distribution of population over the territories of the Kingdom.

2. The Jordan Valley Potential and Development

2.1. WATER SHARING

The Jordan River Valley of the Hashemite Kingdom of Jordan extends from the Yarmouk River in the north to the northern shore of the Dead Sea in the south. Legally, the definition of the Jordan Valley takes its southern end to the city limits of Aqaba on the Red Sea.[1] The borders of the Kingdom define the western bounds of Valley, and the sea level contour defines the eastern borders,

[1] This definition was stated in the Jordan Valley Development Law No. 18 for the year 1977 that created the Jordan Valley Authority as amended on 21st May 1977 to include the Dead Sea, the southern Ghors and the Wadi Araba within the definition of the Jordan Valley.

with two exceptions. The contour 300 m above sea level constitutes the eastern boundary of the Valley within the confines of the Yarmouk gorge and the Zarqa gorge, and the contour 500 m above sea level defines the eastern bounds of the Valley from the northern shores of the Dead Sea to the city limits of Aqaba.

Development of the Jordan River Valley became the focus of the Jordanian government soon after the country received a wave of Palestinian refugees in 1948. The United Nations Relief and Work Agency for the Palestinian refugees (UNRWA), established in 1949, came to Jordan's assistance in this effort, as did the Technical Cooperation Agency of the United States (TCA, also known as Point IV). In 1952, they put up \$856,000 and \$929,000, respectively, to conduct the studies and preliminary site investigation works for a dam on the Yarmouk at Maqarin. Jordan also approached Syria and signed a bilateral treaty to utilize the Yarmouk River in June of 1953. As mentioned, the primary objective of the Jordanian government was to develop irrigated agriculture in the Jordan River Valley within its jurisdiction. At that time, this included the East Bank (present-day Jordan) and the West Bank (occupied by Israel since 1967).

The attempts to proceed with the Maqarin dam project gained momentum when UNRWA allocated \$40 million for the dam construction in 1953. In July of that year, UNRWA, TCA and the Jordanian government appropriated the remaining funds necessary for the initial expenditures and the recruitment of workers, and the vision was ready to be set in motion (Stevens, 1956). However, the attempts to pursue real implementation came to a halt when Israel, the lower riparian on the Yarmouk, filed protests with both the US State Department and the U.N against the project, claiming that it jeopardized its rights in the River. The United States then initiated an effort of shuttle diplomacy (1953–1955) between the Arab parties and Israel, headed by a U.S Presidential envoy, Ambassador Eric Johnston. He succeeded in forging an agreement with the Arab Technical Committee (the arm of the League of Arab States in the negotiations) and, separately, with an Israeli team headed by the Minister of Finance. The agreement came to be known as the *Johnston Plan* or, formally, the Unified Plan of the Jordan Valley.[2]

The elements of the Unified Plan included storage facilities to regulate the flows of the Jordan River and its tributaries, distribution systems of water shares, division of water, and supervision of the Plan. Jordan (including the West Bank) was allocated specific annual shares from the Upper Jordan (100 MCM to be drawn from Lake Tiberias), the flows of the side wadis within its jurisdiction (175 MCM east side wadis and 52 MCM west side wadis), 16 MCM of ground water split equally between East Bank and West Bank, and the residual flow of the Yarmouk River after deducting Syria's share at 90 MCM and Israel's share at 25 MCM/year. That residual flow (Jordan's share) was estimated to be 377 MCM, assuming and including a return flow from Syrian

[2] For details on the Johnston Mission, see Haddadin (2001: 46–126).

uses estimated at 26 MCM/year (Jordan Valley Plan, 1955). Time proved this return flow estimate to be on the high side.

The above share of Jordan totals 720 MCM/year, sufficient to irrigate a total area of arable lands of 36,000 ha in the East Bank and 6,000 ha in the West Bank. The respective water shares, net of evaporation, would be 479 MCM for the East Bank and 241 MCM for the West Bank. Lebanon was allocated 35 MCM from the Hasbani tributary; Syria 20 MCM from the Banyas, 22 MCM from the Upper Jordan and 90 MCM from the Yarmouk. Israel was allocated the residual flow of the Upper Jordan, estimated at 554 MCM/year after the deduction of shares to Lebanon, Syria and Jordan.

The League of Arab States wanted more time to decide on the Unified Plan. The Secretary General of the League, Abdul Khaleq Hassounah, informed Ambassador Johnston of their position via a letter on 15 October 1955.[3] Nevertheless, the Unified Plan became the cornerstone of US policy regarding water projects in the Jordan River basin.

2.2. THE EAST GHOR CANAL PROJECT

In the aftermath of the Suez Campaign, the United States began to take hold as the major foreign player in the region. Jordan terminated its treaty with the United Kingdom, whose influence in the region faded drastically in the wake of the Campaign.

On April 28, 1956, Salim Lahoud, foreign minister of Lebanon, made an overture to the US Ambassador in Beirut, Mr. Heath, regarding the Unified Plan. Lahoud expressed desire of the Arab States, especially Lebanon, to avert war with Israel. He noted that repeated violation of the ceasefire between Syria and Israel was tied to the fact that Israel was trying to implement unilateral plans to divert Jordan River waters. He further proposed that, since the Unified Plan was not formally ratified by the Arab League, the Arab side and the Israeli side would each work separately to implement their respective share of the Plan within their own territories and in the demilitarized zone (between Syria and Israel) if necessary. The results of these Lebanon–US contacts culminated in a partial and separate implementation of the Unified Plan by only two riparian parties: Jordan and Israel, with possible integration later into the comprehensive Unified Plan including the other two countries, Syria and Lebanon, when the political environment may permit.

Jordan, with assistance from the Food and Agriculture Organization (FAO), conceived of a “pilot scheme” for irrigation in the Jordan Valley to be undertaken in preparation for implementation of a plan to irrigate within the full arable lands in the Jordan Valley, as envisioned in the Unified Plan. The

[3] For full text of the letter see Haddadin (2001: 121).

recommendations for the pilot scheme were set forth in a report released on July 12, 1956 by FAO expert Mr. S.N Simansky. In that report, he proposed the building (in stages) of a 60 km-long canal in the East Ghor[4] which would draw water from the Yarmouk River and the east side wadis, for the irrigation of about 10,000 ha of agricultural land.

On the Arab side, the political union between Egypt and Syria in February 1958 triggered a rival union between Iraq and Jordan, which were both ruled by the Hashemite family. In Lebanon, President Camile Chamoun decided to renew his tenure for a second term, triggering violent opposition that led to civil war. Developments thereafter culminated in a military coup in Iraq, bringing an end to the Hashemites there and consequently the collapse of the Iraq–Jordan union. Popularity of Egyptian President Nasser went skyrocketing in the Arab World, while Jordan's reputation sank to a bottom low.

At this time, he United States became eager to support western-leaning Jordan, and responded positively to the country's request to implement the "pilot scheme" in the Jordan Valley. However, through its diplomatic mission in Amman, the US made it a condition that Jordan agree not to draw from the Yarmouk River more water than allocated to it under the Unified Plan. Jordan conceded to that condition.[5] With it and other conditions related to the technical aspects of the scheme met, a Project Agreement was concluded between Jordan's Development Board and the US International Cooperation Administration (ICA) on May 31, 1958 (Ministry of Planning, 1958). In that Agreement, the Jordanian Government promised to take "appropriate, timely action to provide for only economic, resident-operated farm irrigation units to receive water under the East Ghor Canal Scheme." The Agreement claimed that the Scheme would "provide a reasonable standard of living and… enable such resident operator (a) to pay a pro-rata share of the annual costs of operation and maintenance of the East Ghor Canal Scheme and (b) to repay a pro-rata share, over a reasonable period of years, of an appropriate share of the construction costs incurred in the construction of the Scheme." The Scheme and the enacted law described below initiated Jordan's attention to water management in the Jordan Valley. A parallel law, which established the Central Water Authority in 1959, focused attention on water management outside the Jordan Valley.

2.2.1. Legal provisions

To mobilize the Scheme, a law was enacted in February 1959 that provided for the establishment of an "East Ghor Canal Authority" to be in charge of the Project's implementation, operation and maintenance. That was Law no. 14 for

[4] Ghor is the Arabic word for the low lands of the Jordan Valley; it is used interchangeably with "the Jordan Valley".

[5] For the Aide Memoire of the United States Charge d' Affairs in Jordan and the response of the Jordanian Foreign Minister on 25 February 1958, see Haddadin (2001: 143–144).

the year 1959, famous for its land reform provisions which allowed for land expropriation and partitioning in accordance with irrigation requirements. It also had land re-distribution provisions, whereby some irrigated farms were provided to the land owners on a sliding scale basis, and others to landless farmers. The land reform provisions were the first of their kind since the establishment of the Emirate of Transjordan in 1921.

2.2.2. Social and political grounds

The East Ghor Canal Law was a first in its substance and ideology. It came at the time when land reform laws were enacted under the neighboring "revolutionary" regimes of Egypt, Syria and Iraq. It was different in many ways than the laws passed in these countries, and consequently more successful. There were certain political and social grounds that formed the base for that Jordanian law number 14 for the year 1959.

The land reform concept was unprecedented in Jordan. To have the law enacted, the Government had to lobby with the powerful tribal and social leaders in the Jordan Valley. The Prime Minister held sessions with those leaders and informed them that their unproductive, yet arable, lands in the Jordan Valley would be transformed to be productive lands through irrigation. He emphasized that the irrigation networks would be built by the government, and there would be social and economic returns for the Government from this undertaking. In a sense, the government would be a partner to the land owners in their ownership of the lands made productive through state investment in irrigation infrastructure. The social leaders resented this notion and did not condone the expropriation of property for any reason, as the new law would allow.[6] Despite their objections, however, the fact remained that Jordan was technically under Emergency Law, making the Prime Minister the supreme military governor.[7] In that capacity, he was able to pass the law without overt public protests.

The social grounds for the development of the Jordan Valley were rooted in the notion of partnership between the state and the land owners, whereby the state would bear the cost of irrigation infrastructure. Through that partnership, the landowners would relinquish part of their ownership to the state, allowing it to redistribute land to landless farmers. However, the recipients of irrigated

[6] Conversation on 12 December 2008 between the author and Mr. Nimr Zeinati, the son of one of the social leaders consulted on the matter. Nimr was appointed member of a committee to lobby the public in the Jordan Valley to accept the provisions of land reform. He speaks of the TVA law the first draft of the Unified Plan for the Development of the Jordan Valley that was worked out by the consultants Chas T. Main as a subcontractor for the Tennessee Valley Authority (TVA). That was on account of a consulting assignment made by UNRWA to TVA to prepare a plan for the development of the Jordan Valley, and it was the first draft that Eric Johnston carried to the region as his proposal for a Unified Plan.

[7] Jordan came under Emergency Law in the wake of a military coup attempt in April 1957. The Emergency Law was lifted in 1989 when the King announced that Jordan would enter a new era of democracy and a return to the Constitution was declared.

farms paid for irrigation rights at the rate of JD 40 ($120) per dunum of irrigated land.

In the process of bringing the lands into productivity, the Government created tremendous job opportunities in the Jordan Valley. People came from all over the country to take jobs as construction workers. Surveyors, equipment operators, engineers, supervisors, etc. were also recruited from across the nation. The jobs in agricultural production and supporting services were snatched up mainly by Jordan Valley residents, many of them Palestinian refugees.

The political grounds were clear. The desire of the US to support the development of the Jordan Valley was conditioned on two provisions:

- Provision 1: That Jordan would not draw from the Yarmouk River more water than allocated to it under the Unified (Johnston) Plan, thus enforcing the provisions of the said Plan on whomever needed American support.
- Provision 2: That a law would be enacted in Jordan to open a window for the Palestinian refugees to resettle in the Jordan Valley, either by owning land or by working and maintaining an acceptable standard of living. The major population centers of Palestinian refugees in the Jordan Valley were at Rawda, Karama, Khazma, Kreiymeh, Waqqas and North Shuna.

These two provisions were pivotal in American policy regarding the Jordan River basin. The resettlement of Palestinian refugees in the Jordan Valley was an important card in the hands of Eric Johnston, used to convince Israeli leaders to agree to the Jordan Valley Plan during his shuttle diplomacy (1953–1955).

The US had other political interests in contributing to Jordan's development aspirations in that it kept Jordan away from approaching the Soviet Union. At the time, it was very popular in the eyes of Arabs to be in alliance with the Soviets, and Egypt, Syria and Iraq were strongly leaning toward doing so. The Arabs blamed the West for the catastrophe it befell the Palestinians, seeing the event as rooted in the Balfour Declaration of 1917, wherein the Foreign Minister of the UK, Lord Balfour, stated that the Government of His Majesty views with favor the establishment of a National Home for the Jews in Palestine. Nevertheless, keeping allies in the Middle East was important for the US. As the leader of the Free World in the Cold War era, the US had to fight to defend newly independent colonies of the French in Indo China and the British in South Asia and the Middle East against communism.

2.2.3. Land redistribution provisions

As mentioned above, the East Ghor Canal Law number 14 for the year 1959 carried provisions that were unprecedented in the history of the Kingdom. It had articles for land redistribution such that the newly-created East Ghor Canal Authority would be able to expropriate the lands in the Jordan Valley, set up committees for appraisal of values of lands thus expropriated and transform the assets of landowners into capital monetary values recorded in official records as capital assets credited to their owners. Table 1 shows land ownership in dunums before and after reallocation under the new law, as decided by the East Ghor Canal Authority. It excludes those owners who had developed their lands in orchards before the Project, who were allowed to keep their orchards with the consent of the Council of Ministers.

TABLE 1. Land Ownership Before and After Reallocation Under Law No. 14 of 1956

Ownership of non-irrigated land (dunums)	**Share in reallocation (dunums)**
40–50	Entire area
51–100	50 plus 25% of the area in excess of 50
101–500	62 plus 17% of the area in excess of 100
501–1,000	130 plus 12% of the area in excess of 500
1,001+	200

Evidently, applying the above criterion to the land owners would leave arable lands over and above the share allocated to them. The East Ghor Canal Authority, operating through committees formed in accordance with the Law, would be free to allocate that land and the land registered in the name of the Treasury to landless resident farmers. The capital cost of such lands would have to be repaid by the new land owners over a 20 year period at an interest rate of 5%. The land owners who gave up lands by virtue of the above land redistribution formula were entitled to financial compensation over a 10 year period with the same interest rate of 5%.

The political and social repercussions of the land redistribution provisions of the Law were unprecedented. The provisions left ample opportunities for landless farmers to be allocated arable irrigated lands under the Project. It has to be recalled that those Palestinian refugees in the northern part of the Jordan Valley (North Shuna, Waqqas) where the Project would start were originally from across the Jordan River in Beit Shean, a city that became part of Israel in 1948. They were considered absentee landowners in their hometown, where a law was passed enabling the State of Israel to acquire their property.

2.2.4. Water management in the Jordan Valley

The Project enabled Jordan to tap its water share of the Yarmouk River and to utilize the flows of the eastern side wadis. The water was diverted from the Yarmouk River via a drop inlet and an approach canal that delivered the water to a tunnel 1 km in length. The tunnel sees daylight at the beginning of the East Ghor Canal which carries water for a distance of 110.5 km. The flow from side wadis discharges into the Canal. It was built in stages between 1960 and 1988. Between 1960 and 1967 Jordan brought under irrigation a total of 12,200 ha using water from the Yarmouk and the side wadis. The annual average inflow into the East Ghor Canal (later renamed King Abdallah Canal) from the Yarmouk was in the order of 120 million cubic meters, close to one third of the Kingdom's share in that river. The Canal dropped down 4 m near its northern end, near the town of Adassiya, providing two advantages. First, it enabled the gravity flow of water from Lake Tiberias to the Canal. Second, the Canal alignment followed the flatter terrain along the Jordan Valley thus reducing the otherwise high construction cost of making deep cuts in rocky mountains. The remainder of Jordan's shares in international waters awaited: (a) the construction of a dam at Maqarin to regulate the flood water and a diversion weir on the river at Adassiya that would enable the diversion of Yarmouk flow into the East Ghor Canal simultaneously allowing the flow of Israel's share downstream and, (b) an arrangement with Israel to release 100 MCM of water annually from Lake Tiberias to the East Ghor Canal at the drop near Adassiya. Unfortunately, neither step was politically possible because of the absence of mutual political recognition between Jordan and Israel, so Jordan had to amend the irrigation infrastructure plan.[8] A dam was built on the Zarqa River that had a capacity of 82 MCM by 1987. The combination of the water from this project and the winter water diverted from the Yarmouk made the resources available to irrigate an additional 6,000 ha in 1979.

The irrigation networks built in the initial stages of the Scheme until 1968 were concrete-lined canals. In some areas, the topography was such that they were placed below arable lands, which were therefore left un-irrigated. On-farm irrigation methods included traditional surface irrigation methods of flood irrigation, furrow irrigation or basin irrigation. Prompted by the need to boost irrigation efficiency and increase agricultural production per unit flow, Jordan followed a plan to convert the irrigation water distribution networks from concrete-lined surface canals to buried pipe networks operating under gravity generated pressure and under pumped heads.[9] The pressure head enabled the irrigation of lands that were located above the surface canals. The farmers responded by adopting modern irrigation methods on their farms and water use efficiency was highly improved. Nevertheless, Jordan faced a new challenge when Syria increased its withdrawal from the upper Yarmouk, resulting in diminished flows downstream. By 2006, the flow of the Yarmouk at Adassiya had dropped to about one third of its average summer flow. In August of 1963,

[8] A Master Plan for the Jordan Valley was formulated by the consulting engineering firms, Michael Baker Inc., and Harza Engineering Company in 1955. The Plan did not envisage a dam on the Zarqa River. Jordan, in absence of a dam at Maqarin on the Yarmouk, decided to have a dam built on the Zarqa River. It was completed in 1977 and raised in 1984.

[9] Credit goes to the late Dr. Guy Lemoigne who headed a World Bank Mission to Jordan in 1973 to appraise an irrigation project proposed for finance by IDA in the northern Jordan Valley. He convinced the Chairman of the Jordan Valley Commission, Mr. Omar Abdallah Dokhgan, to change the designs that were completed for the 18 km extension of the East Ghor Canal from concrete lined canals to pressure pipe networks.

that flow measured 6.5 m^3/s. It had dropped down to 2.1m^3/s in August 2005. The Jordan Valley has been witnessing water shortages despite the much-improved irrigation efficiency.

Water management in the Jordan Valley was thus institutionalized through the mandate given to the East Ghor Canal Authority (1959–1965) and its successors, the Natural Resources Authority (1965–1977) and the Jordan Valley Authority (1977–present). The physical works were manifested in the infrastructure of the East Ghor Canal and its distribution pipe networks, and the administration and human resources were manifested by the government institutions in charge.

2.2.5. The valley shares water resources with urban Jordan

In 1978, a study commissioned by the National Planning Council and performed by a British consulting firm indicated the size of need for municipal and industrial water in North Jordan, where 90% of the population resided. It predicted that roughly 280 MCM of additional water needed to be mobilized in order to meet that need in 2000. The results of the study stunned officials. The King summoned a high-level meeting in which a decision was made to allocate 120 MCM of Jordan Valley water resources per year, and to approach Iraq for the balance (160 MCM). Projects were designed and built to supply Amman with water from the East Ghor Canal at the rate of 90 MCM/year, and another project was implemented to supply Irbid with water from Wadi Arab at the rate of 20 MCM/year. It was thought that more water would become available after the construction of the Maqarin/Wehda dam. In that same meeting, it was decided that the municipal effluent in the Zarqa River catchment should be treated and reused it in the Jordan Valley for irrigation. Thus, treated wastewater was officially introduced as an irrigation water resource. It had been used in irrigation at a modest scale since 1968 when the first wastewater treatment plant for Amman went into operation.

It should be mentioned that the allocation to Amman and Irbid coupled with the increased Syrian abstractions jeopardized the irrigated agriculture in the Jordan Valley. There exists today about 6,000 ha of arable lands in the Valley with functional irrigation infrastructure, but with no irrigation water. Such shortages are pressing farmers in these once-irrigated areas to leave parts of their farms fallow and even to cut some perennial crops.

2.3. A SHIFT IN THE MASTER PLAN

Israel continued to implement its National Water Carrier project, stretching from the south to the north toward Lake Tiberias. In 1962, The United States found a way to provide financial assistance to Israel for the project without causing a stir. Grants were awarded to an Israeli agricultural fund, and the contributions were then covertly diverted to the construction of the National Water Carrier. Nasser of Egypt called an Arab Summit meeting in Cairo in January 1964 to deliberate on what kind of Arab reaction should be adopted to counter the Israeli project that aimed to divert a share of the Upper Jordan flow to the Negev.

The Arab leaders decided on a separate project that would guarantee their shares of water in the Jordan basin without the need to cooperate or coordinate with Israel. The Arab Plan called for the diversion of part of the flows of the Hasbani, the Banyas and the Yarmouk to Arab lands. The Yarmouk would be regulated by a dam at Mukheiba downstream of Maqarin, and a tunnel would divert the Yarmouk water to the adjacent Wadi Arab whence water would be released to the East Ghor Canal. The share in the Upper Jordan, due to be destined to the West Bank via the East Ghor Canal, would thus be guaranteed to flow to it from the Yarmouk Mukheiba dam. Construction activities started in 1965, but the Arab Plan was aborted by the June War of 1967.

2.4. A SHIFT IN THE MODE OF JORDAN VALLEY DEVELOPMENT

The development of the Jordan Valley started in 1959 with the construction of the East Ghor Canal, which proceeded in stages until it crossed the Zarqa River via a siphon. A total of 11,400 ha were brought under perennial irrigation in 1967 plus 800 ha were irrigated only in winter. The Canal and the distribution networks were financed by grants from the United States of America that totaled $12 million.

Until 1967, the Jordan Valley development had focused on irrigation. The infrastructure needed for the population did not go hand in hand with the irrigation development. The East Ghor Canal Authority had a mandate to build the irrigation works, redistribute the farm lands and to operate and maintain the irrigation infrastructure. Production of fruits and vegetables from the Valley supplied the local markets and surpluses were exported to neighboring countries, primarily Syria and Lebanon.

The development process was interrupted by the June War of 1967. The West Bank of Jordan was occupied and the Jordan Valley itself became a theater for hostile operations conducted by Palestinian paramilitary organizations against Israel. Israel responded to these attacks with artillery fire and bombings. The peak of the confrontations occurred on 22 March 1968, when Israeli armored columns crossed the Jordan River and attacked the refugee camp of Karama in the Jordan Valley. The unstable situation in the Valley continued until June of 1971, when the Jordanian Army restored law and order and the Palestinian military factions left the country for Lebanon.

Rehabilitation and further development of the Jordan Valley resumed in 1973, in accordance with a new social and economic development plan. The emerging trend in development was the integration of economic and social development. A Jordan Valley Commission was established by Law number 2 for the year 1973 and was entrusted with the planning and implementation of the plans for the rehabilitation and development of the Jordan Valley. Operation and maintenance of the works was left to the corresponding government agency. The Commission relied on staff from other government organizations to execute its tasks. Later, the Commission was transformed into a Jordan Valley Authority, established by Law number 18 for the year 1977, and was authorized to build its own human resources capacity to deal with its various responsibilities, including retaining the responsibilities of operation and maintenance of water works in the Jordan Valley.

A major objective of the integrated development plan for the Jordan Valley was to bring back the Jordanian population that had left it during the turbulent years (1967–1971). It further aimed at attracting more people to the Valley by creating job opportunities. The economic objective was to maximize the agricultural production and assist in developing the services sector. Projects were identified to expand the irrigated area, increase the irrigation efficiency by adopting pipe irrigation networks and advanced on-farm irrigation systems. 9,300 ha were to be brought under perennial irrigation as a first stage under the plan (1973–1980). The second stage (1980–1990) was to bring the balance of arable land under irrigation.

Parallel projects aimed to create a Valley community that could achieve a decent standard of living. Social infrastructure projects were designed to: (a) prepare plans for towns and villages, (b) supply these population centers with amenities needed by a developing community, (c) build elementary, preparatory and secondary schools, and a vocational training center, (d) link the Valley to the national electricity grid and to the telecommunications network, (e) supply clean domestic water to all the population centers, (f) build four grading, packing and agricultural marketing centers, (g) administer a housing fund to extend loans to families to build their houses, (h) redistribute the parceled lands within the limits of the population centers to owners and to landless residents, (i) build government buildings to house government departments, (j) build clinics and health centers to provide preventive and curative health services, (k) build main highway and farm-to-market all-weather roads and streets and parking lots, (l) organize the farmers into a Farmers' Association whose officers will be elected freely, (m) organize the municipal arrangements for the Valley communities.

The Valley witnessed a boom of development in all fields. Under the Jordan Valley Authority, there was direct public sector involvement in building infrastructure. Financing of infrastructure projects was shared between the Jordan Government and a score of donor institutions in friendly countries. USAID was the leading donor, followed by the Kreditanstalt Fuer Wiederaufbau (KFW) the Kuwait Fund for Arab Economic Development, The Saudi Fund, the Abu Dhabi

Fund, The Overseas Economic Cooperation Fund (OECF) of Japan, the government of the Netherlands, the government of Italy, The Overseas Development Administration of the UK, the IDA of the World Bank Group, and the Arab Fund for Economic and Social Development.

The contribution of the private sector was led by farmers who undertook the on-farm development in modern irrigation systems and agricultural practices. The Jordan Valley Authority encouraged a housing boom by building about 2,000 domestic units and making funds available for the Housing Bank to re-lend to interested Valley residents to build their houses. Residents who did not own land within villages were allocated building plots to build their homes with loans advanced by the Housing Bank, the agent of the JVA. The business environment improved and the population was growing. There were immense economic and social benefits that accrued from the Jordan Valley integrated development approach.[10] The per capita income increased to match the national average by 1986, and various social development indicators improved: the life expectancy at birth rose from 46 in 1950 to 70 in 1986, child morbidity mortality rates fell, more women entered into the labor market, literacy rates improved, and many cultural and traditional habits transformed to the better.

2.5. POLITICAL IMPLICATIONS OF THE JORDAN VALLEY DEVELOPMENT

The development of the Jordan Valley relied heavily on the Yarmouk River water. The Kingdom's share in it was set at the residual flow after deducting 90 MCM/year for Syria and 25 MCM/year for Israel. That residual flow was estimated at 377 MCM/year, split between the East Bank and the West Bank at 296 and 81 MCM, respectively.

Israel was able to block Jordan's intentions to build a diversion dam across the Yarmouk that would facilitate diversion of its share to the East Ghor Canal. As far back as 1961, Israel aborted all Jordan's attempts to build even a "lip" that protrudes into the river, claiming that such a construction would give Jordan a military advantage. Jordan therefore built a "drop inlet" and a short intake canal to divert the water to its territory. The absence of a diversion structure and of a storage facility at Maqarin made the flow past the Jordan intake canal exceed Israel's share many folds, especially in winter months. Israel benefited from this fact and pumped as much water as it could directly use and more to store in Lake Tiberias.

The situation with Israel over water was rectified during the Israel–Jordan peace talks and Annex II of the 1994 treaty – Water Related Matters. Israel's share in the Yarmouk was set at 25 MCM, down from the 95 MCM it had been

[10] For details of Jordan Valley development benefits see Haddadin (2006).

using, and a diversion structure was built across the Yarmouk to regulate diversion of water to the two nations.

Syria is the upstream riparian on the Yarmouk, and therefore technically has the power to take water in excess of its allocated share if it so desires. Starting in 1967, Syria started the construction of dams on the Yarmouk tributaries with the Dara'a dam on the Wadi Zaydi tributary. By 1987, it had a total of 26 dams on the Yarkouk tributaries. In 1988, a new treaty was signed between Syria and Jordan over the Yarmouk, whereby Syria was entitled to both the original share of 90 MCM (the flow of the springs in its territories above 250 m above sea level) and the water impounded by the 26 dams. This, however, did not convince Syria to abide by the new treaty and it continued building earth dams on the tributaries. Their number reached 42 by the year 2005.

In addition to violating the terms of both the 1953 treaty and the 1988 treaty, Syria expanded the use of groundwater in the Yarmouk basin. This negatively impacted the base flow of the river such that it diminished to one third of its flow back in 1963. Overall, it is estimated that Syria is now (2008) using about 300 MCM/year compared to its allocated share of 90 MCM.

Jordan's attempts to build a dam at Maqarin were aborted, first by Israel in 1953, and then by both Israel and Syria from 1977 to 1994. Neither of these two co-riparians would gain much by building the dam. When Israel occupied the Golan Heights in 1967, it gained control of the northern bank of the Yarmouk as far east as Wadi Raqqad. This enhanced its role in stalling the dam construction, for no diversion structure could be built across the Yarmouk on that stretch without its consent.

Jordan exercised active diplomacy with Syria between 1975 and 1981, then again between 1986 and 2000. With Israel, Jordan could not follow a similar path because of the "state of war" that prevailed between the two countries from 1948 to 1994. Jordan called on the United Nations Truce Supervision Organization (UNTSO) and on the good offices of the United States to help settle differences with Israel through supervised meetings. Many such meetings were held between 1979 and 1993 to have the division of the Yarmouk flow between Jordan and Israel adjusted.

Because the Maqarin/Wehda dam was stalled and the need for water in the Jordan Valley increased, Jordan decided to use a depression in the Jordan Valley to store flood water from the Yarmouk by channeling it through the East Ghor Canal. The Karama Dam on Wadi Mallaha was completed in 1997 with capacity of 55 MCM. The winter flow of the Yarmouk receded by virtue of the many Syrian dams in the catchment, and that dam was filled only once.

Finally, the dam at Maqarin (renamed Wehda Dam in 1987) was built and completed in 2006, while the diversion structure on the Yarmouk at Adasiyya was built and completed in 2000. However, the increased Syrian diversions of all the Yarmouk tributaries and its intensive groundwater use left the Wehda

Dam with little water to impound. Climate change may also have an effect on the reduced Yarmouk flows, but this has to be verified.

2.6. CURRENT STATUS OF POLITICAL/LEGAL SITUATION IN THE JORDAN RIVER BASIN

The current status of the political/legal situation in the Jordan River basin is much improved compared to the environment prior to the conclusion of the Jordan–Israel 1994 Peace Treaty. There is a Joint Water Committee (Peace Treaty, 1994) that meets periodically and as needed. It has two subcommittees, one dealing with the Jordan River Valley and another with Wadi Araba. Cooperation is reported to be well despite the cold relations in most other fields stipulated in the Peace Treaty.

Jordan's disengagement of legal and administrative ties with the West Bank in 1988 left a good portion of the "Jordanian" shares in the Jordan basin as defined in 1955 outside Jordan's jurisdiction. Jordan therefore did not include the "Palestinian" water shares in its negotiations with Israel. Those shares are to be negotiated by the Palestinians in their Final Status negotiations with Israel.

The negotiation process with Syria is still dragging on. Syria is not heading Jordan's complaints about its excessive uses of the Yarmouk waters, though there have been several high-level meetings between Jordanian and Syrian officials on the subject. The two sides agreed to have a study conducted by each to determine the causes of the recession of the Yarmouk flow. These studies have been tendered in the two countries and are due to be completed in 2009.

The status of agreements between Lebanon and Israel is unchanged. Israel waged war against Hezbullah in 2006, destroying much of Lebanon's infrastructure. The relationship between the two countries is still tense. Lebanon has been using a fraction of its share in the Hasbani, and almost nothing of the groundwater that underlies southern Lebanon and northern Israel. The two countries will have to settle their water disputes in the context of peace negotiations.

The status of the water relationship between Syria and Israel is a function of the progress, or lack thereof, in their indirect peace talks mediated by Turkey. Again, Syria has exceeded its share in the Yarmouk, but is denied its shares in the Banyas and the Upper Jordan because of Israel's occupation of the Golan. The water disputes have to be resolved in the context of a Syrian–Israeli peace treaty.

3. Recession of the Dead Sea Level

3.1. CAUSES

Three of the riparian parties to the Jordan River basin initiated and expanded unilateral water projects drawing from the basin. Israel implemented irrigation projects in the part of the Jordan River Valley under its jurisdiction, and dried the Hula swamps thus saving about 65 MCM/year of water that was lost to evaporation. Israel further started pumping water from Lake Tiberias into its National Water Carrier, sending Jordan River water all the way to the Negev. Jordan initiated its East Ghor Canal project, drawing water from the Yarmouk and from the East Side Wadis of the basin. It further implemented projects that drew water from Dead Sea side wadis and diverted them for use in agricultural, industrial and municipal purposes. Syria implemented irrigation projects in the eastern Golan and western Horan plains, drawing water from the springs that fed the base flow of the Yarmouk and from dams that were built on the Yarmouk tributaries. Syrian private projects also pumped ground water from the aquifer that fed the Yarmouk base flow, and directly from the river in its gorge. Lebanon implemented irrigation projects in the Hasbani gorge and lately (2002) drew water from the Wazzani springs to serve some villages in Lebanon's south.

The activities of these riparian parties diverted water away from its natural terminus – the Dead Sea. The flow of the Jordan River is a trickle of its former self, consisting mostly of the return flow from agricultural activities in the basin, especially in the dry months. Today, it is estimated that an average of about 200 MCM/year flows into the Dead Sea, down from about 1,600 MCM. Needless to say, the water level there is dropping at an alarming rate.

At the same time, industrial activity at the Dead Sea is also contributing to its decline. Prior to the establishment of the State of Israel, the government of the British Mandate over Palestine granted a concession in 1933 to a company of the Jewish Agency, the Dead Sea Works, to extract minerals from the Dead Sea. That company initially drew fresh water from Wadi Hasa in Jordan before the supply was terminated in the wake of the 1948 war. The Wadi Hasa discharges directly into the Dead Sea. The Dead Sea Works then adopted the technology that depended on evaporation pans to increase the density of the sea water and induce precipitation of Dead Sea salts before they are harvested and processed further. The Dead Sea Works expanded its activities after the State of Israel was proclaimed in 1948.

Likewise, Jordan granted concession in 1956 to the Arab Potash Company to exploit the minerals of the Dead Sea. The company implemented its project to extract potassium chloride from the Dead Sea in 1981. Other activities include the extraction of sodium chloride and bromine. Like Israel, Jordan adopted the technology of evaporation pans to induce precipitation before harvesting of salts. The combined activities of Israel since 1933 and Jordan since 1981 resulted in more evaporation losses from the Dead Sea than the natural evaporation rate would normally induce.

The reduction in water inflow into the Dead Sea coupled with increase evaporation from it by industrial activities resulted in a recession of the level of the sea at about 1 m/year. In parts of the shore that are flat, the Dead Sea water has receded for appreciable distances away from resorts that were coastal back in 1960.

3.2. CONSEQUENCES

The consequences of the Dead Sea recession on the local, and eventually regional, environment cannot be ignored. There are and will continue to be impacts affecting local temperatures, humidity, and air and wind circulation. The changes also impact the drainage of nearby groundwater aquifers, which are more prominent on the east side of the Dead Sea. At the physical connections between those aquifers and the Dead Sea, a balance had been reached between the driving head of the inflow and the constraining head of Dead Sea water above the fishers through which the freshwater of the aquifers flows. As the Dead Sea level recedes, so does the constraining head, and inflow of the freshwater resumes until another balance is reached. With the continuous recession of the sea level, however, a new state of balance is extremely difficult to achieve.

The velocity of water inflow toward the Dead Sea increases as the sea level declines further because the hydraulic gradient increases. The result is an increase in the kinetic energy of the subsurface water flow, which is proportional with the square of the velocity of flow. The increased energy has started to erode subsurface salt layers close to the sea, leading to the formation of dangerous sinkhole development since the mid-1980s. The sinkholes are sizeable, ranging between 15 and 25 m in diameter and between 4 to 7 m in depth. Their occurrence is sudden and is unpredictable. Several such sinkholes occurred on the Jordanian side, affecting farmland and some infrastructure. Others have also occurred on the Israeli side, threatening valuable tourist infrastructure. The abrupt occurrence of the sinkholes cannot be allowed to continue.

The Dead Sea industrial activities on both the Israeli and Jordanian sides cannot be terminated. They have created thousands of jobs and the local communities benefit from their existence. They are foreign currency earners and the added value in the products is high.

3.3. MITIGATING THE NEGATIVE IMPACTS

Neither the cessation of the utilization of the freshwater resources nor the termination of the industrial extraction of the Dead Sea salts is a viable option to mitigate the damages they incur. Both activities have induced the development, growth and progress of communities in Jordan, Israel and Syria. Any cessation of water diversion will upset the population settlement in the developed areas. People will have to migrate out of their current locations mostly to seek jobs in urban areas with all the potential social and economic problems associated with such transfer. The Jordan River south of Lake Tiberias has been transformed into a drain for agricultural return flow where the salinity is high, especially in the dry months when it reaches about 3,500 ppm total dissolved solids. Furthermore, the Dead Sea receding level induces the loss of valuable freshwater from adjacent aquifers and causes the damages detailed above.

To mitigate the adverse impacts on the Jordan River without terminating the uses of the basin's water entails very high costs. Available drainage water can be desalinated and additional desalination of sea water, piped from the Mediterranean across Marj Ibn Amer and the Jezreel Valley toward Beisan, can be added. Brine can be pumped to brine beds along the escarpment where evaporation will leave residual salts from which minerals can be extracted.

The recession of the Dead Sea level might also be mitigated by linking it to the Red Sea at Aqaba. By this linkage, the Dead Sea will receive brine of desalinated sea water piped and channeled from the Red Sea to stabilize its level at 396 m below sea level. The project will further generate desalinated water badly needed by the riparian parties as well as some electricity. Such linkage has been envisaged within a more comprehensive social and economic development plan for the Jordan Rift Valley.[11] The Plan was presented to the Trilateral Economic Committee.[12] The Plan was approved and was promoted by the Committee to proceed. On August 31, 1994, the parties authorized the World Bank, to act on their behalf as the owner of the project, and to contract consulting engineering works to conduct a pre-feasibility study of the Plan. Funds were raised from the U.S Trade Development Agency and the pre-feasibility study was completed in 1998. Later in 2008, the World Bank, with the consent of the riparian parties, awarded two contracts to study the economic feasibility and the social and environmental feasibility of the Red Sea–Dead Sea linkage. The study is now underway, and expected to finish by the early fall of 2010.

4. Conclusion

The chapter elaborated the political and social dynamics involved in the development of the Jordan River Valley within the Hashemite Kingdom of Jordan. This history shows a persistent battle with uncooperative neighbors over shared water resources within the Jordan River basin (especially over a rightful share of the Yarmouk River), in order to support the backbone of this development: irrigated agriculture. Various policies and measures for water management were formulated and implemented, from political water sharing agreements, to the treatment and re-use of municipal wastewater, to the development of more

[11] The "Concept Paper" for such a plan including the Red–Dead linkage was authored by the writer and endorsed by the Jordan Cabinet in February 1994. The writer then, as member of the Jordan delegation to the Trilateral Economic Committee, presented it to the Trilateral Economic Committee on February 24th, 1994 at the U.S. State Department.

[12] The Trilateral Economic Committee was established in October of 1993 in the wake of the Oslo Accord, and consists of the United States as Chair and both Israel and Jordan as members.

efficient irrigation networks and on-farm irrigation systems. The integrated development of the Jordan Valley achieved successes in social and economic development.

Nevertheless, the current status of the Jordan River basin is far from stable, and the prospects for its future certainly seem dim. After years of unilateral water use by the various basin co-riparians, with little regard for water sharing agreements, the Lower Jordan south of Lake Tiberias has been rendered an agricultural drainage course. The consumptive uses of the river's headwaters have reduced the inflow of water into the Dead Sea to a fraction of what it used to be before development. Furthermore, Israel and Jordan's industrial exploitation of the Dead Sea minerals through evaporation pans has increased the evaporation from the Dead Sea. The combination of reduced inflow and increased evaporation has resulted into the recession of its level at a rate of 1 m a year. This has had serious consequences, including freshwater inflow from adjacent aquifers and the formation of sinkholes.

To mitigate the adverse impacts of the consumptive use of the Jordan River waters and the Dead Sea recession, costly projects are proposed. Desalination of the existing flow of the Jordan, along with the desalination of Mediterranean water, could help in environmental rehabilitation of the Jordan River, and the linkage of the Dead Sea with the Red Sea at Aqaba could mitigate the recession of the Dead Sea. Both proposals are costly and require careful examination of their impacts. The economic, social and environmental feasibility study for the Red–Dead linkage has already begun and will be completed in the early fall of 2010.

References

Haddadin, M.J., 2001. *Diplomacy on the Jordan: International Conflict and Negotiated Resolution*, Kluwer, Norwell, MA.

Haddadin, M.J., ed., 2006. *Water Resources in Jordan: Evolving Policies for Development, the Environment and Conflict Resolution*, Resources for the Future Press, Washington, DC.

Jordan–Israel Peace Treaty, 1994. "Annex II – Water Related Matters," Article VII, Jordanian Ministry of Foreign Affairs, Amman, Jordan.

Jordan Valley Plan, 1955. Appendix 3, in: *Diplomacy on the Jordan: International Conflict and Negotiated Resolution*, M. Haddadin, Kluwer, Norwell, MA, 2001, pp. 461–477.

Ministry of Planning, 1958. *Project Agreement for the East Ghor Canal*, an agreement concluded between the Jordan Development Board and the ICA, Amman, Jordan.

Stevens, G., 1956. The Jordan River Valley, in: *Diplomacy on the Jordan: International Conflict and Negotiated Resolution*, M. Haddadin, Kluwer, Norwell, MA, 2001, p. 29.

MANAGING JORDAN'S WATER BUDGET: PROVIDING FOR PAST, PRESENT AND FUTURE NEEDS

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Abstract: Jordan faces continuing growth in water demand, far outstripping its limited renewable resources. Significant efforts have been deployed by the government to maximize the capture of surface water and groundwater, and to develop non-conventional sources such as brackish groundwater, fossil groundwater and treated wastewater. However, with agricultural requirements remaining at over 60% of the total water budget of the country, there is currently (in 2005) a deficit of 461 million cubic meters (MCM)/year out of a total annual requirement of 1,546 MCM. This deficit is met partially by significant over-abstraction of groundwater, leading to the depletion and salinization of the aquifers, and also by undersupplying the demand from the municipal sector and agriculture. While attempting to address water demand, improve supply efficiency in all sectors and increase the use of treated wastewater, Jordan has its hopes for the future pinned on the development of new sources – the transfer of fossil groundwater from the Disi field to Amman in the medium term, and a Red Sea–Dead Sea Conveyance providing desalinated water in the long term. However, such new sources will be expensive, and until they are developed, significant reductions in water supplied to the agricultural sector will be necessary if continued over-exploitation of the aquifers is to be avoided.

This paper traces the growth in water demand in Jordan, and sets out the current supply and demand projections using publicly available figures from the National Water Master Plan 2004 and other public sources. The problems arising from addressing the water deficit are discussed. The measures taken by Jordan to date are described, and the need for additional steps to be taken to deal with the future deficits is highlighted.

Keywords: Water supply; water demand; water resources; water management; water policy

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1. Jordan: The Physical Context

1.1. GEOGRAPHY

The geography of Jordan can be thought of in three zones – (i) the highlands, (ii) the rift valley, and (iii) the steppe. The highlands stretch from the Yarmouk River valley on the northern border, to Ras al-Naqab in the south. Elevation above sea level varies rises to almost 1,800 m in the southern highlands. The settled population of the area historically occupied the highlands, which today include most of the main towns and cities of the country.

To the west, the highlands fall off and descend steeply into the rift valley, which runs along the Jordan River valley from Lake Tiberias/Kinneret in the north, through the Dead Sea basin, and into the Wadi Araba/Arava, until it meets the Gulf of Aqaba in the south. Elevation at the Dead Sea is currently 421 m below sea level. The plain alongside the Jordan River hosts a number of villages and small towns, and is used today for irrigated agriculture. There are also villages in the Southern Ghors area at the south of the Dead Sea basin, whose livelihoods include the Dead Sea industries and irrigated agriculture. The population of the Jordanian side of Wadi Araba is very small, with some small villages of settled Bedouin tribes.

The steppe stretches eastwards as the highlands fall off more gently, and continues across today's border until it meets the Euphrates valley in Iraq. The Jordanian steppe has some groundwater resources (notably in the Azraq basin and in the Wadi Sirhan) but supports only a handful of smaller towns and settlements.

1.2. RENEWABLE WATER RESOURCES[1]

Jordan's existing water resources can be understood in relation to its geography. Annual average rainfall across the country varies greatly, from 600 mm in the northern highlands around Ajloun, 250 mm in the Jordan Valley, 100 mm in parts of the northeastern steppe (the *badia*), to less than 50 mm in the southeastern steppe. The total annual rainfall over the kingdom can vary between 6,000 and 12,000 MCM, but averages around 8,200 MCM/year over the long term. More than 80% of this is lost through evaporation and around 10% is retained in the soil. Around 395 MCM/year infiltrates into the aquifers that underlie most of the country, and the rest is surface run off. There are generally considered to be 12 main groundwater basins, the northern ones being shared with Syria, and providing a net inflow of around 70 MCM/year into Jordanian territory. The Disi aquifer is a non-renewable aquifer and is shared with Saudi Arabia.

[1] There are various data sets on Jordan's water resources. For consistency, the resource and supply data used here is taken from the National Water Master Plan, MWI, 2004.

Groundwater quality varies greatly; the saline levels in abstracted groundwater vary from between 170 ppm to over 3,000 ppm.

Jordan's two main river systems are shared – the Yarmouk is shared with Syria and Israel, and the Lower Jordan is shared with Israel and the Palestinian Territory. The Jordan is fed partially by the Yarmouk, and also from the spill from Lake Tiberias in northern Israel. On the Jordanian side, the river Jordan was historically fed by nine main side wadis, the largest being the Zarqa river. Most of Jordan's surface water runoff drains into the Dead Sea basin, either via the Yarmouk or Jordan rivers, or directly through the side-wadis. Some drains directly into the Gulf of Aqaba, mainly from the Wadi Yutum and southern Wadi Araba. Catchments in the centre of the country have no sea outlet, and sink to the aquifers or drain into mud flats and evaporate.

Taking all this into account, Jordan has a theoretical annual long-term average renewable supply of up to 800–850 MCM although this fluctuates between wet and dry years. This figure includes surface water which can be captured by dams, renewable groundwater – in an average year, the maximum amount of groundwater that can be sustainably abstracted is reckoned to be 275 MCM, with an additional 220 MCM available from springs – and also an allowance from the shared Yarmouk catchment.[2] However, not all of this total quantity can be economically captured.[3]

2. Meeting the Growth in Water Demand

When the borders of the state were drawn, water was not one of the major influencing factors. The population was only around 225,000 in 1922, most of which lived in the 'settled zone' around the highlands, west of the Hijaz Railway line and close to the rain-fed agricultural lands. One problem for the early state was the loss of most of the Wadi Sirhan water resources (15 out of 60 wells) to Saudi Arabia which disturbed the traditional winter pasturing, and made life more difficult for the nomadic tribes (Dodge and Tell, 1996). Almost all agriculture was rain fed. The Jordan Valley was not developed as it is today, with most lowland agriculture concentrated around the flow from the side wadis of the Jordan River and Dead Sea basin, as well as some irrigated orchards in the northern and southern highlands.

Since then, however, the population has grown beyond all expectations. The eastward migrations of Palestinians firstly from the 1948–1949 war, then from the 1967 war put enormous strain on Jordan, and the need to provide food and livelihoods for the increased numbers of people led the government to take the decision to develop the Jordan Valley, using irrigated agriculture as the economic

[2] Jordan considers that it is due an annual allocation of 246 MCM from the Yarmouk catchment. However, much less than this is currently available to Jordan due to up-catchment damming and abstraction by Syria.

[3] The resource figures are discussed in detail in Salameh and Haddadin (2006).

basis. The sources of the irrigation water were to include the Yarmouk, the headwaters of the Jordan and captured rainfall and base flow in the side wadis. Wells were drilled at Mukheibeh in 1982 to provide additional input. In the early 1960s, the East Ghor Canal was built to take water from the Yarmouk southwards and provide irrigation water for the northern Jordan Valley. The canal was eventually extended as far as the Dead Sea, and, now known as the King Abdullah Canal, it forms the backbone of a comprehensive Jordan Valley irrigation network. five dams were built in the highlands to feed into it, and today it supplies eight irrigation development areas totalling around 217,000 dunums. A further two dams were built in the southern highlands to supply irrigation water to the Southern Ghors, where around 58,800 dunums are irrigated.[4] The Jordan Valley Commission was originally created to oversee the irrigation and other social infrastructure planning, but was replaced in 1977 by the Jordan Valley Authority (JVA). The JVA became responsible for the large-scale integrated development of the Valley and the operation and maintenance of irrigation systems. This story is well documented by Khoury (1981).

Significant efforts were employed to supply water to the growing municipal population. Wells were dug to increase the amounts of groundwater supplying the networks, which have now been developed to serve 98% of the population. Eventually, the imbalances between the centres of demand and the most available resources led to the introduction of inter-basin transfers. In the late 1970s, the resources of the Azraq basin began to be transferred to meet the requirements of Amman and Zarqa. Other transfers to Amman, Salt and Madaba were instigated, and in 1987, the transfer of water from the King Abdullah Canal at Deir Alla to Amman began (45 MCM rising eventually to 90 MCM annually). Significant additional infrastructure, including dams and transfer facilities from Mujib, Wala, Hidan and Hasa were developed to provide more water to the municipal and agricultural supply networks. Today, Jordan has 11 storage reservoirs and is continuing to develop additional surface water storage. By 2020, the total capacity of the reservoirs should be around 326 MCM, although the actual available water will be less and will be highly dependant on rainfall.

Irrigated agriculture was also developed in the highland areas, based on groundwater abstraction. This was driven by private initiatives, particularly from the landowners, but was supported by the government. It is now widespread in the northern highlands, significant in parts of the northern badia and Mafraq governorate, in the Azraq basin, and in Disi in the south. Crops grown include wheat, fruit and vegetables. Groundwater-irrigated agriculture in the highlands and steppe now uses over 300 MCM/year – more than the Jordan Valley and Southern Ghors combined. A number of 'desert dams' were built to capture rainwater and are reckoned to increase aquifer re-charge by a total of 20 MCM/year.

[4] Irrigated area figures are sourced from JVA data and refer to areas of irrigation projects in 2002. However, the area of land actually planted and irrigated will vary from year to year, depending on water availability.

The migrations from west of the river were followed by subsequent influxes from Kuwait in the turmoil of the early 1990s, and then by Iraqis moving to Jordan in the wake of the U.S. invasion in 2003. The estimated population rose to 5.35 million in 2005, whereas it would have been around 2.8 million under the prior population growth trends (Haddadin, 2006). The total amount of freshwater supplied to the municipal sector rose to 116 MCM in 1985 and then to 249 MCM in 2002. The water requirements of this growing population against the backdrop of the limited renewable resource means that, according to The World Resource Institute, Jordan has the sixth lowest total renewable freshwater supply per person in the world, at 157 m^3/person in 2005 (World Resource Institute, 2008).[5]

The development of the Jordan Valley was a major achievement. Livelihoods were provided for thousands of people, the development increased the need for the riparian states to maintain peace in the rift valley and the physical nature of the valley was completely transformed. However, the demand for water in agriculture contributed enormously to the nation's overall water demand. The total amount of water supplied to the agricultural sector rose to 500 MCM in 1985, and then to 737 MCM in 1993, before falling to 511 MCM in 2002 due to persistent drought conditions.

By contrast, the amount of water required by industry remained small, with the largest demand coming from the extraction industries at the Dead Sea and the industrial zone in Aqaba. However, by the 1970s, Jordan's water consumption was already leading to rationing of the municipal supply.

3. Managing the Deficit

Table 1 below illustrates how the balance of realizable resources and demand had developed by 2005.

The table shows a deficit of 461 MCM for that year. This is currently being 'met' in a number of ways. Firstly, groundwater is being pumped at levels much higher than the safe yield of 259 MCM. According to the Water Strategy for Jordan, groundwater abstraction was around 437 MCM in 2002, an average over-abstraction of around 160% of the sustainable yield (Water Strategy, 2002).

Secondly, the municipal demand is being undersupplied by pumping water only intermittently to customers. It is estimated that the average daily municipal supply at the consumer[6] fell from 103 to 86 l/person between 1996 and 2001, in comparison to the Ministry's target of 150 l.

[5] These figures exclude water retained in the soil – see Salameh and Haddadin (2006).
[6] I.e. taking network losses into account.

TABLE 1. Predicted Balance of Supply and Demand for the Year 2005[7]

Category	Quantity (MCM/year)
Resources	
Renewable groundwater	259
Surface water (base flows and reservoir safe yields)	382
Treated wastewater (not flowing into reservoirs)	34
Additional resources*	344
Total resources	**1,019**
'Demands'	
Municipal, industrial and tourism demands	433
Agriculture requirements	1,114
Total 'demand'	**1,546**
Groundwater return flows from losses	66
Deficit	**−461**

Thirdly, the agricultural sector does not receive the amounts of irrigation water that it requires. The total supply for irrigation in the Jordan Valley and Southern Ghors fell from 300 MCM in 1996 to around 200 MCM in 2002, although the water used in the highlands remained around 300 MCM during that same time period. The total supply to the agricultural sector in 2005 was therefore less than 50% of its requirements, as calculated in the National Master Plan. The percentage of the total water supply delivered to the agricultural sector fell from 78% in 1995 to 64% in 2002 as a result of the need to prioritize the municipal supply.

Fourthly, the authorities have adopted a policy of treating brackish groundwater and wastewater for reuse in irrigation to reduce the need for freshwater. In 2003, there were 27 groundwater desalination plants in operation and seven under construction. Jordan also embarked on a wastewater treatment plant upgrade programme to improve the quality of the treated wastewater available for reuse. For example, the Khirbit As-Samra plant serving Amman treats wastewater suitable for reuse in the Jordan Valley. Its capacity was expanded in 2007 to 100 MCM/year, and it currently treats over 50 MCM/year. The figure of 34 MCM in Table 1 does not include the growing contribution from this plant, since it discharges to the King Talal reservoir and is included in the table as a reservoir yield. The total amount of treated wastewater available in 2002 was around 70 MCM, and it is estimated that up to 240 MCM of wastewater

[7] As predicted in the Ministry of Water and Irrigation's National Water Master Plan (2004).

* These include additional contributions from shared water resources, treatment of brackish groundwater and non-renewable groundwater.

could be treated for reuse within 20 years if enough effort was made (Scott et al., 2003).

Fifthly, efforts have begun to restrict the amount of groundwater used for agriculture outside the rift valley. In 2002, a Groundwater By-Law was introduced to license and control abstraction, prevent the drilling of new wells and apply penalties for over-abstraction. For a number of reasons, the authorities have had difficulty in enforcing this adequately, but it remains a powerful tool to manage abstractions and is likely to be enforced more effectively in the coming years.

Additional efforts have recently been focused on developing additional supplies. The Zarqa-Ma'in desalination plant supply came online in 2006, and together with the Mujib Dam and transmission system, provides 38 MCM/year to Amman, as well as irrigation water to the Southern Ghors. The Wihdeh Dam came online in 2006, although is yet to contribute significantly due to the drought conditions and upstream abstractions by Syria. Construction of the Disi pipeline is due to begin in 2009 and will bring 100 MCM/year of non-renewable groundwater from the Disi field to Amman from 2011 onwards.

At the institutional level, government strategy has been to increase the involvement of the private sector in the delivery of retail water services in the hope that this will lead to more investment in network improvements and a reduction in physical losses. Total unaccounted for water averaged around 55% between 1996 and 2001, although only around half of this is estimated to be physical losses.[8] In 1999, management of water supply in Amman was packaged into a management contract with a French-led consortium, and since 2007 has been managed by a government-owned private company – Miyahuna. In 2004, the Aqaba Water Company was set up, also government-owned but operating along private lines, and water management for the Northern Governorates Water Utility was recently given to a management contract with private sector involvement. These companies have all embarked on loss reduction programmes, in response to their contractual requirements to try to reduce their unaccounted for water. The government's goal is to reduce the physical losses to 15% by 2020.

4. Future Supply and Demand Predictions

In 2004, the Ministry of Water and Irrigation updated its National Water Master Plan based on detailed modelling of demand, and taking into account the phasing of new supplies. A summary of the resulting supply and demand predictions is presented in Table 2 below.[9]

[8] The rest is administrative errors caused by meter errors, theft, unbilled water and so on.

[9] The National Water Master Plan is currently being updated again, and revised figures should be available later in 2009. Also, the water budget is being reviewed by the Royal Water Commission who will soon release a new Jordan Water Strategy with updated predictions.

TABLE 2. Predicted Balance of Supply and Demand, 2010–2020

Category	**Quantity (MCM/year)**		
	2010	**2015**	**2020**
Resources			
Renewable groundwater	259	259	259
Surface water (base flows and reservoir safe yields)	404	419	433
Treated wastewater (not flowing into reservoirs)	69	89	101
Additional resources	511	454	456
Total resources	**1,244**	**1,220**	**1,250**
‘Demands’*			
Municipal, industrial and tourism demands	493	561	634
Agriculture	1,120	1,101	1,052
Total ‘demand’	**1,612**	**1,661**	**1,686**
Groundwater return flows from losses	63	62	63
Deficit	**306**	**379**	**373**

The table is straightforward to interpret. The values for groundwater reflect the long-term average renewable resource, shown as unchanging over time despite the recent drought conditions Jordan has been facing. The surface water figures are slightly increasing to reflect additional water which will become available from new storage reservoirs, and to take into account a number of network improvement measures which are phased to come in during the time period. The quantities of usable treated wastewater are increasing modestly as more treatment plants are developed and supply networks are upgraded. The ‘additional resources’ referred to in the table include surface water from the shared water bodies: the Yarmouk (167 MCM, although this is still under negotiation with Syria), and the Jordan (which is governed by the Peace Treaty with Israel and other agreements). It also includes non-conventional sources such as desalinated seawater (5 MCM/year desalinated in Aqaba from 2010 onwards), groundwater from non-renewable aquifers (e.g., Disi), and quantities of desalinated groundwater rising from 39 MCM in 2010 to 47 MCM in 2020. There is no contribution from the proposed Red Sea–Dead Sea Conveyance project.

To model the demands, a population growth projection was used which predicts a population of between 7.8 and 9.2 million for the year 2020.[10] The

* Note that none of the above figures reflect ‘demand’ in the economic sense. Instead they reflect a supply requirement, determined based on certain assumptions.

[10] Recent work by the Greater Amman Municipality estimates that the population of Amman alone will be 6 million by 2020.

water demanded by this growing population was calculated based on certain demand assumptions, including a growing average domestic usage requirement. For example the daily per capita usage was 86 l in 2001, but is targeted to rise to 150 in urban areas and 132 in rural areas by 2020 to meet internal norms for a healthy population. The municipal demands take into account network losses, assumed to decrease from 30% to around 25% in the coming years. Specific demand projections were made for industrial development taking into account an industrial park in Irbid and development of oil shale in the Karak region, as well as some specific planned tourism and residential development projects in Aqaba and at the Dead Sea.

For agriculture, the 'demand' figures are determined by the area of land developed for agriculture, cropping patterns, efficiency of irrigation and farm management and efficiency of network and losses. The agricultural requirement is seen to be reducing slightly due to projected improvements in irrigation efficiency and some anticipated reductions in groundwater abstraction in the highlands. However, although the agricultural demand figures take into account all irrigible areas of the Jordan Valley, the actual quantities supplied may well be significantly lower, due to supply constraints, especially in years of low rainfall.

The table illustrates that, despite the efforts and successes to date, large deficits persist, with a deficit of 373 MCM anticipated in 2020. This will continue to be serviced by over-abstraction of groundwater and undersupply of both municipal and agricultural demand with reallocations for agriculture in different areas. Scenario modelling was carried out on different demand growth rates, agricultural allocations and intra-basin groundwater transfers.

5. Continuing Problems from Managing the Deficit

The majority of Jordanians are unaware of the serious problems which are caused by managing this deficit. Over-abstraction from the aquifers has caused serious environmental problems, including the lowering of groundwater levels, reportedly by 40–80 m in the Amman-Zarqa basin, and up to 100 m in Jafr basin. Since pumping from this basin to Amman began in the late 1970s, the Azraq wetlands have been drying up, degrading the habitat for birds and other wildlife (Scott et al., 2003). Springs in Shawbak have gone dry from pumping by large farms in the area. Groundwater salinity is rising in many areas, and some aquifers could be facing close to irreversible damage. Also, the reduction in perennial surface water in the Jordan River, from historic flows of 1,300 MCM to perhaps as low as 50–100 MCM annually, has led to severe degradation in the ecosystem there. The near elimination of flow into the Dead Sea basin has disturbed the balance between inflow and evaporation to the extent that the levels of the Dead Sea are now falling by more than 1 m/year, reducing the amenity value of the area and causing the formation of dangerous sinkholes along its shores.

The domestic undersupply and the rationing programme lead to network and infrastructure problems such as infiltration, pressure shocks and meter problems, and leave stored water vulnerable to biological pathogens (Decker, 2006). In 2007, 19% of Amman's subscribers still had less than 24 h/week supply, and 76% had less than 48 h supply (Miyahuna, 2007). The situation is much worse in rural areas. Villages in the Jordan Valley report that water supplies often come at 10 day intervals, and often for less than 12 h per supply. This has an inequitable effect on lower-income groups who cannot afford to purchase additional water from trucks or provide additional storage to compensate the undersupply. The undersupply also constrains economic activity, and leads to financial hardship, especially for low-income families who use the water to grow food crops in home gardens and to water animals. This leads to theft from the supply network, which increases the inequity and infrastructure maintenance requirements and reduces the available revenue.

Irrigated agriculture supplied with surface water and treated wastewater by the Jordan Valley Authority (JVA) also suffers as the JVA rations water during dryer years. This uncertainty makes it difficult for farmers to plan and invest in the long term. JVA sometimes rents unusable lands during dry years to partially offset the losses to farmers, but this is not a long-term solution. The use of treated wastewater for agriculture also restricts the type of crops that can be planted, depending on the water quality. Also, the persistent use of treated wastewater on the same plots is leading to rising soil salinity in some areas, which need a freshwater source for periodic flushing of the soil (Scott et al., 2003). However, despite the restrictions in the Valley, it is interesting to note that the amount of irrigation water used by agriculture in the highlands did not fall, but actually rose between 1996 and 2002 to around 300 MCM, and is probably closer to 350 MCM today. The introduction of the Groundwater By-Law in 2002 is designed to better regulate the amount of groundwater used for agriculture.

6. Looking to the Future

Despite the efforts made to date by the authorities, the deficit persists. Over-abstracting the aquifers cannot continue indefinitely. More treated wastewater will be made available for irrigation as the treatment plants are upgraded. The new supplies from the Mujib, Zarqa-Ma'in relieve some of the pressure on Amman and the upcoming Disi transfer will contribute significantly for a time. However, new supplies will be increasingly expensive to develop; it is estimated that from now on, new supplies will provide water at a cost of $4/m^3 to $5/m^3 (Scott et al., 2003), and the interest of donors in financing increasingly costly infrastructure without also addressing other problems in the sector is waning.

The authorities are continuing to take steps to address the problem. There are continuing moves towards institutional reform, with decentralization of responsibility for network operations and maintenance to the utilities and involvement of the private sector in retail water delivery. Those remaining supply areas not currently receiving private sector support are being required to enhance performance. The Water Authority's Project Management Unit is being upgraded to provide more of a regulatory role to further encourage the reduction of non-revenue water, which should help reduce leakage. This is linked with an increasing emphasis on cost recovery. Operational costs are recovered for the municipal/tourism/industrial supply only in some areas. The price of agricultural water is so low that operational costs are not nearly recovered, while the incentive to consumers to invest in significant water-conserving measures and actions is weak. There is no recovery of capital costs from the water charges in any sector. Prices remain subsidized either by central government or by donors. The more the water utilities are required to recover costs, the more they will be incentivized to better management and higher network efficiency. Tariff reform remains a political hot potato, but with price as one of the key drivers to demand, this will increasingly be on the agenda, particularly with regard to agriculture. Donors regard weak institutional capacity as an obstacle to further progress, and also point out the lack involvement of non-water sector institutions and end users in decision-making in the sector. This is being addressed partially in the agricultural sector, with the formation of water users associations, but remains an issue in the municipal sector, where locally elected representatives have little say over water decisions.

Domestic demand management is gently being addressed with awareness raising, promotion of water-conserving practices and the promotion of low water use landscaping techniques. However, with current municipal supplies so severely restricted, domestic/municipal demand management will provide few significant savings other than a reduction of unnecessary losses. There is scope for a reduction in mismanagement and wastage by institutions, which is currently being addressed by a water auditing programme. Industrial demand management is also being promoted, with a new emphasis on cleaner production techniques. Bakir (2001) provides a useful overview of the means, difficulties and benefits of demand management in middle eastern countries.

There is also some scope in realizing additional water as a result of trans-boundary agreements with Syria and Israel. Following the construction of the Wihdeh Dam, discussions with Syria over the sharing of resources of the Yarmouk basin have developed, and there remains scope for negotiations with Israel over allocations from the Tiberias and Yarmouk catchments. In the future, a basin-wide multilateral agreement involving all the riparians – Lebanon, Syria, Israel, Jordan and the Palestinian Authority – may lead to a more favourable allocation of resources to Jordan.

The Government's hopes remain pinned on developing new supplies. Recent statements by water sector officials place emphasis initially on the new Disi supply, and then on the water from a proposed Red Sea–Dead Sea Conveyance project (RSDSC) as the main solutions to Jordan's water problem for 2022 and beyond. The RSDSC is currently undergoing a technical and economic feasibility study and environmental and social assessment, by the three riparian parties – Jordan, Israel and the Palestinian Authority – and could produce up to 850 MCM/year of desalinated water for the regional budget, although not all would necessarily be available for Jordan. However, even if it goes ahead, this will likely be a very expensive solution, as would the alternative option of desalinating sea water in Aqaba for supply to the urban centres in the highlands. Detractors argue that bringing on board such expensive supplies will only delay the much-needed sectoral reforms discussed above.

Without the RSDSC – the implementation of which is by no means certain, and which will produce expensive water if implemented – pressure on the agriculture sector will grow under current assumptions. Between 2010 and 2020, between 69% and 62% of Jordan's water 'demand' will come from agriculture, although the sector's contribution to national GDP has reportedly fallen from 7.9% in 1990 to 2.3% in 2002 (Haddadin, 2006). Unless alternative affordable sources of municipal water are found,[11] pressure will mount to reduce the groundwater used currently used for agriculture. Critics of the agricultural allocation argue that, since this water attracts high government subsidies, there is little incentive to increase efficiency. Although the sector has begun to respond by increasing irrigation and farm management efficiencies and by increasing the use of treated wastewater, there are growing calls for a reduction in subsidies to agricultural water, which would give rise to efficiency improvements in on-farm management and supply network, and promote the cultivation of crops which have a higher return for water consumed. Although the amount of irrigated area in the Jordan Valley is reduced in dry years, there are calls for significant restrictions on groundwater use for agriculture in the highland areas, and for more effective enforcement of the Groundwater By-Law. The figures show that if the amount of water supplied to agriculture could be reduced by 35% by 2020, the deficit would disappear. Some argue that the loss of livelihoods based on agriculture would lead to increasing urbanization and unemployment, which would be even more costly to the kingdom. Others argue that much of the labour in the sector is non-Jordanian and would simply leave the country without impact on domestic unemployment, whilst main profiteers – wealthy landlords – would be able to withstand the loss of revenue. In addition to ongoing regional instability and normal population growth, Jordan's investment in tourism infrastructure, as well as increasing likelihood of significant developments in oil

[11] One possible source to be investigated is the non-renewable sandstone aquifer that underlies extensive areas of the Kingdom.

shale production in Jordan, mean that future water demand projections may continue to rise sharply. If the use of water to support these industries brings additional financial resources into play, then higher returns on the water supplied may be realized, and the development of more expensive solutions may become feasible. However, until then, the authorities must continue to act on all fronts – increasing efficiency, reducing losses, managing water demand, enforcing groundwater abstraction limits, and must seriously address the demand from the agricultural sector. The deficit will remain significant, but groundwater over-abstraction cannot continue indefinitely. Water will be an increasingly important factor in political discussions (both local and regional), whether the Red Sea–Dead Sea or another regional option is enacted. All stakeholders will have an increasingly informed part to play.

In 2009, the Royal Water Commission will produce a new Water Strategy with an updated water budget for the next 20 years that takes into account the above realities. It will also set specific targets for the sector in areas of demand management, water supply, institutional reform, water for irrigation, wastewater reuse and the development of alternative resources.

References

Bakir, H., 2001. *Water Demand Management and Pollution Control; Keys to Securing and Safeguarding the Water Supplies of the Eastern Mediterranean Region in the 21st Century*, in WHO/UNEP Regional Conference on Water Demand management, Conservation and Pollution Controls, Amman, Jordan, 2001 (January 6, 2008); http://www.emro.who.int/ceha/pdf/proceeding%2001-water%20demand%20management1.pdf.

Decker, C.W., 2006. Managing water losses in Amman's renovated network: a case study, *Management of Environmental Quality*, 17(1): 94–108.

Dodge, T. and Tell, T., 1996. Peace and the politics of water in Jordan, in: *Water, Peace and the Middle East; Negotiating Water Resources in the Jordan Basin*, J.A. Allan, ed., I.B. Taurus, New York, pp. 169–184.

Haddadin, M.J., ed., 2006. *Water Resources in Jordan: Evolving Policies for Development, the Environment, and Conflict Resolution*, Resources for the Future, Washington, DC.

Khouri, R.G., 1981. *The Jordan Valley*, Longman, London.

Ministry of Water and Irrigation, Jordan (MWI), 2002. *Jordan's Water Strategy and Policies*.

Ministry of Water and Irrigation, Jordan (MWI), 2004. *National Water Master Plan*, GTZ.

Miyahuna – Amman Water Company, 2007. *Annual Report*.

Salameh, E. and Haddadin, M.J., 2006. The Population – Water Resources Equation, in: *Water Resources in Jordan: Evolving Policies for Development, the Environment, and Conflict Resolution*, M.J. Haddadin, ed., Resources for the Future, Washington, DC.

Scott, A.S., El-Nasser, H., Hagan, R.E., Hijazi, A., 2003. Facing water scarcity in Jordan: reuse, demand reduction, energy and transboundary approaches to assure future water supplies, *Water International*, 28(2): 208–216.

World Resources Institute, Earthtrends, *Water Resources and Freshwater ECO Systems* (January 6, 2008); http://earthtrends.wri.org/pdf_library/data_tables/wat2_2005.pdf.

A PALESTINIAN SOCIO-LEGAL PERSPECTIVE ON WATER MANAGEMENT IN THE JORDAN RIVER–DEAD SEA BASIN

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Abstract: The dilemma of water in the Jordan River Basin, as an element of conflict and a factor for cooperation, continues to occupy researchers and professional water experts in the region and globally. The sheer severity of the water crisis, the stagnation in water negotiations, the general deterioration of the political situation in the West Bank and Gaza Strip, the lack of cooperation by Israeli water institutions and the weakness of the Palestinian water institutions are all factors that dampen aspirations for finding acceptable solutions to this seemingly endless problem. Given that water is a fundamental component of human life, this conflict has clear social and economic implications for the welfare of Palestinians. It also has legal consequences that manifest themselves in the continued violations of Palestinian rights in equitable utilization of the shared resources. While the picture is certainly gloomy, a few genuine efforts to put an end to this dilemma are quite noteworthy. From the point of view of this paper, prodigious collective efforts are needed for initiatives to bear fruit. Piecemeal approaches are no longer viable, and there exists the pressing need to find a more holistic and integrated approach. The main pillars for this approach are *confidence* and *trust* among the parties. Once these are in place, a common vision for long-term involvement and commitment to resolve the conflict can be put in place and further operationalized. To this end, serious assessments of the current initiatives must be conducted with a view to establish a responsive vision, a strategic plan and the resources needed for future interventions to resolve the conflict.

Keywords: Jordan River Basin; dilemma; confidence; cooperation; vision

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1. A Diagnosis of the Palestinian Water Crisis

The water crisis in the occupied territory is increasingly severe. Not only does the Israeli government continue to deny Palestinians the right to develop new fresh water resources from the existing shared groundwater aquifers and the Jordan River, but it continues to confiscate land with existing water infrastructure and resources. In the West Bank, the average per capita consumption is less than 60 l/day. This low figure does not even consider the "unaccounted-for water problem", whereby roughly 50% of the total water supply is lost to leaks in old and deteriorating network infrastructure. These amounts do not even cover for the basic human needs for drinking, food preparation, and hygiene.[1] Demand is eclipsing supply as population grows at an average rate of 3.7%. Agriculture – the backbone of the Palestinian economy – remains the major consumer of water, yet the sector's capacity to implement proper management strategies and increase wastewater treatment and reuse is virtually non-existent. Furthermore, more than 50% of the population continues to depend on cesspits and antiquated systems for wastewater disposal, creating increasingly dangerous environmental and health consequences.[2] Not only does such pollution contaminate already scarce and precious water supplies, but the Palestinian Ministry of Health reveals a host of negative health indicators caused by poor environmental conditions.[3]

The water quality problem is especially pressing in the Gaza Strip, where water is becoming completely inappropriate for human consumption and even irrigation. The already limited quantities of water in the Gaza Coastal Aquifer are threatened by saltwater intrusion from over-pumping, by the uncontrolled discharge of untreated sewage into the ground and by the excessive use of fertilizer in agriculture. According to the Palestinian Environment Quality Authority, untreated wastewater discharge is causing public health risks through direct exposure, as well as through reuse in irrigating crops. The total annual wastewater production in the area is estimated to be 40 million cubic meters, of which only 30 million cubic meters passes into sewage networks. The remaining quarter that is disposed of in cesspits or pit latrines should be cleaned out using vacuum tankers and transported to a treatment plant or disposal area designed especially to deal with liquid waste. The present practice, however, is to dump the waste into the nearest wadi, into agricultural drainage channels, or onto open fields (Alfarra and Lubbad).

[1] WHO standards call for a minimum of 100 l/capita/day for the basic needs from water.

[2] In March 2007, an overburdened wastewater treatment plant in Northern Gaza collapsed, killing five people, including two children, and displacing thousands.

[3] The Ministry of Health reported in 2007 an increase in diarrhea episodes among infants and children under 5 years of age; 11.7% of them were suffering from severe diarrhea (WHO, 2007).

2. What Does the Water Conflict Look Like Today?

The disputed water resources in question between Israel and Palestine include those of the Jordan River's Basin, including the Dead Sea and the shared groundwater aquifers. Although the water conflict rarely manifests in the form of physical violence or acts, the verbal and media violence is extensive. Palestinians often denounce Israeli policies in media broadcasts or publications, in national, regional and international platforms, and various public forums. The Israeli response is often to highlight the general severity of the water crisis in Israel, while accusing Palestinians of bad practices with regard to water use, protection and disposal.

Within these two discourses, the official Israeli position asserts that all existing utilizations are *de facto* establishing water rights, while the Palestinians continue to demand their legal entitlement from the shared resources based on the principles of international law. Permanent sovereignty, equitable and reasonable utilization and the issue of compensation represent the backbone of the Palestinian position. Israel, though it officially recognizes the water crisis on both sides, does not admit the root causes of the crisis on the Palestinian side. The Israeli claim might be summarized by the following:

> all the region is facing scarcity, increased depletion of freshwater resources and dramatically increased demands and therefore solutions to this should come from new and additional nonconventional sources outside the current available and the currently used by Israelis.

From this position, the Israelis repeatedly and consistently point to the water crisis in Israel and highlight the wise and efficient measures they undertake to mitigate it. At the same time, they intensify investment in alternative solutions that increase the amount of water from non-conventional sources, such as desalination and wastewater treatment and reuse. In doing so, they ensure that there is enough water to offer at a real price to the Palestinians – water that might be considered a replacement to their legal entitlements from the shared freshwater resources. This tactic defies all principles to which the Palestinians adhere and further widens the gap between the two sides in reaching a settlement to this dispute.

At the political level, there is no permanent official agreement between the Palestinians and Israelis on the principles that govern their relationship with regard to the utilization, development and protection of shared watercourses. The 1995 Interim Agreement between the PLO and Israel recognized the Palestinian water rights, but there was no definition of what these rights include.[4] This is an important discrepancy which continues to shape the both

[4] See specifically Annex II of Appendix III Article 40 in Israeli–Palestinian Interim Agreement on the West Bank and the Gaza Strip, 1995.

parties' positions with regard to this issue. The first track negotiations – the formal negotiations between the PLO officials and the State of Israel officials – are currently semi-frozen, except for some meetings between President Abu Mazen and the Prime Minister Ehud Barak on the six final issues including water, and the "secret" meetings between the chief of negotiations Abu Ala' and Tzipi Levni on the same issues. Minimal information has been revealed on the content of these meetings and even less on their results.

As for the second track negotiations – all other informal negotiations – and under the umbrella of some peace initiatives,[5] some Israeli and Palestinian experts are achieving good progress in finalizing "a Draft Water Agreement" to be presented to the officials on both sides. These efforts will never bear fruit without the blessing and consent of the politicians and policy makers from both sides. Extensive lobbying work has to be conducted to ensure that such thing is possible.

3. The Governance Crisis

The PA suffers from an absence of proper governance structures at the national level. For obvious reasons, this governance crisis complicates the task of enforcing laws and regulations. The continued Israeli occupation, the persistent lack of control over water resources, the inadequate professionalism on the Palestinian side and lack of commitment by international agencies are among many factors contributing to this problem.

One of the primary reasons for the weakness of Palestinian institutions at the national level is a lack of adequate and consistent support by international organizations. After the signing of the Oslo Accords, efforts to build-up and implement an official Palestinian Water Authority between 1995 and 2001 were thwarted by the second Intifada, which caused donors to shift their support from the realm of development to that of emergency as the political situation deteriorated and newly-built infrastructure was destroyed by Israeli military actions.

The Palestinian National Water Council, whose mandate is to take major policy decisions in the field of water in Palestine, is not yet fully operational.[6] Although the German Government[7] is investing in building and operationalizing this body, the political interests and the overlaps between the Palestinian

[5] In August 2008 and under the auspices of the Geneva Initiative, a group of experts (the author is one of them) met in Maryland, USA to elaborate a draft agreement on water to be considered by officials on both sides.

[6] The National Water Council was established by the Palestinian Water Law No. 3 for 2002. The Council is composed of representative from the major relevant ministries and authorities in the Palestinian territory including the Ministries of Agriculture, Industry, Health and the Environment Quality Authority.

[7] The support by the German Government is provided through the GTZ which is an international cooperation enterprise for sustainable development with worldwide operations.

ministries' mandates still constitute a major obstacle to the realization of its mandate. Unless there is a political will at the highest level to activate this Council, it will continue to be mere ink on paper and the dream of inter-sector coordination on water will be an illusion.

At the District level, the plan in 1995 was to establish integrated regional water/wastewater utilities in the northern, central and southern West Bank using World Bank soft loans. These plans were suspended due to the reluctance of the World Bank to invest in the unstable political context created by the second Intifada.

The work on restructuring the West Bank Water Department as a National Water Utility functioning on commercial basis still continues using French Aid.[8] However, the relationships, roles and responsibilities between this Utility and the PWA are not yet defined and/or agreed upon. At the local level, the establishment the Joint Services Councils[9] in the various governorates in the West Bank marks a good step in the right direction. However, the relationships between these councils on one hand and the municipalities, utilities and the PWA on the other are not yet clear. Conflict of roles, mandates and jurisdictions are inevitable unless the roles are clearly divided between all stakeholders both vertically and horizontally.

The formal, however temporary, institutional water management mechanisms between the Palestinians and Israelis were established under the auspices of the Interim Agreement (also known as the Oslo II Agreements) signed between the PLO and the State of Israel in 1995.[10] Today, this mechanism is hardly functioning due to the inherent asymmetry between the two parties and persistent conflict over the basic foundational issues regarding legal obligations over water. The decisions made within this mechanism were in favor in Israel as they were mainly bound by the need to protect the status quo of existing Israeli water use. Presently, this mechanism does not represent the Palestinian aspirations of the type of cooperative framework that should be in place. To that end, the author believes that the core and substantial disputes have to be clarified and resolved first before a new institutional mechanism is put in place.

4. Socio-economic Implications

The lack of access to water in the Palestinian territories is a major factor contributing to the general state of deprivation and poverty of the Palestinian people. Water is a fundamental component of nearly every sector of society;

[8] The French Agency for Development AFD has been supporting the restructuring of the Bulk Water Utility in the West Bank to become the operational arm for the Palestinian Water Authority.

[9] These are councils that are established at the local level for water and wastewater management. The JSC is managed by a Board that consists of 20 local Authorities (15 municipalities and 5 village councils).

[10] Schedule 8 of Article 40 of Annex II Appendix III of the Interim Agreement established a mechanism known as the Joint Water Committee.

such limitations pose a serious threat to economic welfare and general living standards. This crisis has visible socio-economic implications, in that those in the marginalized and poor areas suffer most.

In general, poor rural villages receive their water supply from traveling tankers. With this system, they pay higher prices than those in the towns and cities – sometimes up to 5 times the price.[11] The uncontrolled water-vending market is a result of the governance gap mentioned above and cannot be solved unless this governance gap is addressed and resolved. The absence of adequate rules and regulations to regulate this type of sale in the West Bank and Gaza Strip coupled with the lack of monitoring continue to prohibit the proper control of this activity.

Furthermore, most of the water used in agriculture remains in the hands of private owners, as established by Ottoman land rights and Jordanian laws and regulations. The newly-adopted Palestinian Water Law No. 3 for 2002 stipulates that land ownership does not confer water ownership and that any person is granted rights to use water through a license or permit.[12] Despite the PA's effort to reform this sector and develop policies and laws that shift the rights from private owners to the government, the enforcement remains difficult and the reforms have been slow to take hold. This means that the rich farmers who own the water can still abuse this right, taking advantage of poorer farmers through uncontrolled pricing.

As mentioned in section one, the Palestinian water crisis has very serious environmental health implications. As is often the case in the realm of environmental justice, these problems disproportionately affect the poor. Poverty in the Palestinian rural areas is a result of the lack of access to basic resources (such as land and water) and to services such as health care and education. Isolation and marginalization makes it even more difficult for poor people to gain access to resources and services. Additionally, infrastructure in rural areas is inadequate – only 70% of the rural population connected to the water network while more than 50% are not connected to the sewage network.[13]

Water-related diseases, especially in the poorer Gaza Strip, are among the most common causes of illness and in some cases deaths. Bad sanitation and the lack of hygienic practices significantly increase diarrheal and infectious diseases and allow for worm infections. Moreover, and since adequate water is needed for food production the lack of it lead to malnutrition especially among mothers and newly born children (Alfarra and Lubbad).

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[11] In the West Bank the price of 1 cubic meter reaches 25 NIS while very recently in Gaza the amount they pay for water from private desalination plants is 50 NIS (a phone call with Mr. Omar Majdalawi in Gaza, December, 2008).

[12] Palestinian Water Law No. 3 for 2002.

[13] Figures from the Palestinian Water Authority, on file with author.

5. Efforts to End the Crisis

The Israeli–Palestinian water conflict has seen intensive research and debate over the past few years. From the point of view of this paper, only a few of these efforts are considered relevant to contributing to an effective resolution of the conflict.

Since the signing of the Oslo Accords, western donors have channeled considerable funds to the Palestinian Authority. A considerable portion of this funding has gone to support various initiatives in the realm of water. They can be categorized as follows:

1. Initiatives by international donors with a predetermined vision and agenda based on the status quo (e.g., USAID and the World Bank)
2. Initiatives by humanitarian and relief organizations triggered mainly by emergency situations rather than a development prospective (e.g., Red Cross, Oxfam, UN agencies)
3. Initiatives motivated by the “peace building” objectives (e.g., Switzerland, EU, Czech Republic and local peace groups)
4. Initiatives that at least appear to be purely technical, and aim to serve the Palestinian “state-building” objectives (e.g., France, Germany, Norway)
5. Regional/Multilateral initiatives by donors who have good intentions but are not influential enough to make a change (i.e., Norway)
6. Macro initiatives that have pure political motivation

5.1. INITIATIVES BY INTERNATIONAL DONORS WITH A PREDETERMINED VISION AND AGENDA BASED ON THE SATUS QUO

For the majority of international donor agencies, the points of departure for Palestinian water initiatives are that (i) the conflict can be resolved without addressing the water rights issues raised by the Palestinians, (ii) that there is no extra fresh water in the region available to the Palestinians, and (iii) that there exists the need to develop new and additional water resources to satisfy the emerging demand. Essentially, they work within the political/legal status quo, embarking on projects with little consideration to the issue of water rights and how it might affect the success or failure of the proposed initiative.

The support provided by USAID in the West Bank, for example, has focused on fulfilling parts of the Israeli obligations within the Interim Agreement. One initiative targeted the deteriorated water infrastructure in the West Bank and Gaza Strip without due considerations for the fact that, without adequate water (quantity and quality) running through them, these infrastructures will deteriorate and become old before they are actually utilized. Furthermore, USAID is motivated by a specific political agenda, as demonstrated by the fact that it suspended initiatives in the Palestinian territories when Hamas came to power after the 2006 elections. Currently, USAID has resumed some activities in the West Bank which target the private and small business sectors as well as the humanitarian and relief sectors.[14]

Likewise, the World Bank does not give due consideration to the issue of water rights during the course of its project planning and implementation. These initiatives generally focus on internal reforms through the restructuring of the water sector on the basis of economic efficiency, involving projects like the establishment of three regional water utilities in the West Bank, for example. This particular process was disrupted by the deterioration of the political situation. However, in Gaza the Coastal Utility has been established and it is basically functioning with minimum resources. The relationship between this utility and the PWA in the Gaza Strip has yet to be clarified and agreed upon. The solutions to increase the Gaza good-quality water are still to be sought. This overall approach that focuses on the internal reforms without linking them with the need to establish firm Palestinian water rights is deficient. Without adequate water resources, their vision for efficient reforms and economic viability will be defeated.

5.2. INITIATIVES BY HUMANITARIAN AND RELIEF ORGANIZATIONS, TRIGGERED MAINLY BY EMERGENCY SITUATIONS

As the water situation in the Palestinian territories generated various humanitarian emergency situations, the need for more assistance from humanitarian and relief organizations became increasingly clear. The destruction of the water infrastructure by the Israeli military operations, the closure of areas and the restricted mobility necessitated the intervention of groups like the Red Cross and UNRWA, which normally intervene in times of war. Such interventions are short term, and generally focused on maintaining minimum hygienic standards, as well as preventing thirst and starvation. That said, their efforts are triggered mainly by emergency situations rather than a development prospective.

5.3. INITIATIVES MOTIVATED BY THE "PEACE BUILDING" OBJECTIVES

Numerous cooperative projects on water-related issues do exist between Palestinians and Israelis. Many of these initiatives seek to use cooperation over water as a possible means for peace building in the region. They are generally supported by well-intentioned governments like Switzerland, who sponsored the Geneva Initiative in 2003. The key deficiency in most of these initiatives

[14] In 2008, 150 million has already been transferred as budget support to the Palestinian Authority., The United States also has pledged to provide $148 million in humanitarian aid through the United Nations (Lawder, 2008).

lies in the relevance of projects or activities emanating under these initiatives. The fact these projects hardly address the core contested issues within the water conflict renders them ineffective in many ways. For example the efforts made by the Israeli Palestinian Center for Research and Information (IPCRI) always emphasize the need for finding *practical* solutions to the Palestinian water crisis.[15] They rarely address the rights or legal entitlements of the Palestinians for shared freshwater resources, but rather focus on advocating the protection of current Israeli water use and the search for new and additional water sources to resolve the Palestinian conflict.

5.4. INITIATIVES THAT APPEAR PURELY TECHNICAL AND AIM TO SERVE THE PALESTINIAN "STATE BUILDING" OBJECTIVES

These initiatives are considered the best examples of projects that serve the long-term national vision for strong Palestinian water institutions. However, because they do not properly address the water rights issue, these efforts continue to lack the desired impact.

For example, between 1995 and 2002, Norway supported the institutional and capacity-building initiatives behind the establishment of the Palestinian Water Authority (PWA). This support included the development of water management tools for the PWA to become an effective regulator of the water sector. Although Norway was also working in parallel on the second track multilateral negotiations between Israel Jordan and Palestine[16] it did not attempt to bridge these two efforts. This led to a mismatch between the results and expectations at the national and regional levels, giving minimum acknowledgement to challenges at the national level. The French government,, on the other hand, has been providing technical support to the PA for building the West Bank Water Department which is proposed to be the National Water Utility in the West Bank and the operational arm for PWA. The German government has for many years supported the Jerusalem Water Undertaking which is proposed to be on of the water utilities in the West Bank. Additionally, the German government has been supporting efforts to correct the governance structure by funding the operationalization of one of the important decision-making bodies in the water sector: the National Water Council (NWC). As stipulated in the Water Law No. 3 for 2002, the NWC is composed of representatives from the

[15] Most of the IPCRI water conferences mainly focus on topics like demand management, water quality problems, and other technical topics away from the core issues including the equitable and reasonable utilization and rights to water according to international water law, see generally http://www.ipcri.org/ files/ water/water-papers.html (December, 2008).

[16] The 1991 Madrid Conference established a framework for multilateral talks among Israel and the Arab states to discuss economic, social and environmental issues essential to long-term regional development and security. The Water Resources Working Group has focused on four areas: data availability, water management and conservation, water supply and new concepts for regional cooperation and management. The U.S. is responsible for ACRS (along with Russia) and for the Water Resources Working Group (see Peters, 2000).

main ministries and has powers to take strategic decisions with regard to water resources management and regulation. Despite the importance of the above initiatives for building strong institutions and the foundations for the Palestinian State, there remains the need for parallel efforts that address the water rights issue.

5.5. REGIONAL/MULTILATERAL INITIATIVES BY DONORS WHO HAVE GOOD INTENTIONS BUT ARE NOT INFLUENTIAL ENOUGH TO MAKE A CHANGE

Between 1992 and 2002, Norway attempted to play the role of mediator between Israel and Palestine for water conflict. Jordan was also part of this mediation process. The main aim of the joint intervention was to promote the combined role as a technical and scientific advisor in a complex policy environment. The model applied was to engage governments by having them agree on various "scientific" processes. It was hoped that the outcome of these processes would be to provide information for decision making which could subsequently form the basis for an agreement on principles and practices for cooperation in management of joint resources. The Implementing NGO, the Centre for Environmental Studies and Resource Management (CESAR), has attempted to act as a facilitator in two separate, but interlinked, processes simultaneously, as well as to provide regular services to individual parties. At the same time, it emphasizes confidentiality to maintain confidence. This has led some representatives of the parties to question CESAR's integrity and to ask to whom it is actually beholden – to one of the parties? Some of the parties? Norway? The US State Department? CESAR has been at the centre of obtaining, managing and distributing information and financial resources from the Norwegian Ministry of Foreign Affairs – a role that has proven a key asset for the organization. This, however, has been in a manner which has not been fully transparent to all parties. The result is a situation of frustrated "dependency" on CESAR.

In 2003, the Norwegian government commissioned an evaluation of the Norwegian-funded water activities in the Middle East.[17] The results of the evaluation indicated that all projects served to initiate a dialogue with the various parties and to promote cooperation, despite being implemented in a complex and often difficult political environment. However, it also confirmed that actual outcomes of the projects and the processes they were intended to support have been poorly-planned, and many of the projects have been implemented at a high cost (especially the more investment-oriented ones).[18] Following

[17] See generally Claussen et al. (2004). The author of this paper was the water legal expert on this evaluation.

[18] These projects include the Water Atlas, the Waternet, the Zai Treatment Plant in Jordan. See generally Claussen et al. (2004).

this evaluation, the Norwegian government decided to suspend its support and to undertake a more in-depth review of its involvement in this complex sector.

5.6. MACRO INITIATIVES WITH PURELY POLITICAL MOTIVATIONS

One of the most significant initiatives under this category is the proposed "Red–Dead Canal" project, which would convey water from the Red Sea to the Dead Sea through a massive conduit. The claimed objectives of this project are to "save the Dead Sea" from further drying-up, to facilitate an extensive water desalination regime, and to generate hydropower in the process. The benefits of the project would be shared among Israel, Jordan and the Palestinians, giving it a strong edge as a regional cooperative peace project. From the view point of this paper, there are substantial grounds to believe that the motivations for USAID and the World Bank to invest in this project are political. For Israel, the political gains to be had from this project are many and could be summarized in the following: (i) Israel would be presented to the world as a country that encourages cooperation, and would be especially praised for including the Palestinians in this initiative; (ii) By implementing this project, the attention would be diverted from the real problem that is causing harm to the Dead Sea; i.e., Israel's National Water Carrier that diverts water from the upper Jordan and robs the basin of its replenishing water source. The motivation of the Palestinian participation is also political, assuming that their participation in this project is a confirmation and acknowledgment by Israel of their riparian rights in the Jordan River. The Palestinians are fairly confident that their gains from this project will be minimal; the fact that they have no physical access to the Dead Sea is one good indicator. Finally, it is believed that the Jordanians are the only party that is genuinely interested in this project from a non-political perspective, given the sheer severity of water scarcity in Jordan and the pressing need for additional water resources. Their hopes are high that this project might produce tangible benefits in terms of water, but also in electricity and tourism opportunities.

6. Conclusions

This paper demonstrates the complexity of the Palestinian–Israeli water conflict. It confirms that, to date, there is no common agreement on the overarching principles for the future utilization of the shared water resources. The challenge viewed here is how the parties could be supported to resolve the conflict, irrespective of their unequal power relations. This relies on the notion that there can be a role for ethical considerations and good intentions. It will require real prodigious efforts by the Palestinian negotiators and the international community to engage the Israelis in serious negotiations over water and to resume the final status negotiations. Of crucial importance is the mutual agreement on the benefits gained by establishing cooperation based on genuine intentions. Technical cooperation is suggested as the entry point for further intensive collaboration and cooperation.

The water-related arrangements established through the Oslo peace process are politically sensitive – one reason that justifies its complete failure in addressing the needs of the population under the stressed political situation. Other reasons for this failure include the asymmetry between the two parties at the technical, political and financial levels. Above all, the fact that the issues of legal entitlements between the parties are not addressed appears to be at the heart of the problem. Israel continues to exercise full control over all water resources, including the transboundary groundwater it shares with the Palestinians.

The paper also finds that, in the vast effort to resolve the conflict, the fragmented efforts and the diversity of motivations and approaches have had minimal success in achieving the desired progress. A serious assessment of past and ongoing initiatives in the field of water conflict resolution is necessary, and future plans should draw on the various lessons learned. Furthermore, prodigious collective efforts are needed for initiatives to bear fruit. Piecemeal approaches are no longer viable, and there exists the pressing need to find a more holistic and integrated approach. The main pillars for this approach are *confidence* and *trust* among the parties. As a precondition for a successful holistic approach to cooperation on water issues, both parties must acknowledge the need for a common base in the interest of optimization and sustainable management of shared resources. This will build the required trust and confidence.

The key here is to have a vision to which all stakeholders can aspire to and work towards achieving. This vision should be translated into actions at the national, regional and international levels. Governments and Ministries of Foreign Affairs who are willing to be involved in Palestinian–Israeli water conflict resolution need commit to this vision and develop a proper division of responsibilities and tasks. The core contested issues within the problem have to be put on the table for resolving. The Israeli government and the Palestinian Authority must commit themselves to finding solutions and address them without hesitation.

Bibliography

Alfarra, A. and Lubbad, S., 2008. Health Effect Due To Poor Wastewater Treatments in Gaza Strip, unpublished study; http://www.ipcri.org/watconf/papers/amani.pdf.

Alster, J., 2001. Water Laws, Rules and Regulation: Israel, Water Supply, Economics and Pricing.

Applied Research Institute, 1996. *The Environmental Profile*, Palestine, Bethlehem.

Claussen, J. et al., 2004. Evaluation of CESAR's Activities in the Middle East Funded by Norway, Royal Norwegian Ministry of Foreign Affairs, Evaluation Report 3/2004 (December, 2008); http://www.oecd.org/dataoecd/22/3/35162580.pdf.

Daibes, F.M., 2003. *Palestine Case Study Data Collection Reports and Synthesis*, International Water Law Research Institute (IWLRI), March (June, 2003); http://www.dundee.ac.uk/law/water.

Daibes, F., 1995. *Summary on Water Resources of Palestine*, unpublished paper prepared for the Palestinian Water Authority, Ramallah.

Ellan, N. Minutes of Meetings of the Joint Israeli Palestinian Water Committee, period covered from November 1995–January 1999.

GTZ, 1998. *Middle East Regional Study on Water Supply and Demand Development*, Concluding Report prepared by Israeli, Jordanian and Palestinian Study Teams. Sponsored by the Government of the Federal Republic of Germany and the Ministry for Economic Cooperation and Development (BMZ), Implemented in cooperation with the German Agency for Technical Cooperation (GTZ), *Desalination*, 136(2001): 105–108.

IMA, 1998. Hydrological Services Annual Report, Israeli Ministry of Agriculture (IMA).

IPS, 1994. The Palestinian–Israeli Peace Agreement: a Documentary Record, Institute for Palestine Studies (IPS), Washington, DC.

Israel–Jordan: Common Agenda for the Bi-lateral Peace Negotiations, 14 September 1993, Washington, DC, 32 ILM 1522 (1993).

Israel–Jordan–Palestine Liberation Organisation Declaration on Principles for Co-operation on Water-Related Matters and New and Additional Water Resources, 13 February 1996, Oslo, 36 ILM 761 (1997) (March, 2003); http://www.mfa.gov.il/.

Israel–Palestine Liberation Organisation: Declaration of Principles on Interim Self-government Arrangements, 13 September 1993, Washington, DC, 32 ILM 1525 (1993) (came into force 13 October 1993) (May, 2003); http://www.jmcc.org/peace/agreements.html.

Israel–Palestine Liberation Organisation: Agreement on the Gaza Strip and the Jericho Area, 4 May 1994, Cairo, 33 ILM. 622 (1994) (June, 2003); http://www.us-israel.org/jsource/Peace/gazajer.html.

Including:

Annex I – Protocol Concerning Withdrawal of Israeli Military Forces and Security Arrangements

Annex II – Protocol Concerning Civil Affairs

Annex III – Protocol Concerning Legal Matters

Annex IV – Protocol on Economic Relations between the Government of the State of Israel and the PLO, representing the Palestinian people

Gaza–Jericho Agreement – letters.

Israel–Palestine Liberation Organisation: Wye River Memorandum (Interim Agreement), 23 October 1998, 37 ILM 1251 (1998) (June, 2003); http://www.palestinecenter.org/cpap/pubs/19990729ib.html.

Israel–Palestine Liberation Organisation: The Sharm El Sheikh Memorandum, 4 September 1999, 38 ILM 1465 (1999).

Israeli–Palestinian Interim Agreement on the West Bank and the Gaza Strip, 28 September 1995, Washington, DC, 36 ILM 551 (1997) (May, 2003); http://www.ariga.com/treaties/ interim. html.

Including:

Annex III – Protocol Concerning Civil Affairs

Annex IV – Protocol Concerning Legal Affairs

Annex VI – Protocol Concerning Israeli–Palestinian Cooperation Programs

IPCRI. Collection of Papers Israeli Palestinian Center for Research and Information (IPCRI) (December, 2008); http://www.ipcri.org/files/water/water-papers.html.

Johnston Negotiations on the Jordan River Basin, 1955. (May 2003); http://ocid.nacse.org/qml/research/tfdd/toTFDDdocs/92ENG.htm.

Lawder, J. 2008. U.S. aid to Palestinians to total $550 million: official. *Thomson Reuters*, Dalgleish, J., ed., 21 May (December, 2008); http://www.reuters.com/article/worldNews/idUSWAT00953720080521.

Palestinian Central Bureau of Statistics, 1997. Population Census.

Palestinian Statements at the Middle East Peace Multilateral Negotiations First Round Vienna 1992, Second Round Geneva 1993, Third Round China 1993, Fourth Round Jordan 1994, Sixth Round Greece 1994, Seventh Round Jordan 1995 and Eighth Round Tunis 199. On file with the Author.

Palestinian Water Law No. 3 for 2002, on file with author (December, 2008); http://debwani.net/ar/files/debwani%20(48).doc.

Peters, J., 2000. The Multilateral Arab–Israeli Talks: A Primer, *Information Brief*, No. 22, 28 January (December, 2008); http://www.thejerusalemfund.org/carryover/pubs/20000128ib. html.

PWA, 2000. Reference Framework for the Palestinian Position on the Water Issue, Official Reports by the Palestinian Water Authority (PWA), 16 April.

Statement to the Middle East Peace Multilateral Negotiations Palestine Delegation, Position Paper Presented to the Working Group on Water (1st – Seventh Rounds). On file with the author.

Statistical Abstract of Israel, No. 49 for 1998.

Trolldalen, J., ed., 1997. *Water Laws, Water Institutions and Water Supply Economics: in the Hashemite Kingdom of Jordan, the Palestinian Authority and the State of Israel*, CESAR, Oslo.

Treaty of Peace Between the State of Israel and the Hashemite Kingdom of Jordan, 26 October 1994, Arava/Araba Crossing Point, 34 ILM 1995, 43 (May, 2003); http://www.mfa.gov.il and http://ocid/nacse.org/qml/research/tfdd/toTFDDdoc/168ENG.htm.

Including:

Annex I (a) – Israel–Jordan International Boundary Delimitation and Demarcation

Annex II – Water Related Matters

Annex IV – Environment

UNDP, 1993. Water Resources Action Programme Study on Water Resources, United Nations Development Programme (UNDP).

WHO, 2007. *Report on the Health conditions in the occupied Palestinian territory, including east Jerusalem, and in the occupied Syrian Golan*. Sixtieth World Health Assembly. Agenda Item 14. 15 May, World Health Organization, http://www.who.int/gb/ebwha/pdf_files/ WHA60/A60_ID5-en.pdf.

MANAGING PALESTINE'S WATER BUDGET: PROVIDING FOR PRESENT AND FUTURE NEEDS

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Abstract: The political situation in Palestine is unstable and stagnant due to the ongoing and the "not-going-on" peace process negotiations. The parallel on-the-ground activities in all sectors in both the West Bank and Gaza Strip are inadvertently affected by this political-socio-economic climate. Water and all of its accompanying components and works is one of the most fundamental, challenging and critical problems facing Palestinian society as a whole. The lack of water resources (or the lack of access to water resources) further aggravates the usual competition between different uses (domestic/municipal; agricultural; and industrial). The gap between available water resources and the demand for water resources is increasing with time. Actual consumption per capita is decreasing every year as natural population growth is coupled with the same supply levels and extremely limited development. Development in all aspects in Palestine is constrained and repressed by the lack of adequate water supplies. Brief sectoral descriptions are presented, along with up-to-date data on water supply and demand. A generalized presentation of the growing gap between water supplies and demands is illustrated, along with potential management alternatives or options for the future water and wastewater sector in Palestine.

Keywords: Palestinian water demand; Palestinian water supply; Palestinian water consumption; water resources versus demand gap; management options

1. Introduction

Historically and geographically, Palestine (as it was known prior to 1948) had more than a 90% Arab Palestinian population who had access to sufficient

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C. Lipchin et al. (eds.), *The Jordan River and Dead Sea Basin: Cooperation Amid Conflict*,

water resource supplies for their various domestic and agricultural purposes. A record of these water resources and their annual supply in 1947, before the establishment of Israel on the coast of Palestine, is shown below (Table 1):

TABLE 1. Annual Water Supply from Available Sources in Palestine (1947) (NAKBA, 2005)

Water source	**Annual average (MCM)**
Rivers and springs	1,200
Valleys outflow	500
Underground waters	500
Grand total	2,200

However, following the Jewish occupation of about two thirds of Palestine and the formation of Israel in 1948, the remaining Palestinian lands became separated from each other. The coastal remnant fell under Egyptian administration, and became known as the 'Gaza Strip'. It was isolated from the hilly portion which became under Jordanian administration, and is known as the 'West Bank'. Between 1948 and 1967, due to lack of funding and concentration of any available funds and efforts on helping the thousands of Palestinian refugees who were forced out of their homes in the 1947–1948 Jewish–Arab war, little if any development of water resources or water distribution networks was carried out by either governmental administration in the Palestinian territories.

In 1948, the Palestinians not only lost most of their coastal lands and plains, but also lost access to the outflow of Arab Rivers in northern Palestine. Most importantly, they were cut off from Lake Tiberias. After the 1967 war, however, *all* major Arab water resources in the Jordan River Basin, as well as those in the West Bank and Gaza Strip, came under Israel's control, available for Israel to use as it wished. This further encroachment on Palestinian lands meant further control of Palestinian rights in the West Bank and Gaza Strip, including those with regard to water resources and their utilization. Immediately after winning the 1967 war, the Israeli government proclaimed military laws for control and use of the waters in all the occupied areas of the West Bank and Gaza Strip, as well as, of course, total control of the other mentioned Arab lands and waters in the north of Palestine.

Following this 1967 occupation of Arab lands, the surface water resources of Arab countries (Syria, Lebanon, Jordan and Palestine) essentially became the water resources of Israel. The Israeli National Water Carrier diverted the headwaters of the Jordan River at Lake Tiberias, water was pumped directly from the Jordan River, and various projects were set up to drill into the valuable aquifers under Palestinian lands (replenished by rainfall in those lands), either in the West Bank and Gaza Strip directly, or along the Green Line borders, and often at unsustainable rates. Figure 1 illustrates the concentration of Israeli wells alongside the border of the West Bank (pumping groundwater from the Western Aquifer which recharges on the lands of Palestine, making it a trans-boundary aquifer system according to international water law). It also shows the concentration of wells pumping groundwater outside the border of the Gaza Strip, catching the transboundary Coastal Aquifer's flow before it enters the Gaza Strip.

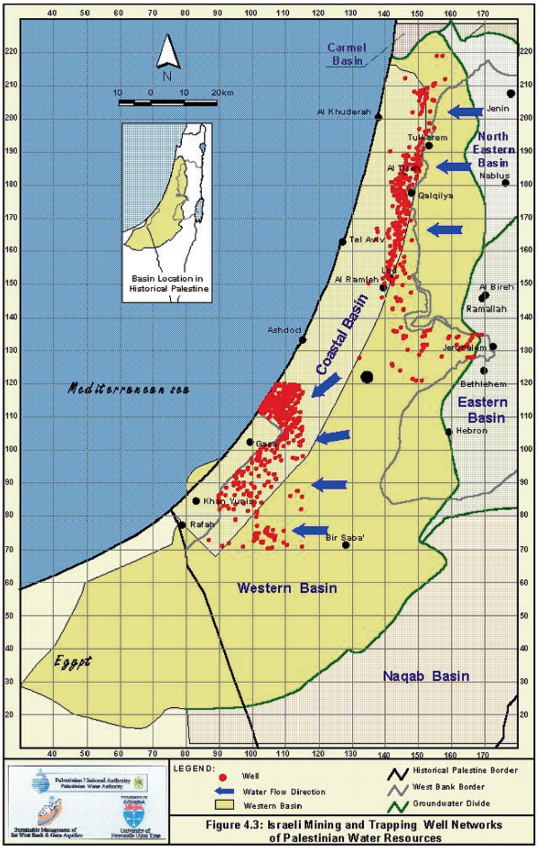

Figure 1. Map of Israeli pumping of groundwater along the borders of the West Bank and Gaza Strip (Source: Aliewi and Assaf, 2003; included in SUSMAQ, 2001 project)

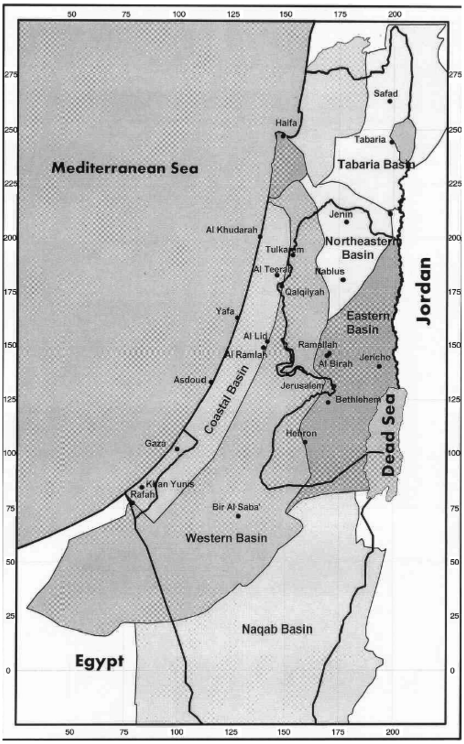

Figure 2. Location map of Palestinian and Israeli Aquifer Basins (Source: Aliewi and Assaf, 2003)

Note: The aquifer basins of the West Bank are the Western, Northeastern and Eastern which are all part of the mountain ridge running north/south – and the extreme southern edge of the shallow Coastal Aquifer for the Gaza Strip (Figure 2).

From 1967 to the present day, the West Bank and Gaza Strip have struggled with infrastructure for water supply, sewerage and solid waste. Not only has there been extremely limited development of new projects, but existing infrastructure has been rapidly deteriorating. This has resulted in insufficient service coverage with unreliable and dwindling quantities, large losses within the systems, as well as the build-up of potential contamination and pollution, creating both point-source and non-point effects. The Israeli 'operator' has also cut off supplies periodically, thereby discriminating unfairly between Palestinians and Israeli settlers when shortages or problems occurred, especially during periods of drought (Assaf, 2004).

At the signing of the Oslo Agreement in 1995, Palestinian abstraction from the West Bank's three mountain aquifers (Western, Eastern, and Northeastern) was documented at 118 million cubic meters (MCM) per year. As of 2007, it was 106 MCM/year (PWA, 2008). At the same time, the Palestinian territories have experienced rapid population growth over time (from 3.5% to 4% per year), further contributing to the decrease in the per capita supply of fresh water for Palestinians. Table 2 summarizes current water resource estimates in the West Bank (WB) and Gaza Strip (GS), and actual Palestinian abstraction rates. With projected population growth, it is clear that water demand will continue to increase in the future.

TABLE 2. The Palestinian Aquifer Basins and their 2007 Abstractions (Aliewi and Assaf, 2003; SUSMAQ, 2001; PWA, 2008)

Aquifer Basin	**MCM of water**
West Bank's Western Aquifer Basin ~95% to Israel, 5% to Palestine Range of annual recharge: 335–450 MCM/year Safe yield: 360–380 MCM/year	2007 Palestinian Use: 224.91 MCM/year from wells, plus 2.43 MCM from flowing springs
West Bank's Northeastern Aquifer Basin ~80% Israel, 20% Palestine Range of annual recharge: 130–200 MCM/year Safe yield: 100–140 MCM/year	2007 Palestinian Use: 14.54 MCM/year from wells, plus 10.90 from flowing springs
West Bank's Eastern Aquifer Basin ~65% to Israel, 35% to Palestine Range of annual recharge: 100–172 MCM/year Safe yield: 75–120 MCM/year	2007 Palestinian Use: 21.69 MCM/year from wells, plus 31.48 MCM from flowing springs
Gaza Strip's Coastal Aquifer Basin Natural renewable amount: 50–60 MCM/year There is an annual deficit in the water budget	2007 Palestinian Use: 167 MCM/year from wells, There are no springs in the Gaza Strip.

2. Present and Future Palestinian Water Demand by Sector

2.1. DOMESTIC/MUNICIPAL SECTOR

For 2007, the total water use by the domestic and municipal sectors in the West Bank and Gaza Strip has been estimated to be 165 MCM/year. Approximately 86 MCM/year was used in the West Bank, and roughly 79 MCM was used in Gaza Strip. The overall supply rate (including losses) for urban domestic purposes in the West Bank is estimated to vary between 46 liters/capita/day (l/c/day) in Tubas and 297 l/c/day in Jericho. The overall loss or unaccounted-for-water (UfW) rate is estimated to vary between 26% (in Ramallah) and 44% (in Tulkarem), with an average of 37% of the total supply. The loss rate in un-piped areas was assumed to be 25%.

All localities in the Gaza Strip are considered to be connected to a water distribution system. The per-capita domestic consumption rate based on total supply is estimated to be approximately 217 l/c/day. However, groundwater quality in the Gaza Strip is quite poor, and only a small percent is considered potable. Also, the average overall loss rate is estimated to be about 45%; 40% is estimated to constitute physical losses out of the system and 5% unregistered connections and meter losses. The network distribution efficiency ranges from 45–60% and, of course, this affects negatively the actual water per capita consumption (e.g., thus being actually 90–130 l/c/day).

The future municipal water demands comprise the domestic, public, livestock, commercial and touristic water needs. The demand projections are estimated based on the WHO standards of 100 l/c/day as a minimum and 150 l/c/day as average domestic water consumption. The 70 l/c/day allowed to the Palestinians in the West Bank is well below this guideline. Other consumption rates (including commercial, industrial and livestock consumption rates) are projected as a percentage of the municipal water demand. Assuming the estimated physical loss rate drops to between 8% and 12% to by the year 2010 – a goal that is virtually impossible given the lack of time and money (PECDAR, 2001) – the total domestic demand of 302 MCM/year projected for the year 2010 gives a total domestic/municipal annual per capita water demand of 69 MCM/year (189 l/c/day).

Based on the domestic consumption in line with the WHO standards of 100 l/c/day as a minimum, on the WHO average of 150 l/c/day in the future and on the Palestinian population growth pattern, the following domestic water consumption in the West Bank and Gaza Strip is expected: 260 MCM in 2010 (160 West Bank and 100 Gaza Strip) and 450 MCM in 2020 (285 West Bank and 165 Gaza Strip) (PECDAR/PWA, 2001).

2.2. INDUSTRIAL SECTOR

Due to the constraints imposed on the economic sector in Palestine during the last 42 years of occupation, the industrial sector made a limited contribution to the overall economic development. Consequently, the existing situation of the industrial sector in Palestine (which consists mainly of light and small industries, including quarries, food processing etc.) does not represent the type of stable industry that could be achieved. This implies that the current figures for industrial water demand cannot be utilized for the projection of future water demands. It is stated that the present industrial water demand in Palestine represents about 8% of the total municipal water demand. The fact that it is included in the total current domestic consumption, however, makes it very difficult to estimate. In actuality, the industrial water demand is closer to around 16–20% of that total.

The future industrial water demand for the year 2010 had been estimated at 48 MCM/year (PECDAR/PWA, 2001), but is more likely to be around 25–30% of that.

The national vision at the beginning of the Palestinian Authority regarding the industrial sector was the establishment of 9–12 Palestinian industrial estates, eight of which are to be distributed among the different Governorates of the West Bank, and four in the Gaza Strip. Plans and efforts have continued towards establishing these industrial estates or parks. Currently, the two in the Gaza Strip are obviously not functioning or have been destroyed. Sites for the four in the West Bank (Jenin, Jericho, Bethlehem and Hebron) exist but are undeveloped being hampered by land issues, infrastructural delay, and investment limitations. These goals for the industrial sector inherently represent a projected increase in water demand in the sector.

2.3. AGRICULTURAL SECTOR

Despite the fact that the agricultural sector is constrained by the overall limitations on land and water resources, it consumes the major share of water in Palestine. The role of agriculture is particularly important in the Palestinian economy due to its high contribution to the GDP and to its role in employing Palestinian workers. It plays a major role in national trade, as agricultural products used to constitute between 20–25% of the national commodities export (being artificially lower now due to the political situation).

Irrigated agriculture constitutes more of the total agricultural production than rain-fed agriculture (not including field and orchard crops).Irrigation water in the West Bank is coming from groundwater in the form of wells and springs, and only from wells in the Gaza Strip. The current (2007) irrigation water supply is about 155 MCM/year, about 68 MCM of which are utilized in the West Bank coming from springs and wells. It is important to note that water supplies for irrigation are either shallow, small, old wells or natural springs. Natural springs face the severe problem of discharge variability, and thus these spring sources are not reliable water sources. Although the average discharge of the springs used in agriculture is about 45 MCM/year (2007) in the West Bank, this spring discharge is low in dry years and high in wet years. Due to lack of storage structures, large volumes are lost in wet years. In the year 2010, annual agricultural water demand has been estimated at 360 MCM/year (407 MCM for 2020), which is more than double the current irrigation supply. Wastewater reuse is often cited as an alternative, but it is important to note that such a technique or policy can only be incorporated into the agricultural sector after the time lag needed for infrastructure development, i.e., construction of waste-water treatment plants and piped networks for collection and distribution.

3. Water Supply and Demand in the West Bank

For ease in envisioning Palestinian Districts in the West Bank, see sketch below. Tables 3-10 document the 2007 data of the Palestinian Water Authority for water supply and demand. The 2008 data (which was not yet available in a complete form) shows a reduction in water supply, and therefore a reduction in consumption l/c/d (PWA 2008).

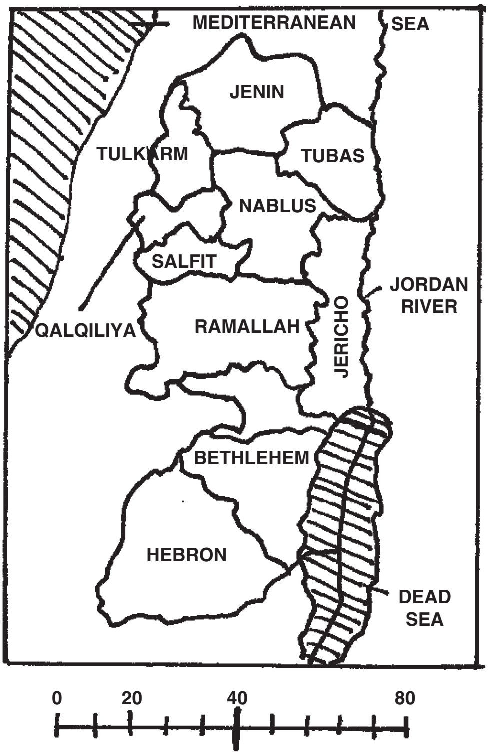

Figure 3. Sketch of districts in the West Bank (Source: Palestinian Water Authority, 2008)

TABLE 3. Distribution of Palestinian Water Resources and Purchased Waters in the West Bank (2007)

District	Population in the West Bank Districts	Palestinian Controlled Water Resources (MCM)	%	Purchased Water (MCM)	%	Total Water Resources (MCM)
Jenin	256,212	3.9327	0.74	1.378	0.26	5.3107
Tubas	48,771	0.623	0.76	0.197	0.24	0.82
Tulkarem	158,213	7.9426	0.96	0.325	0.04	8.2676
Nablus	321,493	7.8703	0.71	3.149	0.29	11.019
Qalqilia	91,046	5.836	0.93	0.466	0.07	6.302
Salfit	59,464	0.121	0.06	1.879	0.94	2
Jericho	41,724	2.666	0.59	1.85	0.41	4.516
Ramallah	278,018	2.82	0.21	10.875	0.79	13.695
Jerusalem	159,000	0.591	0.07	7.46	0.93	8.051
Bethlehem	176,515	1.561	0.18	7.103	0.82	8.664
Hebron	551,130	6.697	0.4	10.166	0.6	16.863
Total	2,141,590*	40.661	0.48	43.82	0.52	84.481

* Excluding East Jerusalem.

TABLE 4. Distribution of Types of Palestinian Resources (2007)

District	Municipal wells (MCM)	Springs (MCM)	JWU* (MCM)	PWA wells (MCM)	Other sources agricultural wells	Total (MCM)
Jenin	1.242	0.1361		1.576	0.9786	3.9327
Tubas	0.501	0.122				0.623
Tulkarem	7.052	0			0.8906	7.9426
Nablus	5.447	2.3733			0.05	7.8703
Qalqilia	4.886	0			0.95	5.836
Salfit	0	0.121			0	0.121
Jericho	0	2.636			0.03	2.666
Ramallah	0	0	2.82		0	2.82
Jerusalem	0	0		0.591	0	0.591
Bethlehem	0**	0***		1.561	0	1.561
Hebron	0.72	0		5.977	0	6.697
Total	19.848	5.3884	2.82	9.705	2.8992	40.661

* JWU = Jerusalem Water Undertaking (a regional utility).

** Bethlehem well (Beit Fajjar) needs to be connected to the Palestinian supply network (180 m^3/h).

*** Artas Spring has not been included.

TABLE 5. Distribution of Purchased Water (2007)

District	WBWD* wells (MCM)	From inside** West Bank (MCM)	From inside green line*** (MCM)	Total including settlements (MCM)	Settlement usage from West Bank purchased water (MCM)	Total (MCM)
Jenin	0	0	1.378	1.378	0	1.378
Tubas	0	0.197	0	0.197	0	0.197
Tulkarem	0	0.325	0	0.325	0	0.325
Nablus	1.345	2.221	0	3.566	0.417	3.149
Qalqilia	0	0.205	0.261	0.466	0	0.466
Salfit	0	1.139	0.74	1.879	0	1.879
Jericho	0	1.85	0	1.85	0	1.85
Ramallah	0.535	1.48	9.63	11.645	0.77	10.875
Jerusalem	0	0	7.46	7.46	0.002	7.46
Bethlehem	2.646	1.906	2.957	7.51	0.406	7.103
Hebron	3.013	0.96	6.652	10.63	0.459	10.166
Total	7.54	10.284	28.05	45.677	2.054	43.82

* WBWD = West Bank Water Department.

** Wells controlled by Israel.

*** I.e. inside Israel.

TABLE 6. Average Water Supply in the West Bank Districts (2007)

District	Population in the West Bank districts	Total water supply (MCM)	Average supply (l/c/day)
Jenin	256,212	5.3107	57
Tubas	48,771	0.82	46
Tulkarem	158,213	8.2676	143
Nablus	321,493	11.019	94
Qalqilia	91,046	6.302	190
Salfit	59,464	2	92
Jericho	41,724	4.516	297
Ramallah	278,018	13.695	135
Jerusalem	159,000	8.051	139
Bethlehem	176,515	8.664	134
Hebron	551,130	16.863	84
Total	2,141,590*	84.481	108**

* Excluding East Jerusalem.

** 108 l/c/day ignores the average of 37% of unaccounted for water (UfW), i.e., water losses. Thus, the average per capita consumption is around 70 l/c/day.

TABLE 7. Average Water Consumption and Unaccounted for Water (UfW)

District	**Population in the West Bank districts**	**Available water (MCM)**	**Consumed quantities (MCM)**	**UfW (MCM)**	**UfW (%)**	**Average consumed (CM/year)**
Jenin	256,212	5.3107	3.64	1.67	31.4	39
Tubas	48,771	0.82	0.55	0.27	32.5	31
Tulkarem	158,213	8.2676	4.62	3.65	44.1	80
Nablus	321,493	11.019	7.02	4	36.3	60
Qalqilia	91,046	6.302	4.49	1.81	28.7	135
Salfit	59,464	2	1.26	0.74	37	58
Jericho	41,724	4.516	3.14	1.38	30.5	206
Ramallah	278,018	13.695	10.15	3.55	25.9	100
Jerusalem	159,000	8.051	5.66	2.39	29.7	98
Bethlehem	176,515	8.664	5.3	3.36	38.8	82
Hebron	551,130	16.863	10.81	6.05	35.9	54
Total	2,141,590*	84.481	56.65	28.86	34.2	72

* Excluding East Jerusalem.

TABLE 8. Average Supply and Needs Deficit (2007)

District	**Population in the West Bank districts**	**Needed quantity [demand] (MCM)**	**Available quantity (MCM)**	**Deficit (MCM) [excluding UfW]**	**Consumed quantity (MCM)**	**Actual deficit (MCM) [including UfW]**
Jenin	256,212	14.03	5.3107	8.72	3.64	10.38
Tubas	48,771	2.67	0.82	1.85	0.55	2.12
Tulkarm	158,213	8.66	8.2676	0.39	4.62	4.04
Nablus	321,493	17.6	11.019	6.58	7.02	10.58
Qalqilia	91,046	4.98	6.302	−1.32	4.49	0.49
Salfit	59,464	3.26	2	1.26	1.26	2
Jericho	41,724	2.28	4.516	0	3.14	0
Ramallah	278,018	15.22	13.695	1.53	10.15	5.07
Jerusalem	159,000	8.71	8.051	0.65	5.66	3.05
Bethlehem	176,515	9.66	8.664	1	5.3	4.36
Hebron	551,130	30.17	16.863	13.31	10.81	19.37
Total	2,141,590*	117.25	84.481	33.98	56.65	61.46

* Excluding East Jerusalem.

TABLE 9. Water Budget for West Bank in (2007)

Source	Quantity (MCM)	Domestic use only (MCM)
Domestic wells	32.373	32.373
Agricultural wells	27.934	2.899
WBWD wells	7.54	7.54
Mekorot wells	10.087	10.087
Water from inside green line (i.e., inside Israel)	28.05	28.05
Springs (inside the West Bank)	44.54	5.388
Mekerot supply for agriculture (Bardala)	4.83	0.197
Total	**155.354**	**86.534**
Settlements supply	−2.054	−2.054
Total net for Palestinians	153.3	84.48
Population (West Bank only)	2,141,950	2,141.95
Per capita supply (West Bank only)	71.6 CM/year	39.4 CM/year 108 l/c/day

Explanatory Note: For the West Bank, 108 l/c/day includes an average of 37% of unaccounted-for-water (UfW), i.e., water losses. Thus, the average per capita consumption is around 70 l/c/day.

TABLE 10. Palestinian Water Resources from Ground Water Basins in the West Bank

Basin	Source	Domestic (MCM)	Agriculture (MCM)	Total (MCM)	WBWD wells (MCM)
	Wells	11.67	10.02	21.69	5.66
Eastern	Springs	2.64	28.84	31.48	
	Total	14.3	38.87	53.17	5.66
	Wells	9.27	5.28	14.54	1.35
North Eastern	Springs	2.53	8.37	10.9	
	Total	11.8	13.65	25.44	1.35
	Wells	11.44	13.47	24.91	0.54
Western	Springs	0.22	2.21	2.43	
	Total	11.66	15.68	27.33	0.54
	Total wells	32.37	28.77	61.14	7.54
Total	Total springs	5.39	39.42	44.81	0
	Sub total	37.76	68.19	105.95	7.54

4. Water Supply and Demand in Gaza

The available 2007 data for the Gaza Strip, Palestine, is as follows (PWA, 2008):

- Total abstracted water: 167 MCM/year.
- Domestic Use: 79 MCM/year, or 217 l/c/day.
- (However, with an average of 45% losses, this yields a per capita consumption rate of about 98 l/c/day [of mostly bad quality water].)
- Agricultural Use: 87 MCM/year.
- Renewable water: 50–60 MCM/year.
- Deficit in Water Balance: 100 MCM/year.

It must also be emphasized that the groundwater quality of the aquifer in the Gaza Strip has been substantially impacted by a huge over-abstraction in excess of the sustainable yield of the aquifer, by raw wastewater discharges, by agricultural water return flow and by salt water intrusion due to the mining of the Coastal Aquifer. This problem of deteriorating water quality has actually reached a crisis proportion in the Gaza Strip and has resulted in serious health problems in the population. Only 18% (about 9 MCM) of the total quantity of water supplied in the Gaza Strip can be considered acceptable based on health considerations. This then would be only 13 l/c/day (SUSMAQ, 2001; Aliewi and Assaf, 2003). Desalination is a potential short-term measure that would provide a non-conventional water source to meet domestic needs, thereby allowing the coastal aquifer to be naturally recharged over time by rainfall infiltration.

5. Gap Between Supply and Demand

Throughout most of this area, there is a gap between water supply and water demand. In Palestine, this gap is growing with time because of increase in population and water needs and because the water supply is artificially constrained by the stagnation of the peace process. This gap is having severe adverse effects on both current and future Palestinian socio-economic development as well as on the outlook for lasting peace in the Middle East region. It should be noted that the demand in 2020 in the West Bank will surely exceed the freshwater supply if no further freshwater water sources are developed. This excess in demand will be even greater if treated wastewater is not available for utilization in agriculture (Badran, 1995).

The gap in per capita water consumption between what a Palestinian needs to use and what he currently uses or consumes must be diminished in order to meet the WHO minimal or average standards. Palestinians in the West Bank and Gaza Strip cannot develop their cities and villages in the future without having access to their rightful portion of the waters of their homeland.

Figures 4, 5 and 6 give a good sense of this gap as it stands, and projections for the future. Figure 4 illustrates water resource availability and increasing demand for the region (Palestine and Israel), delineating the sustainable regional water resources at 2,200 MCM/year (black line). The white line represents Palestinian resources, which were plotted to remain constant at year 2000 levels (277 MCM/year) over a 20-year planning period.

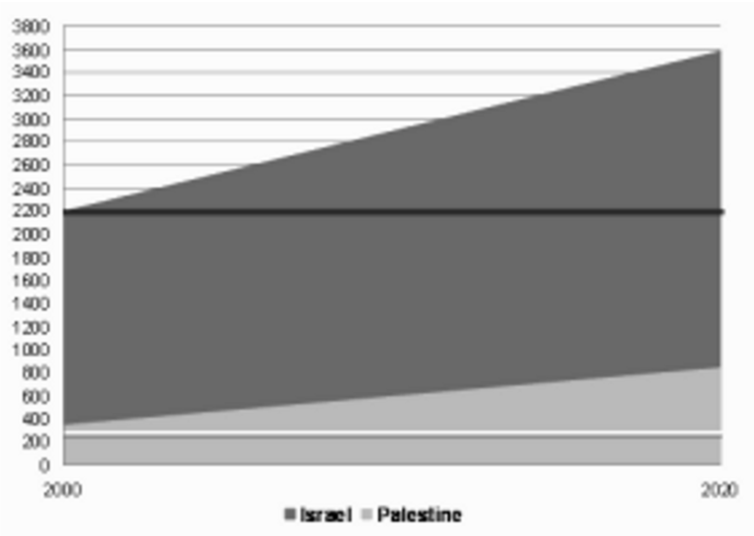

Figure 4. Regional water resources and projected demand (Palestine and Israel) (Estimated values derived from source: PECDAR/PWA, 2001)

Figure 5 shows a projected 129 MCM gap between supply and demand by 2020 in the Gaza Strip if current water availability levels persist (140 MCM supply–269 MCM demand). Similarly, Figure 6 shows a 438 MCM gap between supply and demand by 2020 in the West Bank (137 MCM supply–575 MCM demand) (PECDAR/PWA, 2001). If one considers the present water data (for the year 2007) within the estimated projections of Figures 5 and 6, it reveals the following (PWA, 2008): for the Gaza Strip, Resources 167 MCM, Demand 267, Gap 100; for the West Bank, Resources 155 MCM, Demand 397, Gap 242. It can be noted that the demand value of 267 MCM for the Gaza Strip in 2007 is an outlier point on the projected demand graph, while in the West Bank the demand of 397 MCM is nearer the projected demand slope values. In other words, in the year 2007, the water demand in the Gaza Strip is already exceeding the projected demand curves of 2001 whereas in the West Bank the projections of 2001 still hold.

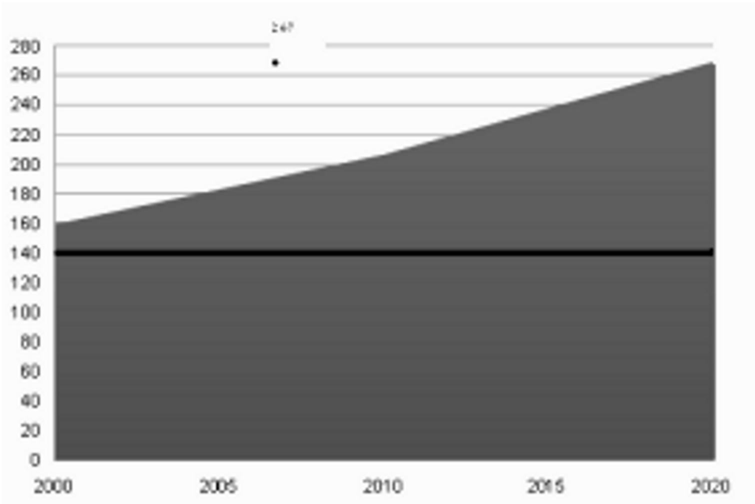

Figure 5. The Gaza Strip with unchanging value for available water resources versus increasing demand. Black line depicts available water resources in the Gaza Strip in 2007 at 140 MCM/year (Estimated demand values derived from source: PECDAR/PWA, 2001)

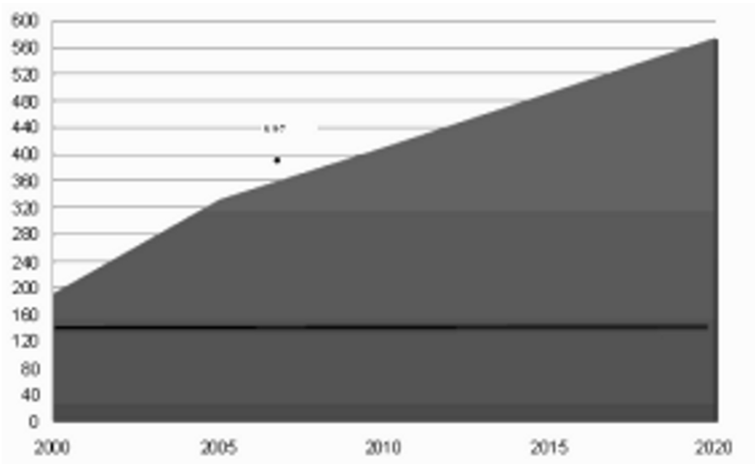

Figure 6. The West Bank with unchanging value for available water resources versus increasing demand. Black line depicts available water resources in the West Bank in 2007 at 137 MCM/year (Estimated demand values derived from source: PECDAR/PWA, 2001)

6. Looking Towards a Solution

The combination of political strife, resource overuse and contaminated sources means that freshwater scarcity will reach a critical level in the near future, if it has not done so already. Add to this scarcity the threats posed by inequality in access and control of water resources in the region, and what evolves is a very urgent humanitarian and environmental crisis. This severe man-made water problem undermines the living conditions and endangers the health situation of the Palestinian people. Thus, it is often the case that the political conflict endemic to this region is a major factor leading to unilateral and unsustainable water management of the Jordan River Basin and the transboundary waters between Palestine and Israel.

A regional approach to the impending water crisis in the Middle East is fundamental to both short and long-term peace and stability. It is a well-known fact that the countries in the region have water resources that cross political boundaries and they are riparians in a major river basin. Just these two geographical and geological facts point to the need for regional cooperation, and to the need for a definition of water rights. It is critical that the region address both the current and future situation in the water sector from a regional perspective.

Having equitable and coordinated water shares in the Palestinian aquifer basins and the riparian share of the Jordan River can definitely fill the gap for Palestinian water demand. One must remember the fact that Palestinians use only a fraction (~15%) of the water resources from the aquifer basins in Palestinian areas, while Israel uses the remaining 85%. Furthermore, the Palestinians currently have no water rights in the Jordan River Basin despite the fact that they are clearly a riparian.

The sustainable development of Palestinian water resources should be based on economic growth, social equity, protection of the water resources and their environment, as well as improved governance. The Palestinian Water Authority (PWA) was made responsible for managing water resources and wastewater with the mandate to capture the most important issues and strategic interventions when developing water resources for supply purposes. This mandate includes (Assaf 2005, Assaf et al., 2004, Assaf 2000 a,b, Assaf and Assaf 1985):

- Pursuing Palestinian water rights.
- Strengthening national policies and regulations.
- Governing water and wastewater investments and operations.
- Enforcing pollution control and protection of water resources.
- Building institutional capacity.
- Promoting regional and international cooperation.

Under the existing water law, the water service delivery will be handled through three regional utilities in the West Bank, and a separate one in the Gaza Strip. These regional utilities will coordinate their activities with the local government network and Joint Service Councils will be established to organize and represent the interests of smaller communities. A separate bulk utility is also planned which will take the responsibility for the development, collection and transportation of bulk water supplies to, from and between the various regional utilities (including the Gaza Strip). The Palestinian Water Authority will be a regulator, will establish standards, and will hold the essential and crucial role of strategic planning and coordination, policy and planning and integrated water and wastewater resource management.

In order to serve nearly all the Palestinian people with a continuous and reliable piped water system with WHO quality and quantity standards, the following needs were recommended in a study by PWA and PECDAR (2001):

- Identification and development of existing and new water sources.
- Rehabilitation of existing wells and springs in order to preserve quality and quantity.
- Rehabilitation and construction of water reservoirs.
- Rehabilitation and expansion of distribution networks.
- Provision of a means to transfer water from area to area when needed.
- Improvement of irrigation networks/practices in order to at least double the irrigated lands in the West Bank so as to ensure a reasonable food security for all Palestinians.
- Setting-up of infrastructure to increase treated wastewater use in the West Bank and the Gaza Strip and provide proper management and education campaigns for assuring acceptance of wastewater re-use.

The industrial and agricultural sectors, which are major consumers of water, have a social and environmental responsibility to ensure that their water use does not curtail the essential domestic uses, either through over-abstraction or pollution of water sources. In addition to complying with national legislation, these two sectors also should minimize water use and promote effective water conservation methods, as well as minimize any contamination of water resources.

Potential management options for the future water and wastewater sector in Palestine cover a wide range, both on the demand and on the supply sides of the problem. The management decision that is most often sought after is demand management – with all of its alternatives, as outlined below:

Demand management options:

- Reducing demand by decreasing losses in the delivery system.
- Reducing demand by shifting quality use in industry and agriculture.
- Reducing demand through crop shifting and other agricultural interventions.
- Reducing demand by the efficient use of rainwater harvesting.

- Reducing demand by the re-use of treated wastewater.
- Reducing demand through socio-cultural interventions.
- Reducing demand by controlling water use through price mechanisms.
- Desalination (including associated infrastructure), which reduces demands on fresh water.

Other conventional, non-conventional and country-specific management options for Palestine include the following:

- Groundwater supply development (including associated infrastructure).
- Surface water development (including the utilization of wadi and urban runoff).
- Sectoral reallocation.
- Changes in agricultural policy.
- Environmental protection and conservation.
- Tanker supply and/or filling points for public use.
- Direct connection to Mekorot (the Israeli water service provider) – *or not?*
- Water transfer (from district to district, from sub-basin to sub-basin, good quality water to augment marginal quality waters).
- Regional administrative and institutional structures.
- Importation of water (either from Turkey, or 'virtual water').

Management options to be considered if one wants to focus on the adaptation to periodic or increasing drought conditions in the region are (Assaf 2005, SUSMAQ 2005):

The re-use of regional water(s)

- Reuse of treated wastewater.
- Reuse of collected and treated storm water and urban runoff.
- Small to large-scale rainwater harvesting schemes.
- Small to large-scale artificial recharge schemes.

The maintenance and development of water resources in wadis.

- Utilization of intermittent wadi flows.
- Development, preservation and utilization of small springs.
- Land use studies, including the return of the practice of extensive land terracing for the beneficial use of available rainfall.

The storage and distribution of scarce waters

- Studies of different types of small to large-scale reservoirs and pools.
- Leak detection surveys and maintenance programs.
- Household water tank surveys and water quality testing.

Adaptive agricultural practices – changing cropping patterns

- Pilot projects for the development of economic industrial crops in the agricultural sector (e.g., jojoba, aloe vera, and bio-fuels).
- Pilot projects for trees and ground-covers to combat desertification.
- Promotion of rain-fed and drought resistant trees and crops to farmers.
- Promotion of both public and individual interest in environmentally needed greenery for the region, i.e., plant-a-tree, fence-your-land with trees, etc.
- Lining irrigation canals, reusing drainage water, improving the efficiency of irrigation practices.

Saving water in the household

- Promotion and pilot projects to illustrate and demonstrate the positive effect of utilizing water-saving and efficient household fittings.
- A demonstration project showing how dual piping (fresh and grey waters) works in a normal household.
- Promoting both public and private participation (i.e., community development) in water, sanitation, and environmental projects.

7. Conclusion

As seen from all of the above, there is not just one way to 'fix' the water issues in Palestine. Diverse technologies – both appropriate local technologies and high-tech solutions – need to be implemented.

It is widely recognized that the current water and sanitation crisis in Palestine is caused by issues related to poverty, inequality and unequal power relationships. While the provision of water supply and sanitation services to the urban population is a serious and growing challenge, it is important to recognize that a large percentage of Palestinians reside in rural areas (or refugee camps) having the most poverty, and the poorest health and water services in Palestine. The current challenge of the rural/camp services gap and the future growth in urban populations requires a balanced approach between urban and rural actions.

Water availability in Palestine is declining with the years due to increasing demands, unsustainable withdrawal rates, inaccessibility to existing supplies, difficulties in finding new supplies, pollution and contamination, and climatic patterns. Often considered a local supply and demand issue, concerns over availability of water resources in Palestine are increasingly beginning to take on regional and international proportions. The challenge will be to develop and manage the policies, programs and projects in Palestine in a sustainable way with the goal of making water available to the people/users and sectors in both space/location and at the right time.

References

Aliewi, A. and Assaf, K., 2003. *Assessment of Water Demand Management in Palestine: Identifying the Gaps and the Constraints, Envisioning Challenges and Opportunities*, 2nd Regional Conference on Water Demand Management and Pollution Control, Sharm Al-Sheikh, Egypt, ESCWA/UNEP/UNESCO/WHO, December 14–17.

Assaf, K., 2000a. *The Palestinian Situation: The Need to Legally Define "Palestinian Water Rights"*, country paper for Palestine presented at Expert Group Meeting on Legal Aspects of the Management of Shared Water Resources, Sharm El-Sheikh, June 8–11 2000. Economic and Social Commission for Western Asia (ESCWA), and Center for Environment and Development for the Arab Region and Europe (CEDARE).

Assaf, K., 2000b. *The Need for Joint Management and Monitoring of the Water "Usage Cycle" in Management of Shared Groundwater Resources: The Israeli–Palestinian Case with an International Perspective*, E. Feitelson and M. Haddad, eds., International Development Research Centre, Ottawa, Ontario, Canada, pp. 75–82.

Assaf, K., 2005. *Basic Needs in Development: Focus on the Water Sector in Palestine*, in: Proceedings of the First Palestinian International Water Conference, entitled: Water: Values and Rights, May 2–4, 2005, Ramallah, Palestine. Published by the Palestinian Academy of Science & Technology and the Palestinian Water Authority, pp. 589–603.

Assaf, K., Attia, B., Darwish, A., Wardam, B., and Klawitter, S., 2004. *Water as a human right: The understanding of water in the Arab countries of the Middle East – A four country analysis*, Global Issue Papers, No. 11, published by Heinrich Boll Foundation, Berlin, September, p. 168.

Assaf, S., 2004. *The Need for Implementation of a Water for Peace Strategy for the Jordan River Basin Countries Through a Shift in Cropping Patterns*, IPCRI Water for Life Conference, Anatalya, Turkey, October.

Assaf, S. and Assaf, K., 1985. *Food Security in the West Bank and Gaza Strip*, ASIR publication for ESCWA/FAO Joint UN Division and AOAD of the Arab League, U.N. Publication, Rome, Italy, October.

Badran, A., 1995. *Water in the Islamic World – An Imminent Crisis*, The Islamic Academy of Sciences, Amman, Jordan.

Commission on Sustainable Water Supplies for the Middle East, 1999. *Water for the Future in the West Bank and Gaza Strip, Israel and Jordan*, National Research Council, National Academic Press, Washington, DC.

NAKBA State Information Service, 2005. *Agriculture and Water Resources in Palestine Before 1948*. http:/nakba.sis.gov.ps/English/life-48-3.html.

Palestinian Water Authority, 2008. *Water Sector Status in the West Bank: Summary Report with West Bank Governorates Short-Term Emergency and Development Plan*, personal communication.

PECDAR (Palestinian Economic Council for Development and Reconstruction) and PWA (Palestinian Water Authority, 2001. *Palestinian Water Strategic Study*, Ramallah, Palestine.

SUSMAQ (Sustainable Management of the West Bank and Gaza Strip Aquifers), 2001. *Technical Background on Water Issues for the Final Status Negotiations, Illustration Report*. Report No. SUSMAQ-NEG #10 V 1.0 Ramallah: Palestinian Water Authority (Palestine) and University of Newcastle upon Tyne (UK).

SUSMAQ (Sustainable Management of the West Bank and Gaza Strip Aquifers), 2005. *Sustainability Assessments of Water Sector Management Options for the Palestinian Territories*, Report No. SUSMAQ-SUS #60 Vo. 6. Ramallah: Palestinian Water Authority (Palestine) and University of Newcastle upon Tyne (UK).

Water in Palestine, excerpts from Palestine Monitor Fact Sheet, If Americans Knew (January 27, 2008); www.ifamericansknew.org/cur_sit/water.html.

SECTION III

INTERNATIONAL COOPERATION IN AREAS OF EXTREME CONDITIONS

MANAGING TRANSBOUNDARY WATERS IN EXTREME ENVIRONMENTS: THE ROLE OF INTERNATIONAL ACTORS IN AFRICA

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Abstract: Africa is a continent of extreme water resource environments with arguably the greatest spatial and temporal natural water supply variability in the world. Africa is also a land of transboundary waters. With the exception of island states, every African country has territory in at least one transboundary river basin. These basins cover 62% of Africa's total land area, and virtually every one greater than 50,000 km^2 crosses at least one national boundary. The management of these transboundary waters in conditions of such variability has been made even more complex by the unique political and economic history of the continent, in particular as related to the involvement of outside actors. In the first half of the 20th century this involvement was related to colonialism. From the second half to the present, it has involved bi-lateral and international donors, lenders and international NGOs. In this paper, we examine the impacts of this influence by first reviewing the development of transboundary water law in Africa. We then examine how the global norms now mentioned in African law, in particular equity in water allocation, have actually influenced agreement content. Finally, we examine the extent to which influences wielded by international actors are a logical response to conditions in Africa's international basins. The results highlight the tangible influences of international actors on the orientation and content of basin level agreements and suggest the use of greater discretion in the application of international paradigms to water management agreements in extreme environments.

Keywords: Transboundary waters; international agreements

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1. Introduction

Africa is a land of climatic extremes with arguably the greatest spatial and temporal natural water supply variability in the world (Walling, 1996). Spatially, climatic variation is evidenced in the range of mean annual runoff in the continent's river basins; for example, from areas of high annual flow in central Africa basins such as the Congo to regions of low flow in the north and south such as the Orange (FAO, 2001; Mwanza, 2003). The temporal variation is seen in intra-annual precipitation and river flow, which tend to be highly concentrated in certain months of the year (Grey and Sadoff, 2006; Mwanza, 2003). Inter-annually, the continent's basins generally endure high rainfall variability between years, subjecting those dependent on natural river flow to periodic droughts and floods with potentially devastating effects (Brown and Lall, 2006).

Africa is also a land of extreme dependence on transboundary waters.[1] With the exception of island states, every African country has territory in at least one transboundary river basin. Furthermore, transboundary basins cover 62% of Africa's total land area, and virtually every one greater than 50,000 km^2 crosses at least one national boundary. In these conditions, most African water management is also, by definition, transboundary water management.

Africa's extreme environments, its transboundary water supply, and its long history of foreign intervention in water law formation provide a rich setting for analyzing how external actors impact transboundary water law in extreme environments. This paper begins with the historical context for the development of transboundary water law in Africa and the role of outside actors. The study then examines how global paradigms and principles, in particular that of equity in water allocation between countries, have actually influenced agreement content. Finally, the paper explores the extent to which global influences on transboundary water law in Africa are aligned with local conditions. The results highlight the tangible influences that the international community can wield over the orientation and content of basin level agreements, and provide insights for both basin managers and the international community on the formation of future agreements in extreme environments and elsewhere.

2. Historical Context: Transboundary Water Law in Africa[2]

To assess how African transboundary water law has changed over time and space, we compiled a collection of 153 agreements, treaties, protocols, and significant amendments which considered water as a scarce or consumable

[1] As in similar studies, we acknowledge differences in meaning of the term "transboundary". Here we follow the definition provided in UNITED NATIONS, WATER FOR PEOPLE WATER FOR LIFE (2003), which classifies transboundary waters simply as those waters which cross national boundaries.

[2] This section draws from Lautze and Giordano (2006).

resource, a quantity to be managed, or an ecosystem to be improved or maintained. We did not include agreements dealing only with boundaries, navigation, or fishing rights. Analysis of treaties combined with contextual knowledge suggested a historical division of transboundary water law in Africa into three periods for discussion: The Colonial Period (1862–1958), The Early Independence Period (1959–1989) and The Late Independence Period (1990–2004).

2.1. PHASE I: THE COLONIAL PERIOD, 1862–1958

In the latter half of the 19th century, the concept of the nation-state was introduced in (or imposed upon) Africa, as colonial powers carved up its vast territory. The particular manifestations of colonial geography in turn determined the specific internationalization of Africa's waters. The Niger basin, for example, became a transboundary water source shared by French and British colonies. In contrast, the Senegal basin, entirely within the realm of French colonial influence, was not internationalized until Guinea gained independence in 1958.

Written agreements concerning Africa's transboundary waters coincided with early stages of European colonization of the continent. Agreements at this stage focused primarily on land acquisition, through which water emerged as a secondary concern. Through an 1862 convention, for example, France acquired land rights from the Danakils, nomadic cattle herders in the Horn of Africa. Negotiations then addressed withdrawal from rivers and springs on the acquired land and allowed France to establish reservoirs "by common consent".

Another set of agreements forming a large body of early transboundary law attempted to alleviate problems of customary access to water resources arising out of newly created colonial boundaries. One such agreement was the *Exchange of notes between France and Great Britain respecting navigation and use of the Great Scarcies River* (1895), relating to a basin now shared by Guinea and Sierra Leone.. The treaty allowed the "riverain inhabitants dwelling on the right bank," put under British rule and cut off from the river by the imposition of a boundary defined in a previous treaty, to "continue to use the river to the same extent as heretofore." A total of 18 agreements from the colonial period dealt with such "native" access issues.

Beyond these relatively minor water-related accords, there are 23 colonial period agreements dealing with more substantive issues. The fact that approximately 60% of these apply to the waters of the Nile river basin is not particularly surprising given its importance to British colonial government with respect to agricultural output and derived revenue as well as the sheer level of water resource utilization in the basin relative to other rivers in Africa at the time (Godana, 1985).

Unlike that over the Nile, the remaining nine substantive water agreements were signed between or among colonial powers. A total of five agreements applied to the Congo, Cunene, Great Scarcies, and Zambezi rivers, all concerning hydropower production. Two treaties over the Gash focused on water-sharing for irrigation projects. The remaining two accords concentrated broadly on water sharing and division in the transboundary waters of French and Spanish Morocco as well as French and British Togoland. Interestingly, none of these basins have suffered from the post-independence tensions now found in the Nile. While there may be a number of reasons for the different outcomes,[3] it seems that there was more consideration for power equality in agreements signed between colonial powers than those signed between a colonial government and an independent African state.

Another interesting aspect of colonial period water agreements is the relatively large proportion (some two thirds) which consider allocation.[4] While flexible water allocation principles are considered integral to resilient transboundary water law, arriving at a consensus can be difficult. Upstream riparians generally argue for 'absolute territorial sovereignty', a concept holding that a state has the right to do as it wishes with the water within its boundaries, while downstream riparians argue for the 'absolute integrity of the watercourse', which holds that upstream riparians can do nothing to impact the quantity or quality of water which would flow out of their territory (Dellapenna, 2001).

According to Dellapenna (2001), actual negotiations tend to move away from these two extreme principles and instead take a vague compromise position known generally as limited (or restricted) territorial sovereignty which allows the "reasonable and equitable use" of international waters so long as they inflict "no significant harm" on co-riparians. In practice, Wolf (1999a) found in a survey of some 150 treaties from around the world that a variety of allocation principles falling between the two extremes had been applied including prior (historic) use, prioritization of use, and equal division.

Of the colonial period agreements which include a conceptual basis for water allocation, most employ criteria based on historic use or historic use combined with an equal sharing of future water usage.[5] Two agreements, one related to the Cunene and another concerning an upstream portion of the Nile basin, use an 'equal shares' approach which divides water benefits 50–50 so long as each riparian makes equal investments in water infrastructure. One final agreement, related to the Gash, uses what might be called a 'needs' approach by quantifying the water required to operate current and possible future irrigation schemes and dividing water to meet those volumes. Irrespective of the conceptual bases used in the treaties, only two – one concerning the Nile and the Gash agreement just discussed – in fact translate stated water allocation criteria into explicit quantities.

[3] Including the fact that some of the agreements are now defunct.

[4] While the sample size here is small, Hamner and Wolf (1998) found that less than 40% of treaties globally included allocation criteria.

[5] Note that this rationale was extremely common in agreements applying to the Nile's waters.

Apparently consistent with global norms at the time, none of the colonial-era agreements in Africa provide for the creation of management institutions such as river basin organizations or technical monitoring bodies. No substantive colonial water treaty mentions groundwater[6] and only one makes reference to water quality. That agreement, signed in 1934 in London by Belgium and the United Kingdom over water rights on the border between Tanganyika and Ruanda-Urundi, is notable as one of the world's first related to transboundary water quality.[7] It states that "no operations…shall be permitted…which may pollute or cause the deposit of any poisonous, noxious, or polluting substance in the waters of any river…" Finally, only a quarter of the period's substantive agreements encourage exchange of hydrological data, and about one third contain conflict resolution mechanisms. None contain provisions for amendment or modification.

2.2. PHASE II: EARLY INDEPENDENCE PERIOD, 1959–1989

The first transboundary water agreement between independent African states was signed in 1959 between Sudan and the United Arab Republic (Egypt). This agreement mirrored the colonial period trend of a strong focus on the Nile, but a number of additional treaties would follow that set the early independence period apart for reasons beyond the colonial status of their signatories. Among other changes, the transition into independence ignited a drastic acceleration in the rate at which agreements were produced. While only 49 agreements were signed during the 96 year colonial period, 72 were completed in the initial 31 years of independence, representing a fourfold rate of increase.

Of the 72 agreements from the early independence period, 13 were not located, one did not meet our criteria for analysis, and an additional 15 are essentially water infrastructure aid packages between an outside, typically Western, country and an African nation or basin organization. While such agreements can clearly impact water use and co-riparian relations, they are closer to what has come to be known as 'transnational',[8] as opposed to 'transboundary' agreements, and so are excluded from the remainder of this discussion.

Analysis of the 43 remaining agreements reveals fundamental changes in treaty nature and content as compared to the colonial period. While most colonial agreements focus on discrete goals such as division of water resources or construction of dams, those in the early independence period shifted to less concrete but more expansive concerns and structures. For example, joint

[6] Though many of the territorial secession and "native" treaties do with respect to well access.

[7] Note that Giordano (2003) did not include this treaty in her analysis.

[8] Transnational agreements, usually facilitating development aid, are between one riparian or riparian organization and one or more non-riparian states. While these agreements apply to transboundary waters and are therefore included in the broad list in the appendix, they do not meet our criteria for analysis and so are excluded from subsequent examination.

management[9] is a goal in 90% of agreements and water development is a goal in about three-quarters.[10]

To achieve these new goals, over three quarters of the period's agreements include provisions for water management institutions – usually called river or basin "authorities", "commissions", or "organizations" – to facilitate collective decision making on management of shared water resources. In fact it is this period that gave rise to the first true transboundary river basin organizations in Africa and saw the formation of the Senegal, Niger, Kagera (a tributary of the Nile), and Gambia basin organizations. Of the agreements behind these organizations, approximately half were designed with specific provisions for modification or amendment in light of changing circumstances or conditions.

The focus on joint management and water development in the early independence period agreements stands in stark contrast to those in the colonial era. However, while the change might be ascribed to the new-found ability of independent states to assert their desires and preferences in transboundary agreements, it may in fact be more a function of a coincident shift in thinking imposed, or at least encouraged, by international organizations and lending institutions involved with signatory states. This new thinking emerged in the 1960s and began to consider negotiations reflected in cooperative management structures within codified agreements as more 'civilized' or 'mature' than strict codifications of allocation or distribution (Nader, 1995). The possibility that this change in focus was a function of a changing global environment rather than the end of colonialism is also consistent with the growth in transnational agreements during the period, as well as knowledge of the role of outside institutions in the formation of at least some transboundary institutions of the time (Dellapenna, 1994; Nakayama, 2003; Wescoat, 1996).

Whatever the case, the new emphasis on joint management and development can be associated with a concomitant reduction in focus on water allocation, with only about 20% of the period's treaties containing any provisions for division. Of these, historic use forms the basis for water allocation in two thirds of agreements, while "needs" and unclear criteria[11] make up the remaining one third. Half of the total include explicit quantifications of volume. Interestingly, all of the basins to which these treaties apply – the Nile, Cunene, and Orange –

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9 An agreement was defined to have "joint management" as a goal if it included an explicit statement regarding the creation of an institution or mechanism through which water resources would be collectively managed as a means to achieve overall benefit and avoid potential conflict. An example is the 1980 Convention creating the Niger Basin Authority whose objective was to promote "co-operation among member States and to ensure an integrated development of the Niger Basin in all fields, by developing its resources particularly in the fields of energy, water resources, agriculture, animal husbandry, fishing and fisheries, forestry exploitation transport, communications and industry."

10 Note that the authors possess only synopses to some of the relevant agreements. When the inclusion or exclusion of a treaty component could not be determined from synopses, the agreement was removed from dominator of the calculation as well.

11 Criteria are considered "unclear" when explicit statements of allocation are made but no rationale for the allocation is given.

are generally thought of as water scarce, with relatively high levels of development and use relative to available supplies (FAO, 2001).

Another difference between the colonial and early independence period is the geographic distribution of agreements. While substantive agreements during the colonial period involved only seven basins and focused on the Nile, those in the early independence period covered 12. There remained, however, a focus on a few basins; approximately 23% applied to the Niger, 17% to the Gambia, and 15% to the Senegal.

A final note should be made regarding the increasing consideration of equity in transboundary African water law in relation to global developments. In 1966, the International Law Association adopted the Helsinki Rules, which provide a set of guidelines for 'reasonable and equitable' sharing of common waterways (Caponera, 1985; Ilomaki, 1999). Later, the United Nations General Assembly created the International Law Commission (ILC), which produced the UN *Convention on the Law of the Non-Navigational Uses of International Watercourses*,[12] a collection of guiding principles for transboundary water management with continued concern for equity. While the convention was not completed until 1997, the process of its formation, along with the Helsinki rules before it, did have a clear influence on equity considerations in binding basin specific transboundary agreements. In the case of Africa, the use of the word "equitable" as a basis for an agreement first appeared in 1986, but only this and one other agreement from the period refer to the concept in relation to water.

2.3. PHASE III: LATE INDEPENDENCE PERIOD, 1990–2004

In total, 36 African transboundary water agreements were signed in the late independence period. Seven of these were transnational and the texts of three others could not be located. On the surface, the 26 which remain appear much the same as those in the period before, and follow the trend towards increasing "robustness". For example, approximately three quarters either assume or create water management institutions,[13] and about half of these institutions contain amendment mechanisms. Furthermore, the percentage of treaties encouraging exchange of hydrologic data increases modestly while fully two thirds now make mention of water quality. Finally, the proportion of agreements containing conflict resolution mechanisms remained near the earlier, already high, levels.

The principal goals of the period's agreements are also outwardly much the same as in the prior period, with emphasis generally placed on joint management of shared water resources and economic development. Close examination of the treaties, however, shows that the goal of "water development" gradually changes

[12] UN Document A/RES/51/229.

[13] Note also that several agreements which do not create joint management structures attempt to create a framework for future creation of such structure.

to "sustainable development" as countries (at least officially) seek to achieve their development goals without placing undue burden on the environment. Of the seven "sustainable development" treaties, environmental concerns appear to play an important role in the agendas and function of three, while the remaining four – all of which involve South Africa – voice only a general concern for environmental sustainability. Like the shift toward joint management in the previous period, the orientation toward sustainable development in this period may reflect a fundamental change in desires within Africa itself or, perhaps more likely, the acceptance of the changing global resource management paradigm with respect to water (World Commission on Dams, 2000).

Less subtle is the shift in spatial distribution of agreements. While treaties in the early independence period disproportionately apply to the shared basins of West Africa, this period's agreements focus on southern Africa. Even excluding the two Southern African Development Community (SADC) agreements which apply broadly to all that region's basins, 27% of agreements apply to the Orange River basin and about 19% of agreements relate to the waters of the Inkomati.[14] Furthermore, South Africa itself is involved in half of the period's treaties.

Another interesting development in this period is the increased inclusion of allocation criteria. Roughly half of agreements possess criteria for dividing a basin's waters stressing the concepts of "equity", "sustainability", "prior use" and "needs". While the inclusion of equity and sustainability principles could increase vagueness, nearly half of these allocation treaties do in fact contain explicit quantifications for how water or its benefits are to be shared.

Finally, it was during this third phase in African water law that the UN officially released its *Convention on the Non-Navigable Use of International Watercourses* (Ilomaki, 1999). More than half of the substantive agreements from the period make mention of 'equity' as either an overarching principle or actual criteria for water allocation. Such treaties were almost certainly influenced by the UN convention and now add to its legitimacy as customary law (Dellapenna, 2001).

3. The Influence of an International Principle: Equity[15]

As indicated above, the concept of "reasonable and equitable utilization", enshrined in the 1966 Helsinki Rules and the UN's 1997 *Convention on the Non-Navigational Uses of International Watercourses*, is one of the defining legal principles in transboundary water law (Mechlem, 2003; Schroeder-Wildberg, 2002). The actual impact of equity on transboundary water treaties, however, remains a subject of dispute. Has this language really made a difference in transboundary water law at the basin level? If so, what substantive difference

[14] Note that the Inkomati is also spelled Incomati.
[15] This section draws from Lautze and Giordano (2006).

has it made? Analysis of the all the treaties in the collection of African transboundary water law reveals that 16 out of a total of 93 either include the words "equity" or "equitable" in relation to water, or explicitly reference to the 1966 Helsinki rules or 1997 IWC. The results of a comparative study indicate both qualitative and quantitative differences between the 16 equity agreements and the others, supporting the assertion that the inclusion of equitable language in basin level transboundary water law is in fact associated with more equitable agreements.

3.1. EQUITY IN TRANSBOUNDARY WATER LAW: QUALITATIVE COMPONENTS

One way to determine whether the introduction of equitable language has marked a substantive change in treaty content is to divide Africa's transboundary water laws into two groups: one whose treaties make reference to equity, and one whose do not. An analysis can then be conducted to determine the extent to which treaty components generally considered important in international water law are found in each group's agreements (Hamner and Wolf, 1998; Conca and Wu, 2002; Matsumoto, 2002; Giordano and Wolf, 2003).

Table 1 shows the results of this analysis. First, it should be noted that no agreements prior to the 1980s made use of equitable language, even if signatories may have intended to incorporate the concept at some level.[16] Second, treaty elements shown in the table also reflect temporal trends unrelated to equity. The table is thus further divided into pre- and post-1980 phases so as to isolate relationships with equity from those with time.

TABLE 1. Qualitative Comparison of Transboundary Water Agreements in Africa

	Agreements making no reference to equity	**Post-1980 treaties making no reference to equity**	**Agreements making reference to equity**
Inclusion of amendment mechanism	22%	16%	69%*
Inclusion of a conflict resolution mechanism	38%	26%	75%*
Provision for exchange of hydrologic data	35%	47%	88%*
Reference to water quality	19%	26%	81%*
Provision for a management structure	33%	72%	88%
Inclusion of the majority of riparians	50%	59%	69%

* Statistically different (.05 level) from post-1980 agreements making no reference to equity.

[16] The 1972 treaty applying to the Senegal provides a good example of this.

From the table, it is clear that those agreements making reference to equity differ from those which do not, with equity agreements more likely to include each of the elements listed, and in four of the six cases, with statistically significant variations. This is a strong indication that accords mentioning equity are much more equipped to consider the "geographic, hydrographic, hydrological, climatic, and ecological factors" contained in the IWC and associated with comprehensively equitable arrangements (Schroeder-Wildberg, 2002).

Is it the *consideration* of equity alone that induces the change in treaty structure, or does equity merely accompany the other treaty components? As for the four elements which were significantly more likely to be included within equity agreements – amendment and conflict resolution mechanisms, provision for exchange of hydrologic data, and reference to water quality – a case can be made that resilient agreements for equitable sharing of resources are in fact more likely to require such components. The ability to amend an agreement may facilitate adaptation of equity to hydrologic and demographic changes even if not invoked, the exchange of hydrologic data provides mutually agreed-upon bases for decision making, and conflict resolution mechanisms supply avenues for dispute settlement should there be misunderstandings.

At the same time, one would hypothesize that treaties claiming equity would be more likely to contain provisions for a management structure and include most riparians, yet neither component shows a statistically significant increase in equity agreements. Given that joint management structures have been a hallmark of African water agreements since the 1980s, one might expect treaties referring to equity to include all or most basin riparians. Although full inclusion is not necessarily a condition for a successful, or indeed equitable, agreement, it stands to reason that the potential for an equitable treaty increases when the interests of most or all affected parties are considered.

To summarize, there are clear differences between the contents of equity agreements and other treaties. While the results shown in Table 1 are generally consistent with the idea that equity treaties require more robust structures, the failure of equity agreements to have greater riparian inclusion limits the applicability of these structures. Still, textual analysis alone will never allow one to unequivocally determine if equity considerations *cause* change in agreement content, or if such changes affect actual agreement function. Analysis of the relationship between equity and allocation can shed additional light on this dynamic.

3.2. THE CORE OF TRANSBOUNDARY WATER LAW: WATER ALLOCATION

While the more qualitative analyses of the previous section demonstrate that considerations of equity are clearly related to general treaty content, they do not indicate whether such considerations impact water allocation – arguably the core of transboundary water law (Wolf, 1999a) – between or among states. Further, these analyses fail to illuminate which, if any, of the commonly suggested criteria for determining equity are actually used in basin level agreements. In order to understand the impact of equitable language on water allocation, three of these criteria – a riparian's share of basin area, its contribution to basin runoff, and its share of basin population – were assessed against the codified water allocations. The results for those agreements that claim to consider equity were then compared with those making no such claim to determine the nature and extent of any differences.

Of the 93 substantive African agreements available for textual analysis, only 34 contain conceptual criteria for allocation of shared waters, and only 8 of these 34 apply such criteria to produce explicitly quantified water allocations. Of these eight agreements possessing quantified water allocations, four claim equity as at least one component of their basis for allocation. Of the four agreements that do not claim equity as a basis for allocation, two employ prior (historic) use as the basis for water allocation and two use needs-based criteria. 'Prior use' bases future water utilization on past patterns, while 'needs'-based criteria incorporate a variety of relatively ambiguous variables such as population and levels of development.

To determine if the four 'equitable' allocation agreements differ in substance from the four that make no claim to equity, the relative water allocations assigned to each riparian state were compared with states' relative land area within the basin in question,[17] its relative contribution to basin runoff,[18] and its share of basin population[19] using the three simple equations below.

$$C_r = \sum_{i=1}^{N} \frac{|A_i - R_i|}{2}$$

$$C_L = \sum_{i=1}^{N} \frac{|A_i - L_i|}{2}$$

$$C_p = \sum_{i=1}^{N} \frac{|A_i - P_i|}{2}$$

[17] The quantity of runoff by basin riparian was calculated using GIS data. Calculations are on file with the author.

[18] Land area occupied by each basin riparian was taken from UNESCO (2003). Data and calculations are on-file with the author.

[19] Basin population by riparian was taken from the TFDD Spatial Database website in most cases. Population figures for the Inkomati sub-basin were derived using GIS data. Calculations are on file with the author.

C_r = Composite Deviation, runoff

C_L = Composite Deviation, land area

C_p = Composite Deviation, population

A_i = Percent of basin water allocated to riparian i

R_i = Percent of basin runoff contributed by riparian i

L_i = Percent of basin land area occupied by riparian i

P_i = Percent of basin population within riparian i

N = Number of riparians

In essence, each equation takes the absolute value of the difference between the percentage of water allocated to a riparian state and that state's share of basin runoff, area, or population. The outcomes for states within a basin are then summed by indicator to give a basin scale result. For expository purposes, the results are divided by two so that values fall between 0 and 100. A composite deviation of 0 indicates that water has been allocated in direct proportion to the given indicator: runoff, area, or population. Conversely, a composite deviation of 100 indicates that water is allocated in direct disproportion to the indicator under consideration. Thus, composite deviations close to 0 show relative equity in water distribution (with respect to a given indicator) while values closer to 100 indicate inequity.

Table 2 provides a summary of the results from application of the methodology to the eight allocation treaties. Values are also averaged by indicator separately for agreements referring to equity and those not referring to equity. These averages are portrayed graphically in Figure 1.

These findings strongly indicate that African transboundary water agreements which make reference to equity are in fact more equitable when analyzed with respect to any of the three measures presented here: runoff contribution, land area, or population. Among those agreements that do not reference equity, the two most inequitable – those with the highest composite deviations – both apply to the contentious Nile river basin. A critique of this analysis may therefore be that these Nile river agreements are perhaps outliers which distort the average for agreements not mentioning equity and create an overstated distinction. However, even when these outliers are factored out, the result still reflects a substantial difference (between 18 and 37 points) from averages of equity agreements.

TABLE 2. Composite Deviations from "Equity" in Relation to Runoff, Land Area and Population

	Runoff	Land area	Population
Agreements making no reference to Equity			
Exchange of notes between the United Kingdom and Italy respecting the regulation of the utilization of the waters of the River Gash, 15-June-1925	50	25.9	36.7
Exchange of Notes Between His Majesty's Government in the United Kingdom and the Egyptian Government in regard to the Use of the Waters of the River Nile for Irrigation Purposes, May 7, 1929	91	81.4	62.7
Agreement between the Republic of Sudan and the United Arab Republic for the Full Utilization of the Nile Waters, 18-Nov-1959	74.3	65.3	50.6
Agreement between the Government of the Republic of South Africa and the Government of Portugal in regard to the first phase of development of the water resources of the Cunene River Basin, 21-Jan-1969	50	36.7	49
Average	66.3	52.3	49.8
Agreements making reference to Equity			
Treaty on the Lesotho Highlands Water Project between the Government of the Republic of South Africa and the Government of the Kingdom of Lesotho. Maseru, 24 October, 1986	36.5	29.1	12.2
Tripartite Ministerial Meeting of Ministers Responsible for Water Affairs Held of the 15th February, 1991 in Swaziland	8.4	2.6	6.4
Treaty on the Development and Utilization of the Water Resources of the Komati River Basin between the Government of the Kingdom of Swaziland and the Government of the Republic of South Africa, 13 March, 1992	0.2	9.8	5.8
Tripartite Interim Agreement Between the Republic of Mozambique and the Republic of South Africa and the Kingdom of Swaziland for Co-operation on the Protection and Sustainable Utilization of the Water Resources of the Incomati and Maputo Watercourses. Maputo, 13 August, 2002 (Incomati Basin)	11.2	13.7	16.5
Tripartite Interim Agreement Between the Republic of Mozambique and the Republic of South Africa and the Kingdom of Swaziland for Co-operation on the Protection and Sustainable Utilization of the Water Resources of the Incomati and Maputo Watercourses. Maputo, 13 August 2002 (Maputo Basin)	5.8	9.2	23
Average	12.4	12.9	12.8

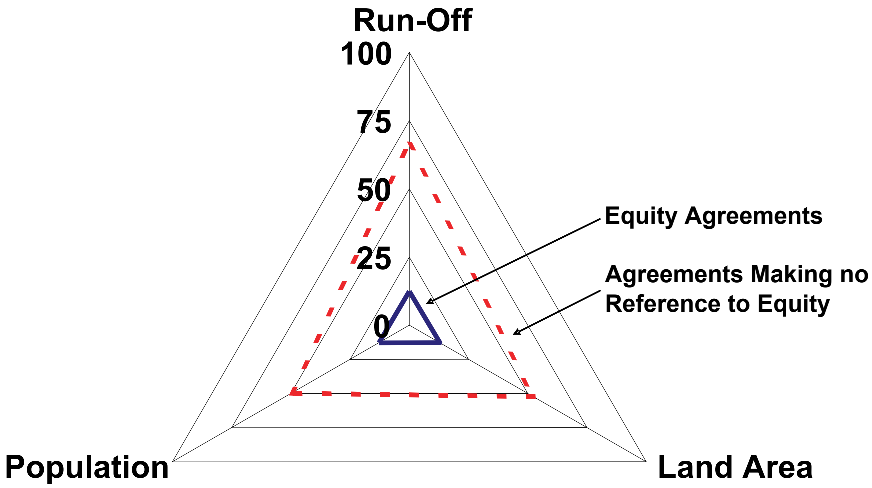

Figure 1. Equity in African transboundary water allocation in terms of runoff, land area and population. The figure indicates average equity levels with respect to basin run-off, land area and population for four treaties which purport to consider equity in allocations and four which do not. Zero indicates absolute equity, 100 indicates absolute inequity. Equity treaties are in fact more equitable by any of the three measures. Interestingly, the choice of measure has little impact on the conclusion

Further, an examination of the least equitable of the equity agreements, the Treaty on the Lesotho Highlands Water Project between the Government of the Republic of South Africa and the Government of the Kingdom of Lesotho, suggests that, if anything, the results may understate the differences between equity and non-equity agreements. While the allocation of water between Lesotho and South Africa is relatively equitable with respect to population (composite deviation of 12.2), it is relatively inequitable with respect to runoff contribution (composite deviation of 36.5). However, the basis of the treaty is fundamentally one of sharing the benefits of water rather than the water itself. Lesotho receives compensation from South Africa in the form of hydropower, a remuneration designed to counterbalance the "inequity" in physical water allocations. Had equity in benefit sharing rather than just physical water allocations been included, the difference between equity and non-equity agreements would be even larger.

The *Lesotho Highlands Treaty* also highlights another caveat related to the methodology. As applied, all basin states are considered in calculations whether or not they receive a codified allocation. In the case of the *Lesotho Highlands Treaty*, only South Africa and Lesotho are in fact party to the treaty even though the Orange River basin to which the treaty applies is also shared by Namibia and Botswana. In this particular case, Namibia and Botswana are neither major riparians nor major contributors of basin runoff, and so their absence from the agreement can have only a minor impact on the equity assessments presented here. However, even in this case, the actions of South Africa and Lesotho have had implications for the other basin riparians, including alterations in flow patterns into Namibia (De Jonge Schuermans et al., 2004). This raises an important question regarding equity concepts in international water law applied at the basin scale: when an agreement does not encompass all riparians, what does equity mean and how should it be determined?

As a final note, the fact that all three criteria against which equity was measured yield similar results indicates that the criteria themselves are highly correlated. If this is generally the case elsewhere, it suggests that theoretic or diplomatic discussions concerning the criteria by which equity should be determined have less practical relevance than may have been assumed. That is, while disagreements may occur on the theoretical basis for equity, the findings for at least the eight cases examined here indicate that application of any one of the three measures will produce similar results.

4. The Influence of Evolving Global Water Management Paradigms[20]

One way to pinpoint the extent to which Sub-Saharan Africa (SSA)'s transboundary water law is influenced by global paradigms is to situate its development in a broader global context. The largest compilation of global transboundary law related to water as a consumable resource (as opposed to, for example, a form of navigation or a national boundary) is found in the Transboundary Freshwater Dispute Database (TFDD).[21] While the collection does not include every transboundary water treaty, the TFDD contains over 400 international water agreements from around the world, signed between 1820 and 2002. Documents in the collection are classified according to several criteria, including basin and countries involved, date signed, inclusion of allocation measures and conflict resolution mechanisms, and, perhaps most importantly, treaty goals (Wolf, 1999b).

To provide an indication of trends in the orientation of global transboundary water law, the collection was used to assess the frequency of agreement goals by decade between 1950 and 2000. Agreements with goals related to economic development, hydropower, infrastructure development, irrigation, and flood control were all considered to reflect a policy of water *development* while those agreements with goals of water quantity, water quality, joint management, fisheries, and technical cooperation were considered to embody an agenda of water *management*. While this methodology to some degree simplifies realities, since water development and management are not mutually exclusive, it is clear from treaty texts that an increased emphasis on management and the environment is

[20] This section draws from Lautze and Giordano (2007).
[21] Available on-line at http://www.transboundarywaters.orst.edu/.

associated with a decreased emphasis on development. Following this method for treaty categorization, Figure 2 compares the percent of agreements by decade that embody an agenda of water development with those that reflect a policy of water management.

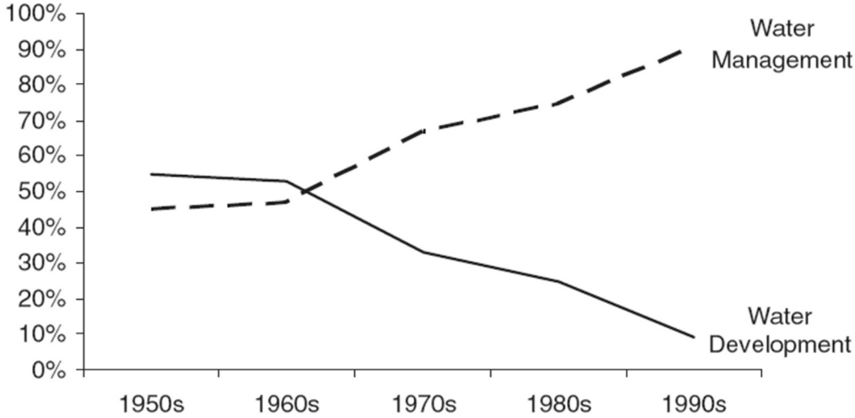

Figure 2. The evolution of global transboundary water law. Data are calculated from the Transboundary Freshwater Dispute Database of Agreements

It is clear from the figure that there has been a sharp decline in the development focus of transboundary water governance over the last 50 years, with less than 10% of treaties aimed at the development of water resources by the 1990s. The development agenda has been replaced by an increased emphasis on division of water resources, on ensuring water quality and on the joint management of shared water resources. These findings suggest a shift in the focus of transboundary water agreements from development of water resources to management of existing resources, as also described at national levels by Saleth and Dinar (2000).

With regard to SSA, however, one might expect results that stray away from the global trend. That is, given the region's relative paucity of storage and high level of poverty, it seems more likely that it would focus on water resource development than in other areas. In order to determine the extent to which this actually is the case, the authors applied the same methodology as used to assess international trends in the TFDD database, but separated the agreements from SSA.[22]

The results, depicted graphically in Figure 3, show that over time a somewhat higher percentage of SSA's agreements do in fact manifest water development goals. Surprisingly, however, the sharp decline in the water resources development agenda embodied in SSA's agreements parallels the rest of the world with the

[22] Note that the Nile basin, 9 of whose 10 riparians fall in SSA, is considered a Sub-Saharan African watershed.

exception of the 1960s. Supporting these results, Lautze and Giordano (2005) assembled and analyzed a larger collection of African agreements than was available in the TFDD[23] and found that the decreased emphasis on water resources development from 1959–1989 to 1990–2004 was matched by an increasing focus on the environment and water quality.

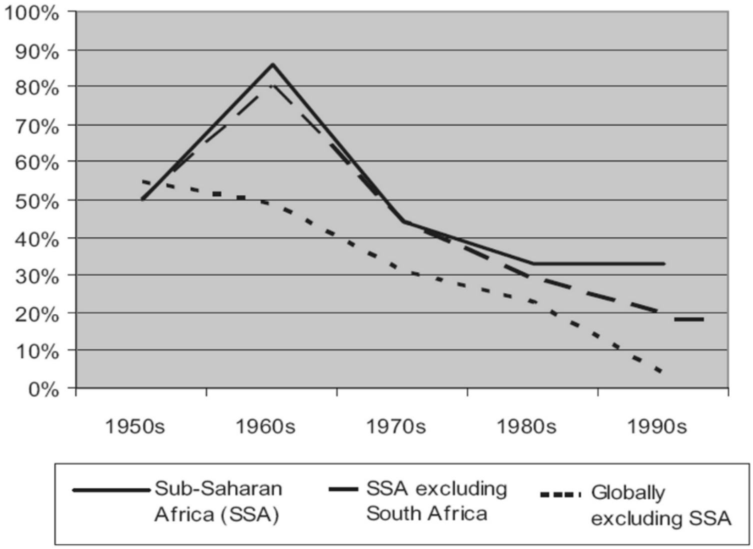

Figure 3. Water development in transboundary water law. The focus on resource development in transboundary water law has declined globally since the 1960s. Despite vastly different water resources and socioeconomic conditions, Sub-Saharan Africa's strategies appear to follow the global trend

In sum, the evidence shows that global transboundary water law has placed decreasing emphasis on water development, and increasing emphasis on environmental conservation, water quality, and water sharing over the last half century. This likely reflects progress in both water resources and economic development, as well as an evolving view of the environment and its value.[24] The evidence also shows that SSA's transboundary water law has undergone similar shifts in focus, despite vastly different levels of water resources and economic development. A closer look at Figure 3 even suggests that the decreasing emphasis on water development in SSA *follows* the global trend, which started a decade earlier and appears to *precede* developments in SSA,

[23] Available on-line at www.africanwaterlaw.org. See also Ashton et al. (2006) for a broader set of water related agreements involving South Africa.

[24] While it may also be true that the adverse health and livelihood effects of dams worked to reduce the emphasis on development, it is increasingly recognized (e.g., King, 1996) that these parameters can be factored into development plans rather than justifying a discontinuation of the development process.

strongly suggesting there may be a "hand-me-down" dynamic by which developed countries pass norms of practice on to developing countries.

5. Discussion

This study has shown that there are clear and ongoing effects of international actors and norms on the contents and orientation of African transboundary water law. This section focuses attention on the degree to which these global influences work to help or hinder progress towards the development goals for which African countries typically strive, and the degree to which such influences are responsive to conditions in Africa.

As concerns equity, there has long been controversy surrounding the role and potential role of international law such as the Helsinki Rules and the IWC in promoting "reasonable and equitable" use of transboundary basins. While it has been shown that the language has had a growing presence in water agreements, there are many reasons to question the motivations of this trend. Is this new emphasis on equity simply pandering to political correctness as a means to superficially meet donor country conditions, or does it trigger tangible improvements in the state of transboundary water management at the basin level? The analysis of Africa's transboundary water law presented here indicates that equity agreements are clearly different from other agreements.

However, a key issue for consideration in attempts to apply generalized legal principles such as those embodied in the 1997 UN Convention is the degree to which institutional needs are basin-specific or can be based on global norms. Analysis of Africa's transboundary water management history provides new insights. For certain key treaty components, there have been clear evolutionary trends from the colonial period to early independence to more recent years. For example, important treaty components have been increasingly included over time: the creation of management institutions, considerations of water quality, inclusion of provisions for exchange of hydrological data, and provision of mechanisms for amendment.

The extent to which the shift away from water resources development can be linked to positive outcomes is much less clear. It would be reasonable to speculate that if any region's transboundary water law would stray from the evolving global paradigms described above, it would be Sub-Saharan Africa's. This is because its levels of both water resources development and poverty are so different from the corresponding global conditions.

It could be argued that the size of SSA's renewable water resources limits absolute levels of potential water withdrawals, yet the percent of SSA's renewable water resources that are stored is relatively small compared to other regions. Generally speaking, the vast majority of withdrawn water comes from water storage, and low levels of water storage will usually lead to low levels of water withdrawal – particularly in regions like SSA with high variability in precipitation (Brown and Lall, 2006).That said, SSA's low water withdrawal is in all likelihood as much a function of the region's paucity of storage as limitations related to the size of its natural water endowment. Furthermore, it should be noted that water resource development shows a highly uneven distribution across the region. Of the 980 large dams in SSA contained in the World Commission on Dams Database (2000), for example, 539 (55%) are located in South Africa. By comparison, there are only two large dams in Tanzania – a country only slightly smaller in area and population than South Africa.[25] Thus, for most countries, the already low average numbers presented vastly overstate conditions within their borders.

The logical corollary to SSA's relatively low levels of total water withdrawal and storage is its comparatively low level of irrigation and hydropower development. Per capita irrigated area is lower in SSA than any other region, limiting the food production capacity and contributing to the region's high rates of undernourishment (FAO, 2003).[26] Similarly, hydropower generation in SSA lags behind other regions of the world. While Europe has harnessed 75% of its hydropower potential, North America – 69%, South America – 33%, and Asia – 22%, Africa lags behind at a mere 7% (IHA, 2003).

Finally, SSA's low levels of water development correspond with is its high level of poverty. It stands out as the world's poorest region by almost any socio-economic indicator, such as, per capita food consumption as just mentioned, the Human Development Index, or life expectancy (UNDP, 2003; FAO, 2003).

External organizations, both technical and financial, are likely to continue playing a major role in future African water agreements. This research suggests that they place considerable emphasis on basin-specific conditions when developing recommendations and when deciding to invoke principles such as those embodied in the UN *Convention on the non-Navigational Uses of International Watercourses*. Indeed, basin hydrologies – such as natural water endowments, rainfall variability, and the local human systems dependent on them – may prove better guides for the types of international responses needed than vague truisms embodied in international principles.

6. Conclusions

There is a wide range of literature showing that institutions, such as those embodied in treaties, evolve in response to changing resource conditions (e.g.,

[25] The figures contained in the World Commission on Dams Database vary somewhat from those found in other sources such as the International Commission on Large Dams Database (2003). However, the relative pictures presented by all such data sources are similar.

[26] Per capita food consumption in SSA stands at approximately 78% of the global average and 82% of developing country average. Further, UNDP data from 1999/2001 indicate that undernourishment was above 30% in SSA, significantly higher than other regions.

Demsetz, 1967; Anderson and Hill, 1975; Hayami and Ruttan, 1985; Mitchell, 2002). In the specific field of water resources, there is now a growing body of literature documenting the policy shift from development to utilization and then to allocation, management, and environmental conservation as supplies become increasingly scarce and priorities change (e.g., Saleth and Dinar, 2000; Gleick, 2004; Shah et al., 2005; Mostert, 2003; Molden et al., 2005). Yet, as already demonstrated for SSA, substantial disparities exist in levels of water resources development among different regions of the world. This suggests that global thinking on transboundary water law, and its application in regional circumstances, may be driven in part by those farther along the trajectory of basin development.[27]

Unfortunately, while some literature exists on the geographical drivers of transboundary water law formation (Bernauer, 1997; Conca et al., 2003; Niasse, 2004; Song and Whittington, 2004), there has been little written examining the possible connection between transboundary policies developed for conditions in the North, which has seen a rapid rate of water resources development since 1950, and those applied in the South, particularly SSA, where less development has taken place. Economically and politically powerful countries and institutions – with their ability to provide or influence financial assistance, positive experience with shifting from development to management as water scarcity levels increase, understanding of environmental problems and environmental perceptions in wealthier regions, and habit of applying state-of-the-art approaches – may have, perhaps inadvertently, caused transboundary water policy in SSA to grow increasingly disconnected from regional priorities. A recent World Bank report (Grey and Sadoff, 2006) even speculates that water policies appropriate in the developed world have permeated aid policy because decision-makers lack stomach to go against accepted developed world priorities and principles. In more practical terms, this has meant an overall reduction in World Bank investments in water resources development in SSA (Conca, 2006).

To be clear, the point is not that water resources development is some panacea that will solve all the region's problems. Neither is it that considerations of Integrated Water Resources Management (IWRM) concepts, joint management, concern for environmental impacts, and value for the natural state of rivers is in some way bad. On the contrary, such concerns are particularly valid in SSA given the continued dependence of many livelihoods on direct uses of natural resources. At the same time, it is unlikely that SSA's high and persistent rural poverty levels will be reduced without additional water resources development. Indeed, high population growth rates and climate change-induced alterations to natural water cycles (Appel, 2006; De Wit and Stankiewicz, 2006) will continue

[27] In fairness, the increasing emphasis on management-related issues may be also partly driven by the fact that such treaties are less contentious than those focusing on dam-building, particularly given the international nature of most of SSA's water resources.

to challenge "traditional" livelihood systems, and SSA's overtaxed ecosystems will make it more difficult for inhabitants to rely on them.

While it might be argued that SSA can "leapfrog" in the development of its transboundary water policies by learning from the knowledge and lessons acquired elsewhere in the world, prematurely employing policies more suitable for projected future water resources conditions may impede economic growth and poverty alleviation – the overriding goals of most sub-Saharan African countries. Concern for demand management and a focus on conservation, in particular, may have steered SSA's policies away from water resources development. As a result, while the direct environmental externalities associated with water development are certainly reduced, the region as a whole remains as food insecure and poor as ever, facing the long-term pressures of environmental destruction associated with such conditions.

As described by Shah et al. (2005), industrialized Europe and North America underwent a 200-year process of water resource development and natural resource degradation that corresponded with their substantial increases in per capita income and food production. Only in the latter part of the 20th century did the importance of natural resources management and conservation begin to outweigh development and its environmental consequences. Most of SSA launched its water resources development efforts much later, largely in the latter half of the 20th century. However, the region has not been afforded the same time to achieve the income and security levels of more industrialized regions. Instead, SSA's period of water resources development was "telescoped" and an agenda of development was diluted with demand management and conservation within just a few decades.

The corollary to this finding is that the focus of SSA's transboundary water agreements has increasingly diverged from addressing actual conditions in SSA to embodying global "best practices" in transboundary water management. While insights contained in these best practices should clearly be appreciated, the most appropriate approaches in SSA are likely those that are more closely aligned with local and regional conditions rather than the "state of the art" elsewhere. This is not to imply that the policy guidance from developed countries is meant maliciously, nor is it to imply that the environment is not important in its own right or as a producer of economic value. Nonetheless, global paradigms and values may be applied too uniformly when the severe poverty and minimal water resources development found in much of SSA would appear to call for more emphasis, and investment, on supply-side interventions than management projects.

While the impacts of outside intervention are often beneficial, there is a danger of applying global models, often developed in non-extreme hydrological settings, when looking for international lessons. For example, when riparian relationships are extreme in terms of international relations, as in the Middle

East, the most important lessons may not come from areas with similar hydrology but rather areas with similar political complexity.

Bibliography

ABN, 2004. *Niger Basin Authority Website* (November 7, 2004); http://www.abn.ne/webeng/index-eng.html.

Allan, J.A., 1999. The Nile Basin: Evolving Approaches to Nile Waters Management, *Occasional Paper 20*, SOAS Water Issues Group: University of London.

Andreini, M., van de Giesen, N., van Edig, A., Fosu, M., and Andah, W., 2000. *Volta Basin Water Balance*, ZEF-Discussion Papers on Development Policy #21, Bonn.

Andreini, M., Vlek, P., and van de Giesen, N., 2002. *Water Sharing in the Volta Basin*, IAHS Publication 274: 329–335.

Barry, B., Pluquet, P., and Andreini, A., 2004. *Water Development Projects in the Volta Basin*, International Water Management Institute, Accra Office.

Beaumont, P., 2000. The 1997 UN Convention on the Law of Non-navigational Uses of International Watercourses: Its Strengths and Weaknesses from a Water Management Perspective and the Need for New Workable Guidelines, *Water Resources Development*, 16(4): 475–495.

Bernauer, T., 1997. Managing international rivers. In Young, O., ed. *Global Governance*. Cambridge: MIT Press.

Biswas, A., 1999. Management of International Waters, *Water Resources Development*, 15(4): 429–441.

Caponera, D.A., 1985. Patterns of Cooperation in International Water Law: Principles and Institutions, *Natural Resources Journal*, 25: 563–588.

Caponera, D.A. and Alhéritière, D., 1979. *Water law in selected African countries: Benin, Burundi, Ethiopia, Gabon, Kenya, Mauritius, Sierra Leone, Swaziland, Upper Volta, Zambia*. Rome: FAO.

Conca, K. and Wu, F., 2003. *Is There a Global Rivers Regime?* Paper presented at the International Studies Association Meeting.

Curtin, S. and Charrier, B., 2004. *Water for Peace Between Conflict and Cooperation: The Role of Civil Society*, Green Cross International.

De Jonge Schuermans, A.M., Helbing, J., and Fedosseev, R., 2004. *Evaluation of Successes and Failures in International Water Management. Orange River Basin, South Africa*. ETH, Zurich. http://www.eawag.ch/research_e/apec/seminars/Case%20studies/2004/Orange_Report.pdf.

Dellapenna, J.W., 1994. Treaties as Instruments for Managing Internationally-Shared Water Resources: Restricted Sovereignty vs. Community of Property, *Case Western Reserve J. Int'l L*. 26.

Dellapenna, J.W., 2001. The Customary International Law of Transboundary Fresh Waters, *International Journal of Global Environmental Issues*, 1(3/4): 264–305.

Direction Générale de l'Inventaire des Ressources Hydrauliques, 2004. *The Volta Basin Countries: (Benin-Burkina-Cote d'Ivoire-Ghana-Mali-Togo) Heading for a Basin Organization*, Government of Burkina Faso.

Dombrowsky, I. and Grey, D., 2002: The Status of International River Management in Africa, in: *Co-operation on transboundary rivers*, I. Al Baz, V. Hartje and W. Scheumann, eds., Nomos, Baden, pp. 83–99.

Easterly, W., 2001. *The Elusive Quest for Growth*. Cambridge: MIT Press.

FAO, 1997. *Treaties concerning the non-navigational use of international watercourses*: Africa. FAO Legislative Study No. 61, Food and Agricultural Organization of the United Nations, Rome.

FAOLEX, 2004. (November 1, 2004); http://faolex.fao.org/faolex/.

Fekoua, L.L., 2000. Colonisation, coopération et conflits – Géopolitique de l'eau en Afrique subsaharienne, Présence africaine, No. 161–162.

Fox, I.K. and LeMarquand, D.G., 1979. International river basin co-operation: The lessons from experience, Water Supply & Management.

Giordano, M., 2002. The internationalization of wildlife and international wildlife law: a conceptual framework and the historic record, *Georgetown International Environmental Law Review*, XIV(4): 607–627.

Giordano, M., 2003. Managing the quality of international rivers: global principles and basin practice, *Natural Resources Journal*, 43.

Giordano, M. and Wolf, A.T., 2001. Transboundary Freshwater Treaties: Global Experience and Implications for Southern Africa. Unpublished.

Giordano, M. and Wolf, A.T., 2003. Sharing waters: post-rio international water management, *Natural Resources Forum*, (27): 163–171.

Global Environmental Facility, 2002a. *Volta River Basin Preliminary Strategic Action Programme*.

Global Environmental Facility, 2002b. *Volta River Basin Preliminary Transboundary Diagnostic Analysis*.

Godana, B., 1985. *Africa's Shared Water Resources: Legal and Institutional Aspects of the Nile, Niger, and Senegal River Systems*, Graduate Institute of International Studies: Geneva.

Hajer, M., 1996. *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*, Clarendon, Oxford.

Hamner, J.H. and Wolf, A.T., 1998. Patterns in International Water Resource Treaties: The Transboundary Freshwater Dispute Database, *Colorado Journal of International Environmental Law and Policy*. 1997 Year book.

Hertslet, Sir E., 1909. *The Map of Africa by Treaty Volumes I–III*, Third Edition, London.

Hey, E., 1998. The watercourses convention: To what extent does it provide a basis for regulating uses of international watercourse? *Review of European Community and International Environmental Law*, 7(3): 291–300.

Hirji, R. and D. Grey, 1998. *Managing International Waters in Africa: Process and Progress*, in: *International Watercourses: Enhancing cooperation and managing conflict*, S.M. Salman and L.B.D. Chazournes, eds., Proceedings from a World Bank Seminar, World Bank, Washington, DC.

Huntington, S., 1996. *The Clash of Civilizations and the Remaking of World Order*, Touchstone, New York.

Ilomaki, J., 1999. *Institutional Challenge of Developing Transboundary Water Resources*, Helsinki University of Technology. Master of Science Thesis.

International Office for Water, 2004. *Draft Report Relative to the proposal for financing Africa–European Union Action Programme to support improved transboundary Basin Management in Africa – The case of the Volta Basin*.

IUCN, 2004. Niasse, M., Iza, A., Garane, A. and Varis, O., La Gouvernance de l'eau en Afrique de l'Ouest, *Droit et Politique de l'Environnement*, No. 50.

Jovanovic, D., 1985. Ethiopian Interests in the Division of the Nile River Waters. *Water International*, (10): 82–85.

Klare, 2000. Resource Competition and World Politics in the 21st Century, *Current History*, 99(641): 403–407.

Lahtela, V., 2003. Managing the Senegal River: National and local development dilemma, *Water Resources Development*, No. 2.

Laki, S.L., 1998. Management of Water Resources of the Nile Basin, *International Journal of Sustainable Development and World Ecology*, 6.

Lautze, J. and Giordano, M., 2006. Does 'equity' really matter in international water law? Evidence from Africa, *Colorado Journal of International Environmental Law and Policy*, 17(1): 89–122.

Lautze, J. and Giordano, M., 2007. Demanding Supply Management and Supplying Demand Management: Transboundary Waters in Sub-Saharan Africa, *Journal of Environment and Development*, 16: 290–306.

LeMarquand, D.G., 1986 *International development of the Senegal River*, Vlachos, E., Webb A.C., and Murphy, I.L. 1986 The management of international river basin conflicts, Proceedings of a workshop held at the headquarters of the International Institute for Applied Systems Analysis, Laxenburg, 22–25. George Washington University, Washington, DC.

LeMarquand, D.G., 1990. International development of the Senegal River, *Water International*, No. 4.

Maïga, M., 1995. *Le fleuve Sénégal et l'intégration de l'Afrique de l'Ouest en 2011*. CODESRIA/Karthala, Paris.

Maluwa, T., 1988. Legal aspects of the Niger River under the Niamey treaties, *Natural Resources Journal*, 28: 671–697.

Matsumoto, K., 2002. *Transboundary Groundwater and International Law: Past Practices and Current Implications*. Oregon State University, Unpublished master's paper.

McCaffrey, S., 1997. *Water Scarcity: Institutional and Legal Responses*, in: *The Scarcity of Water: Emerging Legal and Policy Responses*, E.H.P. Brans, E.J. De Haan, A. Nollkaemper and J. Rinzema, eds., pp. 43–58.

Mechlem, K., 2003. *Water as a Vehicle for Inter-state Cooperation: A Legal Perspective*, FAO Legal Papers Online #32.

Meublat, G. and Ingles, J., 1997. L'éternel retour des grands projets – L'aménagement du fleuve Sénégal en perspective, in: *Regards interdisciplinaires sur les politiques de développement*, J. F. Baré, L'Harmattan, Paris.

Milich, L. and Varady, R.G., 1999. Openness, sustainability, and public participation in transboundary river-basin institutions, *The Journal of Environment & Development*, No. 3.

Ministry of Works and Housing, 1998. *International Waters "Building Block" Study*. Environmental Management Associates Ltd., Accra.

Mitchell, R.B., 2003. International environmental agreements: a survey of their features, formations, and effects, *Environmental Resources Journal*, 28: 429–461.

Molle, F., 2003. Development Trajectories of River Basins A Conceptual Framework, *IWMI Research Report* No. 72.

Mostafa, H., 2004. A River Runs Through It. *Egypt Today* (25)7. http://www.egypttoday.com/arttemplate.asp?ArtID=7&IssueNo=07&IssueYear=04&MagID=ET.

Nakayama, M., ed., 2003. *International Waters of Southern Africa*, United Nations University Press, Tokyo.

NBI, 2005. *Nile Basin Initiative Website* (November 20, 2005); http://www.nilebasin.org/.

Ndao, A. and Sall D., 2002. *Mécanismes de prévention et de gestion des conflits dans le cadre de bassins partagés: L'expérience de l'OMVS*, OMVS, Dakar (November 30, 2004); http://www.riob.org/forum/.

Niasse, M., 2004. Prevenir Les Conflits et Promouvoir La Cooperation dans la Gestion Des Fleuves Transfrontaliers en Afrique de L'Ouest, *La revue en sciences de L'environnement*. 5(1).

Okaru-Bisant, V., 1998. Institutional and Legal Frameworks for Preventing and Resolving Disputes Concerning the Development and Management of Africa's Shared River Basins, *Colorado Journal of International Environmental Policy*, 9: 2.

OMVS, 2004. *La répartition des coûts et charges des ouvrages communs de l'OMVS*, OMVS (November 30, 2004); http://www.imedia.sn/omvs/outils/cam.html.

OMVS, 2004. *Rappel historique* (November 30, 2004); http://www.imedia.sn/omvs/omvs/historique.html.

Pakenham, T., 1991. *The Scramble for Africa*, Avon, New York.

Rangeley, R., Thiam, B., Andersen, R., and Lyle, C., 1994. *International River Basin Organizations in Sub-Saharan Africa*, World Bank Technical Paper Number 250, Africa Technical Department Series, The World Bank, Washington, DC.

Sadoff, C.W., Whittington, D., and Grey, D., 2002. *Africa's International Rivers: an Economic Perspective*, The World Bank, Washington, DC.

Saleth, R.M. and Dinar, A., 2000. Institutional Changes in global water sector: trends, patterns, and implications, *Water Policy*, 2: 175–199.

Schroeder-Wildberg, E., 2002. *The 1997 International Watercourses Convention – Background and Negotiations*, Technical University of Berlin.

Seckler, D., 1996. The New Era of Water Resources Management: From "Dry" to "Wet" Water Savings, *Research Report* 1, International Water Management Institute.

Song, J. and Whittington, D., 2004. Why have some countries on international rivers been successful negotiating treaties? A global perspective, *Water Resources Research*, 40, W05S06, doi: 10.1029/2003WR002536.

Starr, J.R., 1991. Water wars, *Foreign Policy*, 82(Spring).

Tanzi, A., 2000. *The Relationship between the 1992 UN/ECE Convention on the protection and use of transboundary watercourses and international lakes and the 1997 UN Convention on the Law of the Non-navigational uses of international watercourses*. Report of the UN/ECE Task Force on Legal and Administrative Aspects, Geneva.

Tuga, M.B., 2004. *Processus de vision partagée pour le développement durable du bassin du Niger* (December 5, 2004); http://www.riob.org/transfrontalier/dakar-2004/comms/ Bassin_NigerP1.pdf.

Turton, A., 2003. *A Southern African Perspective on Transboundary Water Resource Management*, ECSP Report (9): 75–87.

UCC, 2004. *UNEP Collaborating Centre on Water and Environment* (October 1, 2004) www.ucc-water.org.

UNECA, 2000. *Transboundary River; Lake Basin Water Development in Africa: Prospects, Problems and Achievements*, UNECA, Addis Ababa.

United Nations Educational Scientific and Cultural Organization (UNESCO), 2003. *World Water Development Report. Water for People Water for Life*, UNESCO, Paris.

United Nations, 1984. *Treaties concerning the utilization of international water courses for other purposes than navigation: Africa 56,* Natural Resources/Water Series No. 13, New York, [or U.N. Doc. St/ESA/141]

United Nations, 1997. *Convention on the Law of the Non-navigational Uses of International Watercourses*, http://www.un.org/law/ilc/texts/nonnav.htm.

Van der Zaag, P., Seyam, I.M., and Savenije, H.H.G., 2002. Towards measurable criteria for the equitable sharing of international water resources, *Water Policy*, (4): 19–32.

van Edig, A., van de Giesen, N.C., Andreini, M., and Laube, W., 2001. *Transboundary, institutional, and legal aspects of the Water Resources Commission in Ghana*, Center for Development Research, Bonn, Germany.

van Edig, A., Engel, S., and Laube, W., 2003. Ghana's water institutions in the process of reform: from the international to the local level, in: *Reforming Institutions for Sustainable Water Management*, Neubert et al., eds., German Development Institute, Bonn, Germany.

Walling, D.E., 1996. Hydrology and rivers, in: *The physical geography of Africa*, W. Adams, A. Goudie, and A. Orme, eds., Oxford University Press, Oxford.

Wescoat, J.L., Jr., 1992. Beyond the river basin: the changing geography of international water problems and international watercourse law, *Colorado Journal of International Environmental Law and Policy*, 3: 301–330.

Wescoat, J.L., Jr., 1996. Main currents in early multilateral water treaties: a historic-geographic perspective, 1648–1948, *Colorado Journal of International Law and Policy*, 7(1): 39–74.

White, G., 1957. *A Perspective of River Basin Development*. Reprinted in Geography, resources, and environment volume I: selected writings of Gilbert White, R.W. Kates and I. Burton, eds., University of Chicago Press, Chicago, IL, pp. 39–79.

Wolf, A.T., 1999a. Criteria for equitable allocations: the heart of international water conflict, *Natural Resources Forum*, 23: 3–30.

Wolf, A.T., 1999b. The transboundary freshwater dispute database project, *Water International*, 24(2): 160–163.

World Bank, 1995. *Water Resources Management*, International Bank for Reconstruction and Development. Washington, DC.

World Commission on Dams, 2000. *Dams and Development a New Framework for Decision-Making*, The Report of the World Commission on Dams. Earthscan, London.

Yoffe, S., Wolf, A., and Giordano, M., 2003. Conflict and cooperation over international freshwater resources: indicators of basins at risk, *Journal of the American Water Resources Association*, 39(5): 1109–1126.

TRANSBOUNDARY WATER MANAGEMENT IN THE EUPHRATES–TIGRIS BASIN: DYNAMICS OF REGIONAL COOPERATION, SUSTAINABILITY AND GOVERNANCE

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Abstract: Since the late 1980s, numerous academic studies and non-academic popular writings have argued that the Euphrates–Tigris Basin is one of the transboundary river systems in the Middle East where conflicts would break out due to water scarcity, degradation of water quality and competing water-based socio-economic development policies of the riparian states, namely Turkey, Syria and Iraq. On the one hand, various incidents have occurred since 1970s that have caused tensions among the riparian states. On the other hand, however, the crises and deadlocks in the hydropolitical relations of the co-riparians have also paved the way for various cooperation efforts and initiatives regarding the utilization of the Euphrates–Tigris waters. This study analyzes those efforts and initiatives, as well as various aspects of sustainable water resource management and governance practices that can act as tools for preventing future disputes among the co-riparians in the future.

Keywords: Euphrates; Tigris; regional cooperation; Joint Technical Committee; Three Staged Plan; sustainable water resource management; water governance

1. Introduction

With its combined average flow of 84.5 billion cubic meters per year (BCM/ year), roughly equal to the average flow of the Nile River, the Euphrates–Tigris River system is one of the major transboundary watercourses in the Middle East region. Both rivers rise in the highlands of Eastern Turkey, and then flow across Syria and Iraq. They join each other at Qurna near Basra to form Shatt al-Arab waterway before discharging into the Persian Gulf. The average annual flow of

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the Euphrates River is around 36 BCM/year. Approximately 88% of the river's water potential is generated within Turkey, and the remaining 12% is added in Syria. After originating in Turkey, the Tigris River flows southeast and forms a 32-km boundary between Turkey and Syria before entering Iraq. The average flow of the Tigris is almost 49 BCM/year. Turkey contributes 52% of the river's flow, while the tributaries in Iraq provide the remaining 48%.

In terms of the water volume per capita, riparian states do not currently experience *absolute* water scarcity according to the widely accepted *Water Stress Index* (Falkenmark et al., 1990). According to the 2008 FAO-AQUASTAT figures, the water potentials per capita in Turkey, Iraq and Syria are 3,134 cubic meters water per year (cum/year), 3,389 cum/year and 2,410 cum/year respectively (FAO-AQUASTAT, 2008). However, the amounts of exploitable water resources are much less in those countries due to various geographical and economic factors. Thus, the water volumes per capita decrease to 1,515 cum/year for Turkey and 1,061 cum/year for Syria. The exact amount of exploitable water resources in Iraq is uncertain due to lack of data resulting from the unfavorable conditions in the country since the 2003 American occupation. These figures indicate that both Turkey and Syria may become *water stressed* countries in the near future according to the Index.

The situation gets worse in terms of *perceived* water scarcity. The term does not denote the scarcity in hydrological sense, but it indicates that the current water needs or potential consumption targets of the riparian states are above the amount of water flowing in a river. In the case of the Tigris River, although the actual annual water flow equals to almost 49 BCM, the combined potential consumption targets of the co-riparians correspond to nearly 55 BCM/year, which is 111% of the actual flow of the Tigris.[1] The conditions are even more difficult in the Euphrates. The total potential consumption targets of the riparian states add up to almost 53 BCM/year denoting 148% of the actual flow of the Euphrates.[2] In other words, additional 6 BCM/year water for the Tigris and 17 BCM/year for the Euphrates are needed for achieving the riparian states' future targets without causing any dispute among them. If the water consumption targets of the riparian states remain unchanged, it can be predicted that the future tensions surrounding access to water would be more likely for the Euphrates than the Tigris. In such an environment, each riparian aims to secure the volume of water sufficient for its targeted consumption. This is the primary reason that drives Syria and Iraq in claiming that Turkey should release minimum 700 cubic meters water per second (cum/s) – currently 500 cum/s by

[1] The water contributions/consumption targets of the riparian states for the Tigris River are as follows (in BCM/year): Turkey: 25.44/6.87; Syria: 0.00/2.60; Iraq: 23.43/45.00 (adopted from Ministry of Foreign Affairs of Turkey, 1995: 9).

[2] The water contributions/consumption targets of the riparian states for the Euphrates River are as follows (in BCM/year): Turkey: 31.58/18.42; Syria: 4.00/11.30; Iraq: 0.00/23.00 (adopted from Ministry of Foreign Affairs of Turkey, 1995: 7).

the 1987 Turkish–Syrian Protocol – from the Euphrates River until the final allocation of waters is agreed among the co-riparians.

2. Factors Negatively Influencing the Hydropolitical Relations

In addition to the perceived scarcity of the water in the Euphrates–Tigris Basin, various other factors negatively affect the hydropolitical relations among the riparian states.

Population growth is one of the primary factors putting the utmost pressure upon the availability of water for the co-riparians. The largest population increase in the Middle Eastern countries has been observed since 1985 (UNDP, 2002: 38). According to various estimates, the region's total population may reach 390 million in 2010, and 475 million in 2030 (see World Bank, 2000: 38–44; Laipson, 2002: 177).

The total population of the Euphrates–Tigris Basin countries is around 115 million, 19 million of which live in Syria, almost 26 million in Iraq and more than 70 million in Turkey (UNESCO, 2006: 133, 135; Turkish Statistical Institute, 2008: 2). The rates of population growth are 2.3%, 2.9% and 2.2% in Syria, Iraq and Turkey respectively while the world average is around 1.3%. The population growth in the riparian countries increases the pressure on the carrying capacity of the water resources, leading to excessive water consumption and pollution. Therefore, access to sufficient water by those countries becomes more important each day as the agricultural areas open to irrigation need to be enlarged to nourish the increasing number of people. When coupled with other political and socio-economic problems, the downstream states seek ways to externalize these problems to the upstream states, leading to deterioration of the hydropolitical relations among them.

Another major factor influencing the hydropolitical relations among the co-riparians is the place of water in the economic development policies of the co-riparians. These have strong agricultural dimensions. In these terms, the success in coping with water problems depends on the economic, technological and institutional capacities of the co-riparians since these capacities function in minimizing the effects of the water scarcity and pollution and preventing the negative socio-economic results. The factors affecting the strength of these capacities are the presence of the institutions and policies of water utilization and conservation at the national and local levels, the ability to achieve long-term economic planning and the capacity to create alternative economic sectors in addition to the agricultural sector (see Carius and Imbusch, 1999: 20; Libiszewski, 1999: 27). In this respect, Turkey is more successful in creating economic and institutional capacities and alternative economic sectors. However, in the Southeastern Anatolia region of the country where the Euphrates–Tigris flows, the agricultural sector and related agro-industries gain priority due to the

Southeastern Anatolia Project (GAP), which is a multi-sectoral sustainable development project mainly concentrating on energy generation and agricultural development.

In addition to its utmost importance for the overall economic development, the agricultural development is also directed at improving social justice and consolidating state power in the Middle Eastern countries (Turan and Kut, 1997: 141). This is also the case in the co-riparians of the Euphrates–Tigris Basin, as a result increasing the strategic value of the basin waters.

Another factor that increases the dependency of the riparian states on the water resources is food security policy, leading to the policy of self-sufficiency in agriculture. The policy of self-sufficiency has two basic reasons, the first of which surrounds the ideological orientations. Self-sufficiency in agriculture is seen as a source of national pride and facilitates the continuation of the political system by consolidating the power of the leaders. The second reason is directly related to the national security perceptions of the countries. In order to prevent food shortage in case of a war in the region or an international embargo against their own countries, they attempt to produce basic foodstuff in their territories. However, food self-sufficiency in arid and semi-arid Arab countries seems to be more of a "romantic dream than a reasoned strategy" (Elhadj, 2008: 6) due to various factors including the high costs of production and water scarcity. Hence, insisting on food-self sufficiency policies leads to excessive usage of water resources. This has a lot to do with the fact that the governments provide irrigation water at subsidized prices since the unit cost of water is expensive and profits in agricultural sector are less compared to other sectors. Eliminating subsidies to achieve efficient utilization of irrigation water necessitates important structural changes and is often met with resistance. When it begins to create domestic political tensions threatening the internal stabilities of those countries, the issue is usually externalized to the upstream riparians by demanding more water from them. These dynamics give rise to conflicting national demands upon the transboundary water resources (Appelgren and Klohn, 1997: 92), transforming them into a national security issue.

The history of hydropolitical relations among the Euphrates–Tigris riparian states, especially between 1970s and early 2000s, represents how increasing water demands cause disputes on water utilization. The first serious dispute on the utilization of the Euphrates waters broke out between Syria and Iraq in 1975 after Syria completed the construction of Tabqa Dam in 1973 as a part of the plans to formulate major hydroelectricity and irrigation projects on the Euphrates River. In the meantime, Turkey also completed the construction of Keban Dam, one of largest hydroelectric projects on Euphrates. Iraq also initiated Gharraf Project on the Euphrates and Tigris during the same period.

The impounding of Tabqa dam during winter of 1973–1974 did not create any major tension since Syria responded positively to Iraqi demands to release an extra 200 million cubic meters (MCM) of water from Tabqa in mid-1974 to compensate for the falling levels caused by upstream dams. However, both sides came to the brink of war in the second year when Syria and Turkey impounded part of spring flood in the dams (Naff and Matson, 1984: 93). Iraq accused Syria of reducing the Euphrates flow to intolerable levels, while Syria claimed that the reduction was caused by Turkey's impounding of Keban Dam. One of the reasons that the crisis escalated so rapidly was the ongoing tension between rival Baath Parties in Syria and Iraq.[3] Following Saudi and Soviet mediations, Syria agreed to release additional water downstream from Tabqa in June 1975. In the following years, Iraq continued its claims that Syria had not released sufficient water downstream especially during the periods of drought in 1980s (Beschorner, 1992: 39–40).

As Kut (1993: 5) stated, the water development projects of the upstream riparians "became nightmares" for the downstream riparians in that period when Turkey began to construct Karakaya Dam, downstream of Keban, and Syria initiated feasibility studies of Tishrin Dam, upstream of Tabqa.

Karakaya Dam was not the only step that Turkey took around those years for utilizing waters of the Euphrates and Tigris more efficiently. The water development projects on both rivers were merged under the title of the *Southeastern Anatolia Project* (*GAP* in its Turkish acronym) in 1977.

GAP area covers nine cities in the Southeastern Turkey. It corresponds to almost 10% of Turkey's total surface area, and the population in the project area is also around 10% of the country's total population. Within GAP, there are plans for the construction of 22 major dams, 19 hydroelectric plants and dozens of subsidiary irrigation schemes, projected to irrigate 1.8 million hectares of land and to generate an annual amount of 27 billion kilowatt hours of electricity when it becomes fully operational. According to estimates, the GDP per capita in the region would increase 209% after the completion of the project.

GAP is projected to cost around 41 billion New Turkish Liras (YTL), which is approximately equal to $32 billion as of mid-2008. By the end of 2008, it is expected that almost 26 billion YTL will have been spent, which corresponds to around 62% of the budget. 15 dams have been completed so far; however, only 15% of the planned irrigation investments have been realized (GAP Regional Development Administration, 2008a: 5).

GAP has two broad goals that it aims to accomplish. The first is a development-oriented one aimed at increasing energy generation and agricultural production in the southeastern region of the country. The second is a political goal which could be defined as increasing political stability and eradicating poverty that

[3] The competition between Syrian and Iraqi Baath Parties was continuing from the 1960s. Both parties claimed that they were the primary ideological motors of Pan-Arabism and competed for the role of regional leader. For more on the history and structures of the two Baath Parties and the connection to the water issue, please see Eppel (1999: 217–220), Schulz (1995: 110–112).

aggravates the PKK (a Kurdish nationalist terror organization) terrorism via economic and social development in the region. To this end, the main objectives of GAP were increasing the level of income by improving the economic infrastructure in the region, extending capacities of production and employment in rural areas, improving the absorbing capacity of larger cities, and sustained economic development by utilizing the regional resources more effectively (Nipon Koei Co. Ltd. and Yüksel Proje A.Ş. Joint Venture, 1989: 1–3). While initiated as a water resource management project, GAP turned into a multi-sectoral and integrated sustainable human development project at the end of 1990s by extending its original objectives to include new ones on economic and social development, and by strengthening the institutional capacities in the region.

According to the latest projections in 2008, more than 3.8 million new jobs will be created across the whole country, most of them in the southeastern region. However, there are concerns that this number is too ambitious and there may not be enough financial resources provided to create it (e.g., see Radikal, May 28, 2008). On the other hand, analysts argue that if it could be realized, the creation of new jobs would not only curtail the high migration rates to the other regions of Turkey, but it may also reverse the migration trends back to the region and even attract people from other regions (e.g., see Çarkoğlu and Eder, 2001: 48–49).

After 1980s, GAP has been turned into a source of tension among the co-riparians since Syria and Iraq felt anxieties over its effect on the availability of the Euphrates–Tigris waters for their own ongoing and future agricultural and industrial projects. It was argued that the water flowing to Syria and Iraq would be reduced by 40% and 60% respectively (e.g., see The Economist, 1995/1996: 58) and that the water of both rivers would be polluted as a result of agricultural production. Against these arguments, Turkey claimed that GAP would not diminish the water flowing to the downstream riparians since it is used only small amount of the total flow of the rivers. The water experts in Turkey also argued that, in addition to regulating seasonal fluctuations, GAP would also let Syria benefit from a belt of 30–50 km of the land next to the Turkish border with minimum investment (Frankel, 1991: 285). As to the pollution, Turkey argues that environmental concern is an important dimension of the project. It stressed continuously that after GAP was turned into a sustainable development project, various goals were established, identifying the protection of water, soil, air and the associated ecosystems as priority considerations (see Tomanbay, 2000: 87–88).

The most serious tension revolving around GAP occurred in January 1990 when Turkey began to divert the Euphrates flow to impound Atatürk Dam, the centerpiece of GAP. This construction fueled the anxieties of the downstream states, who felt that Turkey was gaining too much control the transboundary water flow. It was even argued in the media that Turkey's impounding was an "act of war" during the period when Iraq was weak due to its war with Iran and when problems between Syria and Iraq were such that they could not react against Turkey in a coordinated manner (for a comprehensive analysis, see Bengio and Özcan, 2001: 64). The officials of the downstream riparians did not go that much further on the issue, but they claimed that there were major electric cuts in big cities and losses in the winter crops in Syria, and that power plants responsible for 40% of the total national electricity production were shut down in Iraq. Iraqi officials also claimed that the reduced flow would damage the irrigation schemes in the country. Turkey, on the other hand, argued that it had released 750 cum/s water between November 23, 1989 and January 13, 1990 to compensate the diminishing volume of water during the impounding. Turkey also stressed that it carried out its commitment of releasing 500 cum/s water during that period, as stipulated in the 1987 Turkish–Syrian Protocol (Ministry of Foreign Affairs of Turkey, 1995: 19). Later on, in the face of protests from Syria, Turkey sent delegations to the Arab League to explain that this was not a "political maneuver" but only temporary water cut for impounding the dam (Bağış, 1994: 21–22).

Turkey's construction of the other dams along the Euphrates and Tigris Rivers also created tensions of various scales between Turkey and the downstream riparians. After the 1990 crisis, new tensions arose in the last days of 1995 when the credit agreement of Birecik Dam (an after bay dam regulating the regime of Atatürk Dam waters) was concluded. This event stirred Syria to begin lobbying against Turkey in the Arab League and western countries. In the end, Syria, Egypt and six other Arab states (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates) issued the *Damascus Declaration* calling for Turkey to replace the 1987 Turkish–Syrian Protocol with a permanent water-sharing agreement. It was the first time that the other Arab countries explicitly allied with Syria to address its water disputes with Turkey. It is argued that this joint protest was partly a result of Arab states' reactions to Turkey's increasing military, economic and cultural relations with Israel at the time.[4]

In addition to the issues about GAP, one other major source of tension cutting across all the problems was the PKK issue. The relations between Syria and the PKK were especially emboldened after the 1980 military intervention in Turkey when the PKK members had to leave the country and found safe harbor in Syria (see Olson, 1997: 169–170). Syria supported the PKK for a long time

[4] The increasing level of military relations with Israel in mid-1990s was culminated in two agreements on military cooperation. The first one is about the cooperation on military training, dated February 23, 1996. The second one is the agreement on cooperation between the defense industries of the two countries, signed on August 28, 1996. For a detailed analysis of these agreements, please see Özcan (2002: 221–231). The cooperation between Turkey and Israel was not limited to the military sector. The *Free Trade Agreement* was signed on March 14, 1996, and the relations between the two countries were extended into economic, tourism, academic and technical areas as well. Some analysts argued that these initiatives could be seen as the "peak point" in the Turkish-Israeli relations. As an example of these arguments, please see Kut, May 20, 1997.

as a source of leverage in water disputes with Turkey. The two countries linked the water and the PKK issue for the first time in the 1987 Turkish–Syrian Protocol which guarantees a minimum annual flow of 500 cum/s to Syria from the Euphrates. One of Turkey's aims in signing the Protocol was to put an end to Syria's support for the PKK. Indeed, in the second Protocol signed at the same time, Syria agreed to end its support for the PKK and other terrorist groups. Nevertheless, neither this agreement nor the security agreements of 1992 and 1993 were truly successful in ending Syrian support for these groups. This gradually increased the tension between the two sides and evolved into a crisis in October of 1998. The Turkish government and military officials issued statements that they were ready to resort military means unless Syria ended its support for the PKK activities and ceased harboring the group's leader, Abdullah Öcalan. Despite mediation efforts by Egypt and Iran, the crisis escalated very speedily. Since Turkey seemed determined, Syria stepped back and accepted its demands by signing the Adana Declaration on October 20, 1998.[5]

The Adana Declaration was different from the past security agreements signed between the two sides. Syria used much more comprehensive and open expressions in the Declaration. There was no reference to other issues like the water issue, and for the first time, it was agreed to establish a number of implementation mechanisms between the two sides (Benli Altunışık, 2002: 286). After the Declaration, Turkish–Syrian economic, cultural and even hydropolitical relations have begun to develop rapidly as analyzed in the next section.

On the other hand, the hydropolitical relations between Turkey and Iraq were considerably affected by the domestic dynamics in Iraq in the aftermath the 1990 First Gulf War and lately after the 2003 American occupation. From 1995 until recent years, the hydropolitical relations between Turkey and Iraq were not subject to much strain since the domestic and international dynamics in and around Iraq forced the issue of water lower down on the agenda. Another reason Iraq had been carefully abstaining from bringing forward the water issue against Turkey was the expectation that Turkey would be one of the states that help Iraq restore its strained relations within the international fora.

After the American occupation in 2003, Iraq began to bring forward some of its older claims concerning the water issue. For instance, it requests that Turkey increase the amount of water released from the Euphrates to 700 cum/s and that it conclude a permanent water sharing agreement with the other co-riparians. During a visit to Damascus in August 2007, the Iraqi Minister of Water Resources Abdul Latif Jamal Rashid argued that the water problems with Turkey were growing and that an agreement on the Euphrates and Tigris waters was necessary in order to avert a water crisis among the riparian states (Reuters, August 23, 2007).

In addition to these, some important domestic dynamics in Iraq may also deteriorate the hydropolitical relations between the two sides. The most

[5] For more on the crisis, see Aykan (1999).

important one is the potential problems that may arise out of the new structure of the Iraqi Constitution. The paragraph 8 of the Article 107 and the paragraph 7 of the Article 110 arrange the division of authority between the federal government and regional administrations concerning the domestic and international water policies of Iraq. These paragraphs are relatively vague in dividing the authority within the country. This may lead to disputes among the ethnic groups on the issue of equitable sharing and utilization of waters including the Euphrates and Tigris. These potential problems may be externalized to Turkey in the future, causing deterioration in the hydropolitical relations between the two countries (see Mazlum, 2008: 193–196).

3. Dynamics of Regional Cooperation, Sustainability and Governance

Despite the various disputes and unresolved issues among the co-riparians of the Euphrates–Tigris Basin, a number of efforts were also made to achieve regional cooperation on the water issue. When observing the course of events since the beginning of 2000s, it can be argued that the chance for cooperative and peaceful efforts in resolving differences over water issues is higher compared to previous decades. This section provides an analytical account of the past and present efforts toward regional cooperation on the water issue, and examines the important roles of local and national sustainability and governance measures in averting future tensions among the co-riparians.

3.1. LEGAL FRAMEWORKS FOR THE UTILIZATION OF BASIN WATER: BILATERAL AGREEMENTS AND PROTOCOLS

Agreements on water allocation provide legal frameworks for the utilization of transboundary water resources by the riparian states. They also act as conflict prevention mechanisms among the co-riparians. Several such bilateral agreements and protocols have been concluded among the co-riparians of the Euphrates–Tigris Basin since 1920s. The rights and obligations of the riparian states with regard to allocation and utilization of the rivers' waters arise from those agreements and protocols.

Beginning with Turkey and Syria, the most important agreement on the allocation of the Euphrates waters is the Turkish–Syrian Protocol signed in 1987. Before that, several agreements were signed mentioning various aspects of water utilization. The first bilateral treaty was signed on October 20, 1921, in which France was the signatory state on behalf of the mandated Syria. Article 12 of the treaty mentions water supply for the city of Aleppo from Turkey (Caponera, 1991: 5). Article 13 of the Convention of Friendship and Good Neighborliness signed on May 30, 1926 with France refers the previous Article again when mentioning facilitating Syria's access to water from the Euphrates River (see Soysal, 1983: 288–289).

The Protocol delimiting the border between Turkey and Syria was another important agreement addressing the water issue between the two countries (see Soysal, 1983: 385–390). It was signed between Turkey and France on May 3, 1930, and mentions the equitable utilization of common waters for navigation, fishing, industrial and agricultural utilization. Syria, however, questioned the validity of the Protocol in the following years (Caponera, 1991: 5).

It was not until 1987 that another agreement was concluded for regulating the issues on the utilization of the Euphrates water. The latest legal text on the issue is the *Protocol on Matters Pertaining to Economic Cooperation* signed on July 17, 1987, which came about primarily in response to the construction of Karakaya Dam on the Euphrates River. Syria demanded that the indirect commitment given by Turkey be changed to a direct one concerning the release of yearly average of 500 cum/s water downstream during the construction of the dam. As mentioned before, Turkey accepted the Syrian demand assuming that it would end Syrian support for the PKK. The Protocol covers numerous issues including banking, oil and natural gas exploration, livestock transportation and customs formalities, but the issue of water forms the principal subject of the Protocol. The text of Article 6 reads as follows (Official Gazette of the Republic of Turkey, December 10, 1987):

> During the filling up period of the Atatürk Dam reservoir and until the final allocation of the waters of the Euphrates among the three riparian countries, the Turkish side undertakes to release a yearly average of more than 500 cubic meters per second at the Turkish–Syrian border and in cases where the monthly flow falls below the level of 500 cubic meters per second, the Turkish side agrees to make up the difference during the following month.

Article 7 stated that Turkey and Syria should work together with Iraq to allocate Tigris and Euphrates waters within the shortest possible time. Under Article 9, both states agreed in principle to construct and jointly operate irrigation and hydro energy projects.

Much like those between Turkey and Syria, the relations between Turkey and Iraq concerning the waters of the Euphrates and Tigris Rivers are governed by a Protocol annexed to the Treaty of Friendship and Good Neighborly Relations signed on May 10, 1946 and instituted on May 10, 1948 (see UN, 1949: 256–287). Under the *Protocol on Flow Regulation of the Tigris and Euphrates Rivers and of Their Tributaries*, Iraq is assured of (1) access to Turkey by Iraqi technicians for the purpose of surveys and investigations instrumental in the construction of dams, in the installation of measurement and recording facilities and other works needed for the regulation of the flows of the above watercourses in the interest of Iraq (Preamble, Article 1); (2) Turkey's commitment to install and operate permanent flow measurement facilities, and to transmit periodically the readings and recorded data to Iraq (Article 3); (3) Turkey's commitment in principle to accept construction of flow regulation works in Turkish territory but in the interest of Iraq (Article 4); and (4) Turkey's commitment to inform Iraq of projects for water works on any of the Protocol watercourses, and to consult with Iraq with the intention to accommodate the interests of both countries (Article 5).

Turkey and Iraq also agreed to set up a *Committee for the Regulation of the Flows of the Tigris and Euphrates Rivers* to implement the provisions of the Protocol. The Committee would meet under the framework of the *Mixed Economic Commission for Cooperation*. However, it was not until 1980 that a committee was set up under the name of the *Joint Technical Committee on Regional Waters* (*JTC*), analyzed next.

Indeed, as Caponera (1991: 32) argues, the 1946 Treaty forms a "good basis for ensuring cooperative arrangements" between Turkey and Iraq. However, it should be updated according to the current needs of both states. For example, recent developments on GAP could be included to make the Treaty more comprehensive.

Although Turkey and Iraq were not successful in establishing a committee on water issues till 1980, Syria and Iraq managed to establish a joint technical commission by 1962 upon the agreement between the two states to exchange information on the discharge and levels of the Euphrates River. During the negotiations, Iraq raised the issue of its acquired rights and demanded a fixed share of the river's water. However, as Waterbury and Tod (1990: 15–16) state, the two countries only reached to a non-binding bilateral understanding on some technical aspects, failing to agree on issues such as volume allocation, quality of the river's water or seasonal flows. Then, Syria and Iraq began bilateral negotiations in 1966 to achieve sharing of the Euphrates waters, but these negotiations also failed to produce a formal agreement (Waterbury and Tod, 1990: 17). After November 1974, the talks ceased because of the dispute that had developed between Syria and Iraq surrounding the impounding of Tabqa Dam, as mentioned before.

Syria and Iraq held no further talks until 1990 when a crisis developed among the three riparians during the impounding of Atatürk Dam. Both states perceived the water cuts in that period as a sign of potential decrease in the flow of the rivers resulting from Turkish projects. Therefore, during the 13th meeting of the Joint Technical Committee held in Baghdad on April 16, 1990, they concluded a Protocol on sharing the Euphrates waters between them on the basis of ratio. According to the Protocol, Syria committed to release to Iraq 58% of the Euphrates flow entering at the Turkish–Syrian border. Syria, on the other hand, would keep 42% of the Euphrates flow. Thus, the 1990 Syrian–Iraqi Protocol and the 1987 Turkish–Syrian Protocol complemented each other, "creating a de-facto regime" (Kut, 1993: 9).

While forcing Turkey for a trilateral agreement, the conclusion of the 1990 Protocol attests to Syrian and Iraqi claims that the Euphrates waters should be shared according to a determined mathematical formula. Turkey, on the other hand, responded these messages by the *Three Staged Plan* based on the principle of optimum, equitable and reasonable utilization of water resources.

3.2. A TRILATERAL PLATFORM FOR BEGINNING DIALOGUE: THE JOINT TECHNICAL COMMITTEE

The bilateral and trilateral talks among the riparian states could be interpreted as efforts to decrease the level of tension resulting from the water management projects that all three riparians began to implement in the 1960s, and as the search for accommodation among the co-riparians. In these terms, the *Joint Technical Committee* (*JTC*) meetings provided an important platform to share information and views among the riparian states after 1980, albeit a weak one institutionally.

As mentioned before, Turkey and Iraq agreed to form a Joint Technical Committee in 1980 to discuss and finalize the water issues between the two sides. After the first bilateral meeting in May 1982, the JTC began to convene on a trilateral basis with participation of Syria in 1983. From then on, the main objective of the Committee was to study matters on the utilization of regional waters among the three riparian states.

The JTC was authorized in defining methods and processes to determine reasonable amount of water needed by each riparian. For that reason, the main issues on the agenda of the JTC were the exchange of basic hydrological and meteorological data regarding the Euphrates–Tigris Basin, sharing of information on ongoing constructions of dams and irrigation schemes, and discussing the plans about the impounding of Karakaya and Atatürk Dams which were under the construction during that period (Kibaroğlu, 2002: 227).

At first sight, it could be argued that the JTC meetings have not been successful in resolving political and legal disputes among the riparian states. Syria and Iraq continuously demanded that Turkey increase the Euphrates flow of 500 cum/s guaranteed by the 1987 Protocol up to 700 cum/s. Turkey, on the other hand, has been arguing that the current amount would be more than sufficient if the downstream riparians adopted water-saving irrigation technologies and if Iraq's transfer of water from the Tigris to the Euphrates were to be added into the calculations (Gruen, 1994: 267). In addition to these, two central issues could not be resolved during the JTC meetings, ultimately leading to the Committee's failure. The first one was whether the Euphrates and Tigris Rivers should be treated as a single system as Turkey argued, or whether the talks would be limited to the Euphrates River as put forward by Iraq in particular. The second issue, more important than the first one, was whether the final objective of the JTC was to formulate a proposal for *sharing* the basin waters, or to set up a trilateral regime for the *utilization* of the basin waters (Kut, 1993: 10).

The JTC failed to perform its mission after 16 technical and two ministerial meetings. The 17th meeting in Ankara in June 1993 was cancelled when Syria decided not to attend. After a long break, the three sides agreed to initiate technical talks among the water experts who would report to the related ministries during the trilateral ministerial meeting on March 22, 2007 in Antalya. Since this date, the experts of the three riparians meet periodically in trilateral technical talks (Ministry of Foreign Affairs of Turkey, 2007a: 2).

Although they did not prove successful in resolving the disagreements and fostering cooperation, the JTC talks have provided some benefits to the riparian states. First, the Committee meetings functioned as a channel of communication by bringing the issues to the table and discussing the concerns and positions of the riparians. Second, the three sides recognized that the issues on the agenda were more complex than they appeared. Lastly, vital hydrological data and other important information have been exchanged and some proposals have been "more or less" discussed (Kut, 1993: 9).

3.3. A TURKISH PROPOSAL FOR EFFICIENT WATER UTILIZATION: THREE STAGED PLAN

Lack of data on the water and land resources in transboundary basin areas is the major obstacle to the efficient and reasonable utilization of water among riparian countries. The Euphrates–Tigris Basin is not immune to the difficulties caused by this obstacle. There is not much reliable and detailed data on flows and water quality, the quantity and quality of agricultural lands, patterns of irrigation and crops and additional relevant information. One of the immediate effects of the lack of reliable data on water resources is that the total amount of water declared by all riparian states needed for their activities exceeds the amount of the average water flows of both rivers. Hence, it is nearly impossible to make reliable and appropriate decisions concerning the efficient utilization of the basin's waters.

In order to overcome these obstacles and to ensure basin-wide cooperation on the efficient utilization of the waters, Turkey proposed a plan called *Three Staged Plan for Optimum, Equitable and Reasonable Utilization of the Transboundary Watercourses of the Euphrates–Tigris Basin* at the second tripartite meeting of the ministers on June 26, 1990 in Ankara. As can be observed in its title, the Three Staged Plan mainly used the similar terminology developed by the International Law Commission of the UN during the codification of the 1997 Framework Convention on the Non-Navigational Uses of International Watercourses. Hence, the Plan was built on the *needs-based* approach versus the *rights-based* approach.

Indeed, the history of the Three Staged Plan dates back to 1960s. The outline of the plan was completely formed by the engineers of the Turkish General Directorate of State Hydraulic Works (DSI) in a much more comprehensive manner. This outline included three working groups on hydrology, land resources and engineering, each composed of experts from the riparian states (see Kibaroğlu, 2002: 253; Tomanbay, 2000: 95).

The Three Staged Plan is based on two basic principles. The first is that Turkey considers the Euphrates and Tigris Rivers as a single system since the two rivers merge in Iraq to form the Shatt al-Arab waterway and the waters of the two rivers can be used interchangeably because of the Thartar Canal in Iraq. Second, since each country uses different methods for collection, interpretation and evaluation of the data, thereby leading to disparities, it is argued that the inventory of the basin's water resources and land resources should be drawn up and evaluated jointly by the three riparians to realize the most optimum and reasonable utilization of water resources. Three stages of the Plan are listed as follows (Ministry of Foreign Affairs of Turkey, 1995: 35–37):

> 1. The first stage of the plan is to make inventory studies for water resources, which will cover the exchange of whole available data including that of evaporation, temperature, and rainfall over various gauging stations. It also foresees the checking of the measurements.
>
> 2. The second stage is to make inventory studies of land resources, which include soil classification methods, checking water conditions for projects, and calculating irrigation and leaching water requirements based on the studies carried out before.
>
> 3. The third stage will be the evaluation of water and land resources, which will discuss and determine the irrigation type and system for the planned projects aiming at minimizing water losses and to investigate the possibility of modernization and rehabilitation of the projects in operation. Also, based on the project-wise studies, each state's total water consumption will be determined.

Although it might have proved successful in facilitating negotiations, the Three Staged Plan was rejected by the downstream riparians. Nevertheless, it had several advantages that cannot be easily discounted. First, it was a promising plan to overcome the main obstacles in employing standardized data in the negotiations among the riparians and for efficient utilization of the basin's waters. As Turan (1993: 25) put it, it would have been reasonable to irrigate the lands of higher soil quality in order to get higher efficiency in water consumption. Second, the Three Staged Plan was offering some sort of "concealed compromise" among the riparian states (Kut, 1993: 13). This might have also been evolved into the preliminary steps of a regional water management regime based on the optimum, equitable and efficient utilization of the basin's waters in the future.

3.4. INCREASING POLITICAL AND ECONOMIC RELATIONS AND BASIN-WIDE WATER COOPERATION

The dynamics of political and economic relations directly influence the nature and intensity of water disputes among the riparians of a transboundary watercourse. Hence, achieving basin-wide water cooperation could be easier when the riparian states work to constitute mechanisms for settling their political and economic issues as well. Improving political relations, increasing economic cooperation and creating confidence altogether play important roles in increasing the level of hydro-cooperation among the riparian states. The new cooperative atmosphere in Turkish–Syrian relations is an example of this dynamic. As mutual respect between the two states grew through positive political and economic relationships, the stage was set for favorable conditions for cooperation in the water sector. Since the beginning of the 2000s, their hydropolitical relations have moved away from the conflictual past and now look toward a more cooperative future (Mazlum, 2003a: 143).

As mentioned before, Turkish–Syrian relations began to normalize after the Adana Declaration following the 1998 crisis. A number of initiatives were taken to establish implementation mechanisms for achieving cooperation between the two states. For instance, two intelligence officers were sent to the Turkish Embassy in Damascus and a direct phone line was set up between the two capitals. The post-1998 atmosphere between the two countries had positive reflections on the political relations as well. For instance, Syria has carefully abstained from raising the Hatay issue in the last decade. At the end of 2008, Turkey mediated the initial indirect peace talks between Syria and Israel, although these are currently in deadlock due to differences of opinion regarding various issues, as well as Israel's latest military operation in Gaza. Additionally, the intensity of economic relations began to increase especially in the sectors of border transportation and trade. Since the beginning of 2000, Turkish and Syrian government officials and businesspeople have paid numerous visits to revitalize and develop economic relations. These dialogues and efforts culminated in signing of the Free Trade Agreement in December 2004, which entered into force on January 1, 2007. The cultural relations have also been steadily improving since 1999. For instance, the two sides agreed to open their borders to allow the divided families in both countries to unite during religious festivities.

The development of amicable relations between the two states has been reflected in the water issue as well. First of all, during the visit of the Syrian Minister of Irrigation to Turkey in August 2001, the two sides agreed to increase the level of cooperation on water issues. The Syrian minister called for the revival and reactivation of the Joint Technical Committee during the visit. In return, Turkish officials announced that they would distribute the water evenly for the interests of the three riparians in an atmosphere of confidence and reciprocated dialogue (Arabic News, August 23, 2001a). To show its sensitivity on the issue, Turkey tried to provide Syria with 650 cum/s during the few months before the Syrian minister's visit in compensation for the amount of water that it had to reduce less than 500 cum/s in the years 2000–2001 because of a drought in the region (Arabic News, August 23, 2001). During the Syrian minister's visit, a Joint Communiqué was signed between Turkey's GAP Regional Development Administration and Syria's General Organization for Land Development (GOLD) on establishing cooperation in the areas of agricultural water research, rural development, environmental protection and participation of Syrian experts in the international training programs of the GAP Regional Development Administration (NTV News Channel, August 23, 2001). The gradually increasing cooperation between the two government agencies also points to a change in Syria's critical attitude towards GAP since 1980s.

The water issue was again a primary one on the agenda during Syrian Prime Minister Mohammed Mustafa Miro's visit to Turkey in July 2003. The two sides agreed to bring the water issue to the table, although they did not reach a consensus on the process and method of the talks. At that visit, it was also agreed in principle to deepen the cooperation between GAP and GOLD (NTVMSNBC News Portal, July 30, 2003).

The cooperation between Turkey and Syria on water issues is not limited to the Euphrates–Tigris Basin. For instance, the two sides agreed to build a 'Joint Dam of Friendship' on the Orontes River in April 2007, which was a 20-year old idea dating back to 1989 (NTVMSNBC News Portal, April 4, 2007). The technical studies for the dam began in February 2008 (Ministry of Foreign Affairs of Turkey, 2008a: 5).

While the dynamics of the post-1998 period produced increasing cooperation on water between Turkey and Syria, the developments in Iraq during the post-2003 period created different and complex water issues. The Iraqi efforts are mainly devoted to the reconstruction and development of the water and sewage infrastructure that has been seriously damaged due to the embargo against the country in 1990s and bombings during the 2003 American occupation.

The rehabilitation of the Mesopotamian Marshlands in Southern Iraq, new water resources management projects and repairing of a number of water management infrastructures that have suffered from looting are among the other projects badly needed to restore the deteriorated water sector in the country. Provision and distribution of domestic water to people constitute the highest priority since only 30% of the population had access to sufficient and clean water as of mid-2007. Almost 80% of wastewater is discharged into rivers and other waterways without any treatment, leading to an increase in waterborne diseases such as cholera and diarrhea. For instance, according to WHO figures, 30,000 diarrhea cases, of which 3,315 were cholera, had been observed in a recent outbreak between August 14 and October 3, 2007 (WHO, October 3, 2007).

Although a number of US government agencies and institutions have been involved in rehabilitating the water situation and developing water policies in the country, there is still much to be done. The Ministry of Water Resources is one of the first Iraqi government agencies that has developed strategic plans, set up its budget and achieved administrative reorganization (Coalition Provisional Authority, May 10, 2004). It initiated preliminary studies to prepare a master plan for achieving integrated water resource management throughout the country in 2004 (Ministry of Water Resources of Iraq, 2008). Although the budget allocated to the ministry was increased to $150 million in 2004 compared to $1 million prior to the occupation, it will certainly take some time to complete the repair of the old water systems and the construction of new projects.

Some steps towards cooperation were also taken between Turkey and Iraq at the regional level, although not as developed as those between Turkey and Syria. For instance, in a recent trilateral ministerial meeting during the Turkish Minister of Environment and Forestry Veysel Eroğlu's visit to Syria, the three sides agreed to continue the exchange of hydrological data and set up a center in Turkey to train water engineers and experts (Ministry of Foreign Affairs of Turkey, 2007/2008: 4). Apart from these developments, Iraqi water experts participate regularly in the training seminars with their Syrian colleagues, the latest of which was held by the Turkish General Directorate of State Hydraulic Works on October 12–18, 2008 (Ministry of Foreign Affairs of Turkey, 2008b: 6).

However, Turkey's security concerns about PKK terrorism and recent operations against the PKK camps in Northern Iraq may hinder the development of cooperative circumstances in water relations between Turkey and Iraq. Thus, as Daoudy (2007: 29) suggests, future cooperation among the co-riparians will also be influenced by security-related dynamics such as geopolitical and governmental stability.

3.5. SUSTAINABLE WATER UTILIZATION AND GOVERNANCE FOR AVERTING WATER TENSIONS

Increasing political and economic cooperation among the riparian states and providing stability in the region through security-related dynamics cannot be sufficient in averting potential water disputes among the co-riparians if the measures of sustainability and governance are not taken into account in achieving the optimum and efficient utilization of water resources in the basin.

Sustainability in water utilization means much more than relying on technical dimensions and engineering solutions in water resource management. It is the management and governance of water resources that takes into account the needs of present and future generations. The concepts of sustainable water management and human security are linked to each other (Mazlum, 2003b: 347–352). Hence, in addition to technical measures, social, political, economic and environmental policies aimed at individuals and societies become the major tools in achieving sustainability in water management. When local, national and regional sustainability measures are adapted by the co-riparians of the Euphrates–Tigris basin, the pressures on water resources could be released and tensions among the riparian states could be averted (Mazlum, 2006: 29; Haddad and Lindner, 2001: 152).

The first policy to achieve sustainability in the basin needs to address the rate of population growth in order to decrease the excessive utilization of water and to prevent degradation of water quality. More than 90% of available water in Iraq, 88% in Syria and around 70% in Turkey is allocated to agricultural sector. If the current rates of population growth in the region remain at the same level, almost all of the available water would have to be allocated to agricultural production in the near future (Biswas et al., 1995: 493). Therefore, sound family planning policies need to be adopted and the riparian states should allocate sufficient financial resources to do so.

Another policy option to decrease the rates of population growth could be taking measures to decrease infant mortality rates, since poor health conditions often force families to have more children. Also, families in the lower socio-economic strata and agricultural sectors who depend on a child labor force do not want to take risk of having fewer children under poor health conditions. In addition to these, the social security systems in the riparian states need to be improved since in the less-developed regions where the social security systems do not work effectively, parents often believe that having more children provides them a kind of assurance in their elderly life.

Educating women is another strategic policy option in decreasing the rate of population growth. Some studies reveal that the average number of children could drop to two in families where parents have received a secondary education (Myers, 1998: 34–35). Following the trend in other countries of the Middle East, females receive less education than males in some parts of Turkey, Syria and Iraq. This comes up as a factor hindering the efforts to decrease the rate of population growth.

Water demand management at the local and national levels is another crucial policy for achieving sustainability in water management. People are often focused supply-side tools in water management strategies, but come to realize the impact of individual use and adopt more efficient consumption patterns accordingly. Some analysts even argue that the demand management techniques are the only options left for sustainable water management in the Middle East (e.g., Björklund and Kuylenstierna, 1998: 275).

Increasing the efficiency of water consumption in the agricultural sector is one of the principal ways to reduce demand. The efficiency in traditional irrigation methods is very low. It drops even further in the Middle East with excessive water usage and high evaporation rates. The efficiency of irrigation in the co-riparians of the Euphrates–Tigris Basin is not much different, changing between 40% and 60% depending on the irrigation systems used.

In Iraq, the operation and maintenance of the irrigation systems has been inadequate since the early 1990s. The situation was exacerbated by the 2003 occupation. Water efficiency is very low (around 40%) due to the poor quality of the irrigation infrastructure and excessive water consumption in traditional irrigation methods. Modern irrigation methods such as sprinkling and drip irrigation are not extensively used in the country.

Syria is also one of the countries where water is wasted due to low irrigation efficiency (about 60%) and unrestricted demand. The urban water distribution systems also work inefficiently. Irregular maintenance of leaky pipes causes up to 30–50% loss of water in the urban water systems. However, some steps were taken to increase water efficiency throughout the country. For instance, the Syrian National Environmental Action Plan accepted in 2001 includes a number of strategies to stop excessive usage of water, to shift into sustainable irrigation systems, to develop alternative water supply methods such as treatment of wastewater, to develop conservation policies in order to prevent decrease in water quality and to apply integrated water resource management policies throughout the country. In addition, Syria decided to set up a fund for promoting efficient water consumption and use of modern irrigation technologies (Ministry of Foreign Affairs of Turkey, 2007b: 2).

In Turkey, the irrigation efficiency is around 60% in the GAP region. A considerable amount of water is lost in the water distribution systems in the region because of the lack of allocation of sufficient financial resources to maintain the irrigation systems. The technical support provided to farmers to irrigate agricultural lands more efficiently is not at the ideal level (see Aküzüm et al., 1997: 551–552). Some studies including GAP–MOM project were initiated to overcome these difficulties. MOM could be defined as **M**anagement – **O**peration – **M**aintenance of an irrigation system. The main objective of GAP–MOM project was to set up a sustainable MOM model with a bottom-up approach. In these terms, the model includes rehabilitating irrigation infrastructures, designing systems to measure the amount of irrigation water distributed, using the irrigation methods and tools appropriate to the region and training of farmers to irrigate agricultural lands efficiently (Aküzüm et al., 1997: 553–559; Ünver, 1997: 475–476).

Rational pricing of water constitutes an important part of sustainable water management as well. One of the four principles of the 1992 Dublin Statement of Water and Sustainable Development treats water as an economic resource subject to pricing. In the majority of Middle Eastern countries, however, water is treated as a public good due to various political, socio-economic and religious factors. As a result, pricing water especially in the agricultural sectors does not meet the necessary investment costs.

In fact, the issue of water pricing needs to be considered within the framework of general agricultural subsidy policies. Taken in this respect, pricing water on real costs is difficult to achieve and mostly not preferable. Countries usually subsidize their agricultural productions to make them competitive in international markets. Saudi Arabia forms one of the most striking examples of this case by selling wheat at the world prices while producing it at 4 times the world costs.

In the Middle Eastern countries were large portions of society earn a living from the agricultural sector, agricultural subsidy polices carry vital importance for providing political stability. In Syria, for instance, irrigation water is priced at a constant tariff (except for some crops that require more water) that only covers a fraction of investment costs (Sadik and Barghouti, 1994: 25). The conditions are similar in Turkey as well. The levels of prices change according to the region, crop type and irrigation method, but still do not meet the real costs of irrigation (Pamukçu, 2000: 182).

On the other hand, water for domestic and industrial consumption is priced at the unit cost. The unit costs of water change according to the distance from and size of the water resource, and the costs of the necessary processes to make it fit for domestic consumption. However, it is important to note that water pricing should also be just, so as not to deprive some poorer parts of the society from access to sufficient water. Otherwise, unjust water pricing would increase tensions among different socio-economic classes especially living in cities (see Albrecht, 2000: 15).

Covering the costs of pollution from domestic and industrial activities is as important as pricing water in real terms. Here, the principle of *polluter pays*, if employed strictly, could have a positive effect on decreasing the level of water pollution in addition to covering the costs of cleaning polluted water resources. In some countries, including Turkey, pricing of domestic water use already includes wastewater cost at a certain rate, the collection of which is not difficult since it is automatically included in the water bills. However, in Syria, domestic water usage is priced by using two different methods: pricing at a fixed amount monthly and pricing per cubic meter. According to 2,000 figures, the monthly fixed price was around $3.2 and the price per cubic meter fluctuated between 11 and 53 cents. Neither of these sufficiently cover wastewater costs (Ahmad, 2000: 233).

Another key element for balanced and sustainable water resource management and water governance is extensive and democratic stakeholder participation (Jønch-Clausen and Fugl, 2001: 507; UNESCO, 2006: 46). *Agenda 21* states that particular emphasis has to be placed on the introduction of public participatory techniques to assure the lowest appropriate level of participation in water resource management (para. 18.19). These include the participation of local communities, farmers, women, youth and civil society organizations among others.

The main difficulty in centralized water resource management is that local communities expect assistance from the government even for minor issues instead of undertaking grassroots initiatives to solve them (Loucks, 2000: 7). In this regard, the transfer of power to the local level in water resource management and the participation of local water users in decision-making processes both assure that they will take more responsibility in using water resources efficiently and participate more actively in the maintenance of water quality (IUCN, 2000: 27). Therefore, setting up legal frameworks for empowering local communities and increasing institutional capacities of water users associations have the utmost importance in water governance. Also, having water users associations carry out the services of operation and maintenance of irrigation systems would both decrease the expenses of central authorities and increase efficiency in water utilization by local farmers (see Bilen, 2000: 300–301).

Training of farmers is another tool for local participation in water management. In this regard, training of women is also important since the female labor forces in the agricultural sectors of the riparian states are relatively large. For instance, in Syria, it is 3 times larger than the male agricultural labor force (Arabic News, March 26, 1999). In Turkey, especially in the GAP region, a number of intensive training programs are underway for local farmers. GAP Regional Development Administration also organizes other training programs in two broad categories, including *regional and human capacity building*[6] and *exchange of experience*[7] (GAP Regional Development Administration, 2008b). Between 2000 and 2008, more than 50 domestic and international training programs were completed. Some of these programs were organized in Syria.

GAP Regional Development Administration also organizes activities on sustainable human development and poverty eradication from a gender perspective. In this regard, the Multi-Purpose Community Centers (ÇATOMs) were established in 1995. Currently, there are 30 ÇATOMs active in nine cities (GAP Regional Development Administration, 2008c). The goals of ÇATOMs include

[6] The fields of regional and human capacity building are rural development, regional and urban planning, local governments, environment, tourism, entrepreneurial skills, inter-cultural communication, project development, implementation, monitoring and evaluation, leadership, human resources management and water resources management.

[7] The fields in this category are participatory irrigation management, participatory resettlement, women and development, youth programs and the best practices of sustainable regional development in GAP.

increasing the rate of literacy among females, ensuring that they part in the public sphere, developing their productive skills in different job sectors, creating female employment opportunities and increasing maternal and child health, nutrition and hygiene standards of the female population in the region.

4. Conclusion

Although some writers find that the various examples of the crises and disputes among the co-riparians of the Euphrates–Tigris Basin since 1970s strengthen the main arguments of the "water wars/conflicts" literature, the initiatives taken to achieve regional cooperation and to accommodate differences of opinions among the riparian states tell us that there are even stronger efforts to achieve peace. Despite the failure in resolving the disputes among the co-riparians in the Joint Technical Committee talks and rejection of the Three Staged Plan by the downstream riparians in the past, the developments in the last decade opened a new phase in the hydropolitical relations among the co-riparians. When observing the course of events since the beginning of 2000s, it can be easily argued that cooperative efforts in resolving differences over water issues are more likely than in previous decades. Increasing political, economic, cultural and social relations could create a certain level of interdependence among the co-riparians of the Euphrates–Tigris Basin. Once this happens, the cost of deteriorating those relations would be high.

However, there are certain other factors that should be taken into account while analyzing the future of water issues among the riparian states. The most important one is the sustainability of water resource management in the Euphrates–Tigris Basin. In these terms, the issue of population growth in the riparian countries is a critical first step, since it leads to the excessive consumption of water and diminishing water quality. Curbing the rate of population growth necessitates various policy measures that decrease infant mortality rates, educate women in particular and increase the effectiveness of social security systems.

Water demand management at the local and national levels is the second essential dimension of sustainability in water resource management. Here, increasing irrigation efficiency in the agricultural sector, rational and just pricing of water consumption, covering the costs of water pollution and stakeholder participation are the primary elements for achieving sustainable water resource management and water governance in the co-riparians of the Euphrates–Tigris Basin.

Lastly, sustainability measures at the local and national levels should be directed towards achieving overall sustainability at the basin level. In order to realize this, activities at all levels need to be coordinated and directed towards providing cooperation on the sustainable water resource management and achieving sustainable peace in the Euphrates–Tigris Basin.

References

Ahmad, M., 2000. Water Pricing and Markets in the Near East: Policy Issues and Options, *Water Policy*, 2: 229–242.

Aküzüm, T. et al., 1997. Irrigation Management in GAP, *Water Resources Development*, 13(4): 547–560.

Albrecht, U., 2000. War over Water? *Journal of European Area Studies*, 8(1): 11–25.

Appelgren, B. and Klohn, W., 1997. Management of Transboundary Resources for Water Security: Principles, Approaches and State Practice, *Natural Resources Forum*, 21(2): 91–100.

Arabic News, 1999. *Agriculture in Syria and the Euphrates*, 26 March (September 14, 1999); http://arabicnews.com/ansub/Daily/Day/990326/1999032602.html.

Arabic News, 2001a. *Syrian–Turkish Water Talks*, 23 August (September 15, 2001); http://www.arabicnews.com/ansub/Daily/Day/010823/2001082312.html.

Arabic News, 2001b. *The Turkish Waters to Syria*, 23 August (September 15, 2001); http://www.arabicnews.com/ansub/Daily/Day/010823/2001082303.html.

Aykan, M.B., 1999. The Turkish–Syrian Crisis of October 1998: A Turkish View, *Middle East Policy*, 6(4): 174–191.

Bağış, A.I., 1994. Water in the Region: Potential and Prospects – An Overview, in: *Water as an Element of Cooperation and Development in the Middle East*, A.I. Bağış, ed., Ayna, Istanbul, pp. 15–26.

Bengio, O. and Özcan, G., 2001. Old Grievances, New Fears: Arab Perceptions of Turkey and Its Alignment with Israel, *Middle Eastern Studies*, 37(2): 50–92.

Benli Altunışık, M. (2002). Soğuk Savaş Sonrası Dönemde Suriye'nin Dış Politikası: Değişime Uyum Çabası (The Syrian Foreign Policy in the Post-Cold War Period: The Struggle for Adapting the Change), in: *Türkiye'nin Komşuları (Turkey's Neighbors)*, M. Türkeş and I. Uzgel, eds., İmge, Ankara, pp. 259–292.

Beschorner, N., 1992. Water and Instability in the Middle East, *Adelphi Paper No. 273*, The International Institute for Strategic Studies, London, pp. 3–82.

Bilen, Ö., 2000. *Ortadoğu'da Su Sorunları ve Türkiye: Indus, Colorado, Tuna ve Ürdün–İsrail Su Anlaşmalarının İrdelenmesi ve 21. Yüzyılın Su Gündemi (Water Issues in the Middle East and Turkey: Analyzing Indus, Colorado, Danube and Jordan–Israel Water Agreements and Water Agenda of the 21st Century)*, TESAV, Ankara.

Biswas, A.K., Lindblom, L., and Tortajada Quiroz, C., 1995. Sharing Water Resources: Conclusions, *Water Resources Development*, 11(4): 493–494.

Björklund, G. and Kuylenstierna, J.L., 1998. The Comprehensive Freshwater Assessment and How It Relates to Water Policy Worldwide, *Water Policy*, 1: 267–282.

Caponera, D.A., 1991. Legal and Institutional Concepts of Cooperation, Paper delivered to *The International Conference on Transboundary Waters in the Middle East: Prospects for Regional Cooperation*, Bilkent University, Ankara, September 2–3, pp. 1–37.

Coalition Provisional Authority, 2004. *Ministry of Water Resources Assumes Full Sovereignty*, 10 May (May 18, 2004); http://www.cpa-iraq.org/pressreleases/20040510_water.html.

Çarkoğlu, A. and Erder, M., 2001. Domestic Concerns and the Water Conflict over the Euphrates–Tigris River Basin, *Middle Eastern Studies*, 37(1): 41–71.

Daoudy, M., 2007. Benefit-sharing as a Tool of Conflict Transformation: Applying the Inter-SEDE Model to the Euphrates and Tigris River Basins, *The Economics of Peace and Security Journal*, 2(2): 25–32.

Elhadj, E., 2008. Dry Aquifers in Arab Countries and the Looming Food Crisis, *The Middle East Review of International Affairs (MERIA)*, 12(3): 1–12.

Eppel, M., 1999. Syrian–Iraqi Relations: Iraq as a Factor in the Syrian Foreign Policy, in: *Modern Syria: From Ottoman Rule to Pivotal Role in the Middle East*, M. Ma'oz, J. Ginat, and O. Winckler, eds., Sussex Academic Press, Brighton, pp. 210–227.

Falkenmark, M., Lundqvist, J., and Widstrand, C., 1990. *Water Scarcity – Ultimate Constraint in Third World Development, Tema V, Report 14*, University of Linkoping, Linkoping.

FAO-AQUASTAT, 2008. Summary Fact Sheets: Turkey, Syria and Iraq (November 23, 2008); http://www.fao.org/nr/water/aquastat/countries/index.stm.

Frankel, N., 1991. Water and Turkish Foreign Policy, *Political Communication and Persuasion*, 8: 257–311.

GAP Regional Development Administration, 2008a. *Southeastern Anatolia Project Action Plan (2008–2012)*, GAP RDA, Ankara.

GAP Regional Development Administration, 2008b. GAP Training Services, 8 May (May 24, 2008); http://www.gap.gov.tr/gap_eng.php?sayfa=English/gegitim.html.

GAP Regional Development Administration, 2008c. Multi-Purpose Community Centres (ÇATOMs), 28 April (May 24, 2008); http://www.gap.gov.tr/English/Sosprj/catom.html.

Gruen, G.E., 1994. International Regional Cooperation: Preconditions and Limits, in: *Water as an Element of Cooperation and Development in the Middle East*, A.I. Bağış, ed., Ayna, Ankara, pp. 263–288.

Haddad, M. and Lindner, K., 2001. Sustainable Water Demand Management versus Developing New and Additional Water in the Middle East: A Critical Review, *Water Policy*, 3: 143–163.

IUCN, 2000. *Vision for Water and Nature: A World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century*, IUCN, Gland.

Jønch-Clusen, T. and Fugl, J., 2001. Firming up the Conceptual Basis of Integrated Water Resources Management, *Water Resources Development*, 17(4): 501–510.

Kibaroğlu, A., 2002. *Building a Regime for the Waters of the Euphrates–Tigris River Basin*, Kluwer Law International, The Hague.

Kut, G., 1993. Burning Waters: The Hydropolitics of the Euphrates and Tigris, *New Perspectives on Turkey*. (9) Autumn: 1–17.

Kut, S., 1997. Gecikmiş Bir İşbirliği (A Delayed Cooperation), *Milliyet Newspaper*, 20 May.

Laipson, E., 2002. The Middle East's Demographic Transition: What Does It Mean? *Journal of International Affairs*. 56(1) Fall: 175–188.

Libiszewski, S., 1999. International Conflicts over Freshwater Resources, in *Ecology, Politics and Violent Conflict*, M. Suliman, ed., Zed Books, London, pp. 115–138.

Loucks, D.P., 2000. Sustainable Water Resources Management, *Water International*, 25(1): 3–10.

Mazlum, I., 2003a. The Hydropolicies of Turkey and Syria on the Euphrates–Tigris Basin: From the Tense Past to a Cooperative Future, *Relations arabo-turques et Rôle des Elites dans la Modernisation (Actes du IIIe Congrès International Arabo-Turc – Istanbul, 22–26 Mai 2002), Série 8: Dialogues No 9*, Zaghouan, Tunis: Fondation Temimi pour la Recherche Scientifique et l'Information, pp. 143–152.

Mazlum, I., 2003b. Çevre ve Güvenlik İlişkisine Tanımsal Bir Yaklaşım (A Descriptive Approach to the Environment and Security Linkage), in: *Uluslararası İlişkilerde Sınır Tanımayan Sorunlar: Göç, Yurttaşlık, İnsan Hakları, Toplumsal Cinsiyet, Küresel Adalet ve Güvenlik (Borderless Issues in International Relations: Migration, Citizenship, Human Rights, Gender, Global Justice and Security*, A. Kaya and G. Göksu Özdoğan, eds., Bağlam, İstanbul, pp. 333–360.

Mazlum, I., 2006. Su Kaynakları, Çatışma ve Dicle-Fırat Havzası'nda Sürdürülebilirlik (Water Resources, Conflict and Sustainability in the Euphrates–Tigris Basin), *Karizma Journal*, 7(27): 25–40.

Mazlum, I., 2008. Dicle-Fırat Havzası'nın Hidropolitiği ve Türkiye-Irak İlişkileri (The Hydropolitics of the Euphrates–Tigris Basin and Turkey–Iraq Relations), in: *Irak Açmazı:*

Türkiye Açısından Temel Parametreler (Iraqi Dilemma: Basic Parameters from Turkish Perspective), G. Ayman, ed., Boğaziçi University–Foreign Policy Forum Publications, İstanbul, pp. 173–201.

Ministry of Foreign Affairs of Turkey, 1995. *Water Issues Between Turkey, Syria and Iraq*, Ministry of Foreign Affairs, Ankara.

Ministry of Foreign Affairs of Turkey, 2007a. *Su Kaynakları Haber Bülteni (Bulletin of Water Resources)*, No. 2, May–June, pp. 1–3.

Ministry of Foreign Affairs of Turkey, 2007b. *Su Kaynakları Haber Bülteni (Bulletin of Water Resources)*, No. 3, September–October, pp. 1–2.

Ministry of Foreign Affairs of Turkey, 2007/2008. *Enerji, Su Kaynakları ve Çevre Haber Bülteni (Bulletin of Energy, Water Resources and Environment)*, No. 4, November–January, pp. 1–9.

Ministry of Foreign Affairs of Turkey, 2008a. *Enerji, Su Kaynakları ve Çevre Haber Bülteni (Bulletin of Energy, Water Resources and Environment)*, No. 5, February–May, pp. 1–12.

Ministry of Foreign Affairs of Turkey, 2008b. *Enerji, Su Kaynakları ve Çevre Haber Bülteni (Bulletin of Energy, Water Resources and Environment)*, No. 6, October–December, pp. 1–8.

Ministry of Water Resources of Iraq, 2008. *2004 Projects*, 14 September (September 14, 2008); http://iraq-mowr.org/english/Project2004.htm.

Myers, N., 1998. Global Population and Emergent Pressures, in: *Population and Global Security*, N. Polunin, ed., Cambridge University Press, Cambridge, pp. 17–46.

Nipon Koei Co. Ltd. and Yüksel Proje A.Ş. Joint Venture, 1989. *Southeastern Anatolia Project Master Plan Study – Vols. I–IV*, Tokyo and Ankara.

NTV News Channel, 2001. *The Evening News*, 23 August, 17:00 GMT.

NTVMSNBC News Portal, 2003. *Suriye ile Su Meselesi Görüşülecek (Water Issue Will Be Discussed with Syria)*, 30 July (July 31, 2003); http://www.ntvmsnbc.com/news/226729.asp.

NTVMSNBC News Portal, 2007. *Güler: Suriye'yle Dostluk Barajı Kuracağız (Güler: We will Construct Dam of Friendship with Syria)*, 4 April (April 4, 2007); http://www.ntvmsnbc.com/news/404540.asp.

OECD, 1992. *Environmental Policies in Turkey*, OECD, Paris.

Official Gazette of the Republic of Turkey, 1987. *Protocol on Matters Pertaining to Economic Cooperation Between the Republic of Turkey and the Syrian Arab Republic*, 10 December, pp. 5–9.

Olson, R., 1997. Turkey–Syria Relations Since the Gulf War: Kurds and Water, *Middle East Policy*, 5(2): 158–193.

Özcan, G., 2002. İsrail Güvenlik Anlayışında Dönüşüm: Ufuk Ötesi Tehditler ve Türkiye (The Transformation in the Israeli Security Understanding: Threats beyond the Horizon and Turkey), in: *Türkiye'nin Komşuları (Turkey's Neighbors)*, M. Türkeş and I. Uzgel, eds., İmge, Ankara, pp. 213–257.

Pamukçu, K., 2000. *Su Politikası (Water Politics)*, Bağlam, İstanbul.

Radikal Newspaper, 2008. *GAP'ta 3.8 Milyon Kişilik İş İçin Kaynak Yok (There is No Resource for Creating Jobs for 3.8 Million People in GAP)*, 28 May.

Reuters, 2007. *Iraq Calls for Water Treaty to Avert Crisis*, 23 August.

Sadik, A. and Barghouti, S., 1994. The Water Problems of the Arab World, in: *Water in the Arab World: Perspectives and Prognoses*, P. Rogers and P. Lyndon, eds., Harvard University Press, Cambridge, MA, pp. 1–37.

Schulz, M., 1995. Turkey, Syria and Iraq: A Hydropolitical Security Complex, in: *Hydropolitics: Conflicts over Water as a Development Constraint*, L. Ohlsson, ed., Zed Books, London, pp. 91–122.

Soysal, I., 1983. *Türkiye'nin Siyasal Andlaşmaları, I. Cilt (1920–1945) (Turkey's Political Treaties, Vol. I (1920–1945)*, Turkish Historical Society Publications, Ankara.

The Economist, 1995/1996. *Water in the Middle East*, 23 December–5 January, pp. 57–59.

Tomanbay, M., 2000. Turkey's Approach to Utilization of the Euphrates and Tigris Rivers, *Arab Studies Quarterly*, 22(2): Spring: pp. 79–100.

Turan, I., 1993. Turkey and the Middle East: Problems and Solutions, *Water International*, (18): 23–29.

Turan, I. and Kut, G., 1997. Political-Ideological Constraints on Intra-Basin Cooperation on Transboundary Waters, *Natural Resources Forum*, 21(2): 139–145.

Turkish Statistical Institute, 2008. *Haber Bülteni (News Bulletin)*, No. 9, 21 January.

UN, 1949. *UN Treaty Series XXXVII*, pp. 256–287.

UNDP, 2002. *Arab Development Report 2020: Creating Opportunities for Future Generations*, United Nations, New York.

UNESCO, 2006. *The United Nations World Water Development Report 2 – Water: A Shared Responsibility*, UNESCO & Berghahn Books, Paris/New York.

Waterbury, J. and Tod, W.S., 1990. Dynamics of Basin-Wide Cooperation in the Utilization of the Euphrates, paper submitted to the *Conference on the Economic Development of Syria: Problems, Progress, and Prospects*, Damascus, 6–7 January, pp. 1–23.

WHO, 2007. *Cholera in Iraq-Update 3*, 3 October (October 4, 2007); http://www.who.int/csr/don/2007_10_03/en/index.html.

World Bank, 2000. *World Development Indicators 2000*, World Bank, Washington, DC.

HOW INVESTMENT IN WASTEWATER INFRASTRUCTURE HAS IMPROVED WATER QUALITY ALONG THE US–MEXICO BORDER

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Abstract: When Mexico and the United States (U.S.) agreed to the North American Free Trade Agreement (NAFTA), they expected the resulting economic growth to have some adverse environmental side effects. The two parties therefore came to an environmental agreement to create the Border Environmental Co-operation Commission (BECC) and the North American Development Bank (NADB) to cooperate with existing water institutions in addressing water pollution. Mexican, U.S., and bilateral agencies have invested over $1.5 billion between 1999 and 2005 in water and wastewater (W/WW) infrastructure along the U.S.–Mexico border. This infrastructure has reduced water pollution in the Rio Grande, which forms the international border. This paper reports on sources of funds, characterizes W/WW infrastructure investment, and documents water quality improvement. Improvements in water quality have occurred where infrastructure has been added. On the other hand, water quality problems persist where infrastructure investments have yet to be made or have been over-whelmed by regional population growth. This paper is based on information gathered for an EPA report on the impacts of water-related infrastructure along the Mexico–Texas border.

Keywords: Mexico; U.S.; pollution; North American Free Trade Agreement (NAFTA); water and wastewater (W/WW) infrastructure; investment; Border Environmental Cooperation Commission (BECC); North American Development Bank (NADB); Rio Grande

1. Introduction

During debate preceding the North American Free Trade Agreement (NAFTA), both Mexican and U.S. officials expressed concern that economic growth would

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bring about adverse environmental conditions if waste products were not addressed in tandem with growth. Some analysts argued that one potential hazard of NAFTA was that Mexico/U.S. border cities, which were already experiencing environmental problems, would not be able to handle the environmental consequences of growth and the situation would not be sustainable. As a result, Mexico and the U.S. adopted an environmental side agreement for the NAFTA treaty to address water supply pollution and hazardous waste. The North American Development Bank (NADB) and Border Environment Cooperation Commission (BECC) were formed in 1994 to administer U.S. and Mexican funds for environmental infrastructure along the border. They would cooperate with other agencies to improve the environment and safeguard humans from water-borne diseases and hazardous conditions. Since 1994, both nations have been investing significant resources of time, money, equipment and personnel to improve ambient air quality, increase access to and quality of drinking water, extend sewerage coverage, increase wastewater treatment efficiency and strengthen and enforce building codes.

This paper addresses how investment associated with efforts to reduce environmental degradation resulting from economic growth has affected water quality along the U.S.–Mexico border since NAFTA. It reports on the various investments made to mitigate pollution and how water quality has changed. One key issue is whether or not the pre-NAFTA prediction of increased pollution resulting from economic growth was indeed correct. If so, were investments sufficient to mitigate the new water risks?

This study is based on various forms of information, including public documents, electronic data, observations, interviews, and site visits. Interviews and site visits were conducted between April 2005 and October 2007 and during the Binational Rio Grande Summit held November 17–18, 2005, in McAllen, Texas, and Reynosa, Tamaulipas. The project study included evaluation of overall program investment in Texas counties and Mexican states adjacent to the Rio Grande. This paper reports on Rio Grande water quality from Dona Ana County, New Mexico to the Gulf of Mexico. It is based on information gathered for a U.S. Environmental Protection Agency (EPA) report on the impacts of water-related infrastructure along the Mexico–Texas border entitled “How Investment in Water, Wastewater, and Irrigation Infrastructure Has Affected the Mexico–Texas Border.”

2. The Rio Grande Region

Over the past century, economic and social factors have limited infrastructure investment to address the environment and human health in the border region between Texas and Mexico. Economic growth has been continuous, even if constrained by shared natural resources, financial resources, and national interests. Over time, the regional economic base has shifted from agriculture to industrial and commercial activity.[1] Many of the officials interviewed boasted of growth in various economic sectors since 1994, such as eco-tourism, recreation, maquiladora industry, commercial agriculture, and light industry. The border region has experienced significant population growth, most likely as a result of the massive migration of people towards this emerging beacon of prosperity. In 2009, the Mexico–U.S. border area is home to approximately 12 million people who mostly live in 14 sister cities (EPA, 2003: 5). This growth has spawned additional infrastructure needs, and the pace of development is exceeding even conservative planning estimates of available utility capacity. Replacement of aging infrastructure is another concern in many of these communities. Even prior to 1994, municipal or rural water and wastewater investments often responded to infrastructure deficits and were only rarely capable of meeting demands from growth.

During the 1990s, the limited financial resources in low-income communities, limited revenue from services, and lack of regulation made utility service provision difficult in border areas. Most communities were ill-prepared to deal with exploding growth rates and the subsequent need for water and wastewater (W/WW) services.[2] The water infrastructure deficiencies were primarily in rural areas of Texas and in urban parts of Mexico.[3] In unregulated developments outside of Texas cities, known as "colonias", the lack of adequate W/WW systems was compounded with the fact that many residents were unable to assure their health due their poor economic or legal status. Mexican utilities are sometimes unable to collect payments because users are unregistered, cannot be identified, have unique payment arrangements, may be unwilling to pay, or cannot afford to pay.[4] Even if a utility is aware of delinquent payments of users, utilities can be slow to cut off service. Some communities dare not raise rates for fear of backlash from residents. Because of this uncertainty of the payment stream, municipalities have had difficulty financing water infrastructure. Cities on both sides of the border have experienced stress on many of the municipal services they provide, especially on existing utility infrastructure. That said, some water and wastewater systems have failed.

As failures occurred, polluted water produced conditions that exposed humans to a host of hazards. Some residents, especially children, were afflicted with water-borne diseases at rates higher along the border as compared to other locations further away (Warner and Jahnke, 2003). Conditions of poor drinking water quality, exposure to untreated wastewater, and increased levels of pollutants in the Rio Grande received national attention during the 1990s. Studies showed

[1] Observation during field trip by Marcel Dulay between May 20 and June 6, 2005.

[2] Interview conducted by Marcel Dulay with BECC and NADB and mayors.

[3] Interviews conducted by Marcel Dulay during a May 2005 field trip with various colonia residents.

[4] Interviews conducted by Marcel Dulay during a May 2005 field trip with various municipal managers in Mexico.

that the Rio Grande had various levels of pollutants above acceptable water quality limits (IBWC, 2004). Nevertheless, these conditions did not necessarily deter population growth along the border because families adapted to these available resources.[5]

3. Investment

The degrading environment and human health situation along the border brought national attention that sparked various levels of government action. Strong activism from the late 1980s to the early 1990s on the part of border community leaders and state officials resulted in the enactment of legislation to appropriate state and federal funds for infrastructure development that would improve conditions. Mexico and the U.S. joined forces to improve the environment along the border, and cooperated effectively on many transboundary water projects, particularly since NAFTA and its environmental side agreements. Overall, the level of activity along the border has been impressive. Projects have ranged from small self-help activities to large-scale regional treatment facilities costing over $100 million. Hundreds of millions of dollars in revenue bonds funded border colonia water and wastewater projects (Texas Comptroller of Public Accounts, 1998) and a constitutional amendment was made to require that water infrastructure be provided to colonias or other underdeveloped areas. Numerous partnerships to improve the conditions along the border have been formed, such as the Border 2012 Program.

The United States Department of Agriculture (USDA), Texas Water Development Board (TWDB), and Texas Office of Rural Community Affairs (ORCA) are the major infrastructure investors in Texas. These agencies operate independently throughout Texas, but often cooperate on a specific single project or program to improve water and wastewater services in a border community. These efforts are supported with either grants or loans to support public facility improvements such as collection systems, water distribution, treatment, hookups, roads and drainage improvements in economically distressed areas of Texas. These are areas where communities do not have the financial, institutional, and technical capacity to provide water and wastewater services.

Mexican constitutional water law assigns the Mexican Water Commission (*Comissión Nacional del Agua* or CONAGUA) the responsibility of providing citizens with a healthy environment. CONAGUA is responsible for helping local municipalities improve infrastructure in rural and urban areas through planning, rehabilitation, and construction. CONAGUA administers several grant programs to meet these objectives with the intent of decentralizing the responsibility to the state or municipality in the long-term (Secretaría de Medio Ambiente

[5] Interview by Marcel Dulay with Gorge Garcés, General Director of North American Development Bank, Austin, Texas, October and November, 2006.

y Recursos Naturales, 2003). In 1994, the U.S. and Mexico collaborated to create two new bilateral organizations as a result of NAFTA, the BECC and NADB.[6] Although NAFTA's goal was to promote trade and economic growth, the agreement would never have been ratified without inclusion of provisions to improve the quality of the environment. These two institutions are truly joint (a circumstance still unique in the world) with staff and board members who are natives from each of the countries, rather than separated into units defined by nationalities. BECC reviews and certifies infrastructure projects for funding, provides technical assistance during project design, analyzes each project's environmental feasibility, and evaluates a project's potential social and economic benefits. NADB administers the paid-in capital from both countries for loan capacity and grant funds from EPA appropriated through the Border Environment Infrastructure Fund (BEIF), which were mostly used as matching funds against NADB loans.

BECC/NADB's designated priorities were to mitigate the negative environmental effects of rapid economic growth to advance the well-being of the people of Mexico and the United States. This is to be done in a transparent and sustainable manner, open to public participation. The two agencies seek to preserve, protect and enhance the environment of the border region by preventing, controlling, or reducing environmental pollutants through sustainable environmental infrastructure.[7] An initial list of priority projects were in water, wastewater, or landfills located within the 100-km area of the U.S. border and 300-km of the Mexican border. Since 1999, over $1.5 billion has been invested in water-related infrastructure in 14 Texas counties adjacent to the U.S.–Mexico-border and the three bordering Mexican states. Prior to 1999, Texas invested an additional $1 billion in water-related infrastructure; Mexican data are not available for that earlier period. The TWDB, USDA, and ORCA have invested over $1.7 billion since 1959 with El Paso, Hidalgo, and Cameron Counties receiving the largest shares of this amount. The majority of projects have been related to wastewater. The TWDB has invested the most, with over $1.24 billion applied to 443 water and wastewater projects in Texas's 14 border counties since the agency's first project in 1959. Between 1966 and 2005, USDA grants and loans have financed 222 projects in Texas for a total cost of $245 million. Since 1986, 266 CDBG grants worth $102 million for water and wastewater infrastructure have been delivered to communities, counties and colonias adjacent to the Mexico–Texas border, either by ORCA or its predecessor agencies. Texas expenditures have totaled $1.15 billion between 1995 and 2005. Mexican national programs invested $783.3 million in Chihuahua, Coahuila,

[6] See North American Free Trade Agreement (NAFTA), 1994: Part 1, Chapter 1, Article 101.

[7] See Agreement Between the Government of the United States of America and the Government of the United Mexican States Concerning the Establishment of a Border Environment Cooperation Commission and a North American Development Bank.

and Tamaulipas between 1999 and 2005, with the most expenditures applied to urban areas. The projects along the Mexico–Texas border were located in the urban cities of Ciudad Juárez, Ciudad Acuña, Piedras Negras, Nuevo Laredo, Rio Bravo, Ciudad Reynosa, and Matamoros. No data were available on future funding in Mexico.

BECC and NADB had a commitment of $3 billion in start-up capital from the governments of the U.S. and Mexico, with equal contributions from each nation. The capital includes both paid-in capital (cash reserves of $225 million from each country) and callable capital (pledged capital) of $1.275 billion from each country. In addition to loan funds, NADB has received grant funds through annual appropriations from the EPA. Callable capital cannot be used to make loans. Of the total available capital, 90% can be used for border environmental infrastructure projects. The other 10% is set aside for use throughout the United States and Mexico for post-NAFTA related community adjustment. As of the end of 2005, the BECC/NADB had invested over $250 million in 49 water, wastewater and water conservation projects along the Rio Grande. Of these, 35 were on the U.S. side of the border and 14 in Mexico. By 2005 14 projects had been completed, 12 in the U.S. and 2 in Mexico with 35 projects under construction. The funds were spent in the study area with a relatively even distribution between Mexico and the U.S.

4. Water Quality

The Rio Grande is the longest river in both Texas and Mexico and is a source of water supply, an international boundary, a habitat, and a natural resource for millions of people. The Texas Commission on Environmental Quality (TCEQ) divides the river into nine stream segments. A "segment" is a part of a river basin (river, lake, bay, or estuary) with "designated" appropriate water uses (aquatic life, contact recreation, and consumption) and "general" uses (TCEQ, 2003: 74) The most current Texas Surface Water Quality Standards (Title 30, Texas Administrative Code, Ch. 307), herein denoted as TSWQS, includes numerical criteria for conventional parameters (dissolved oxygen, bacteria, water temperature, pH, chloride, sulfate, and total dissolved solids), as well as other parameters such as nutrients, chlorophyll *a*, organics, metals, and toxicity.[8] The TSWQS are used by TCEQ to classify whether a surface water segment's ambient water quality is consistent with the segment's designated and general uses of full or not supporting use, as well as whether there are concerns. If uses of a water body are partially supported or not supported, the water segment is placed on what is known as the U.S. EPA 303(d) List (TCEQ, 2003: 19). When a state puts a water body on this list it means that it is impaired "where required

[8] Texas Surface Water Quality Standards. 30 TAC §307.10. 17 August, 2000.

pollution controls are not sufficient to attain or maintain applicable water quality standards."[9] Seven of the nine segments of the Rio Grande have been listed since 1992.

The uphill battle waged by Mexican, U.S., and binational water agencies towards restoration of the Rio Grande has helped relieve some of these adverse consequences of growth by expanding wastewater coverage, advancing wastewater treatment, and removing direct wastewater discharges. Due to the changes in time, duration, and quantity of the Rio Grande's waters, some say the ecosystem will never be restored. To evaluate the effect of investment, this study considered water quality, human health impacts, and quality of life. It is beyond the scope of this paper to report on all elements of a water quality evaluation. Readers are encouraged to refer to the EPA report for analyses of conventional contaminants, nutrients, organics, and metal parameters.

This study has used available records of each quality parameter, as evaluated at every water quality monitoring station along the mainstem of Rio Grande, drawn from Texas Clean River Program (CRP) long-term monitoring data.[10] A comparison revealed "sweet spots" or "hot spots," showing improvement or degradation respectively, which reflects the pattern of infrastructure investment.

Contact recreation, which is evaluated with fecal coliform, was considered for this paper, as it is the best way to compare established criterion to determine if water and wastewater infrastructure investment has improved the quality of the Rio Grande (TCEQ, 2003: 22). Fecal coliform was chosen as an indicator parameter because it had the largest sample set, had the highest criteria exceedances, and is most related to untreated wastewater discharges, which is the easiest to associate with the availability or absence of infrastructure. The limit for fecal coliform for single samples is 400 counts of colony-forming units per 100 ml (colonies/100 ml) for every segment of the Rio Grande, except for the segment between El Paso and Juarez (Segment 2308 limit is 4,000 cfu/100 ml) (TCEQ, 2003: 9).

Figure 1 presented below demonstrates how infrastructure affects water quality through a "grid graph" which reports station values over time. A grid graph is used to represent the annual average of fecal coliform from each station over time, which takes into account the full range of data and not just maximum values. Ranges of values are represented by shade/pattern. With this structure, a cell represents a particular year and a station located along the river. The grid figure allows visualization of how each station performed for a parameter over time as well as how the stations performed across the years. The figure shows that there are spikes of violations of the water quality standards at various times and place. The evidence of elevated pollution after NAFTA can best be seen

[9] U.S. Environmental Protection Agency, 303 (d) List. http://www.epa.gov/reg3wapd/tmdl/303d.htm.

[10] Texas Commission on Environmental Quality, Sampling Data Query and Surface Water Quality Monitoring. http://www.tceq.state.tx.us/compliance/monitoring/crp/data/samplequery.html.

with the Segments 2314 to 2306 and 2304, where just after 1994 fecal coliform levels began to increase. The lower part of Nuevo Laredo had been discharging prior to 1994. The Rio Grande in the northern part of the city showed evidence of elevated levels starting in 2000. This was around the time of the opening of the new International Bridge. Specific areas of concern due to bacteriological increases are above El Paso/Juarez, below Rio Conchos, below Del Rio/Acuña, Eagle Pass/Piedras Negras, Falcon Reservoir, Rio Grande City, McAllen/ Reynosa, and Brownsville/Matamoros. There were little to no concerns in Segment 2303 and 2305.

Two areas where improvements occurred since 1994 are below Laredo/ Nuevo Laredo (Segment 2304) and around El Paso/Ciudad Juarez (Segment 2308 and 2314). These reductions could be attributed to the reduction of raw wastewater discharges due to the startup of a major wastewater treatment plants (WWTP) in each region. The largest improvement in stream quality resulted from the construction of the WWTP located in the Nuevo Laredo in Segment 2304 that became operational in 1996, with major collection system expansion in the subsequent years. A long trend of exceedances can be observed between 1977 up to the plant start-up. Recent contaminant increases have occurred both downstream and upstream of the plant since 2003, which may reflect city growth over the past 10 years. At present other projects are being completed which will enhance the treatment plant and provide additional collectors and residential connections; these projects provide sewer collection to most Nuevo Laredo (NADB, 2007).

The North WWTP of Ciudad Juarez in Segment 2308 (operational in 2001) provided collection, treatment, and reuse of wastewater, expanding the sewage system in the western colonias of Juarez that never had sewers. This project may have reduced fecal coliform discharges in the area as, after the plant start-up, reduced fecal coliform levels are observed downstream of El Paso/Juarez. Events with the Santa Teresa WWTP (the plant failed and was later bypassed prior to its repair) and the wastewater treatment plant of Doña Ana County in Segment 2314 may account for the spike in 2001 of fecal coliform. A new plant came on-line in the county, which appears to have led to decreases (see the following section for more details). The region had no violations in 2005. Segments 2307 and 2306 downstream of El Paso have not received the same level of early investment as Segment 2308, where elevated levels of fecal coliform extended further than in 2308, reflecting the inconsistent pattern of limited investment occurring at different times in the region.

Fecal coliform concentrations in Segment 2302 have decreased since 1994, which may reflect infrastructure built upstream of Matamoros to bypass the Rio Grande on the way to the Gulf through canals and arroyos for Mexican cities close to the Gulf of Mexico. As the BECC projects in Reynosa were not certified until March 31, 1998 (TCEQ, 2003: 8), it is not easy to explain the data based on infrastructure above Matamoros. Segments 2301 and 2305 had few samples; sample results were mostly below the standard.

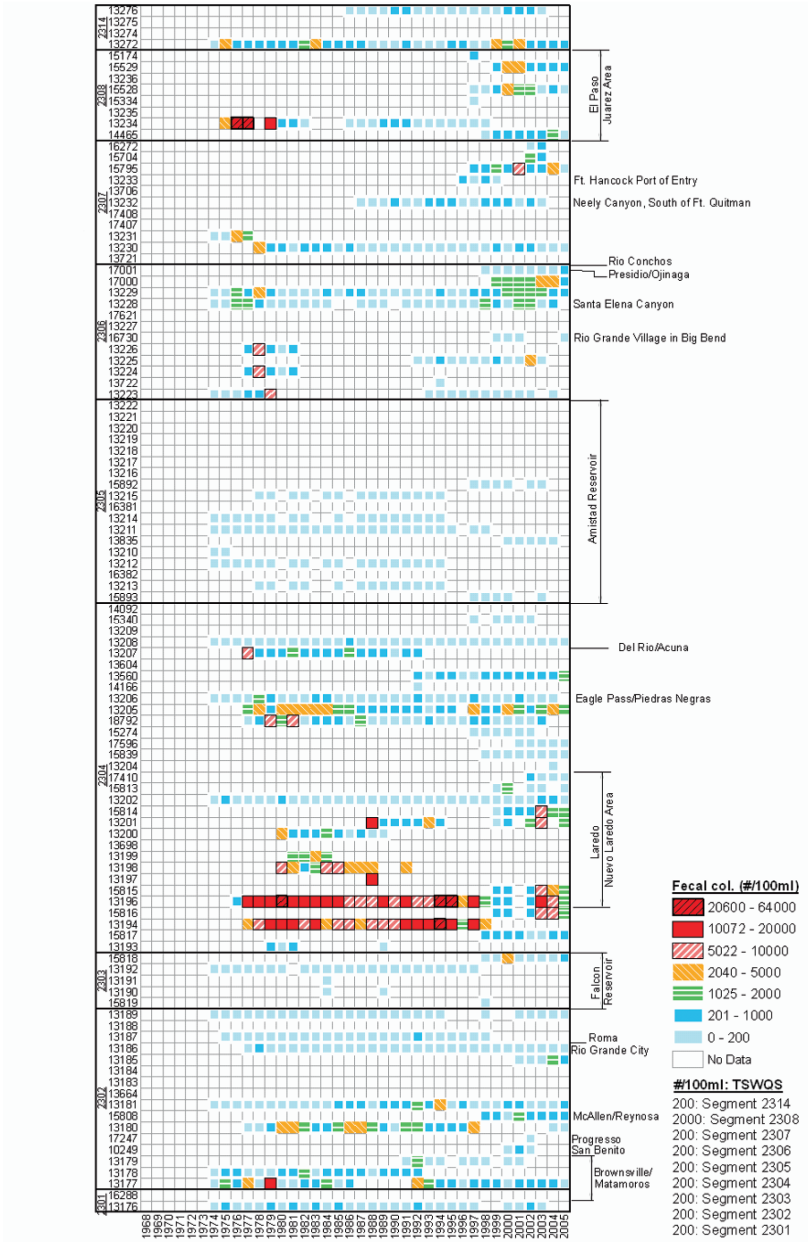

Figure 1. Average fecal coliform concentration in water by station (1968–2005)

5. Future Needs

The U.S. and Mexico have invested billions of dollars to bring utility services to millions of residents along the Mexico–U.S. border. The largest investment has been in the region along the Rio Grande in Texas counties and neighboring Mexico states of Tamaulipas, Nuevo Leon, Coahuila, and Chihuahua. These investments have improved utility services and produced a better environment, but the difficulties in investing throughout *all* parts of the border has meant that this progress has only occurred in certain areas. There is an existing backlog of over $543 million in unfunded proposals for water and wastewater projects along the Texas–Mexico border filed with BECC/NADB (BECC, 2006). Some cities that experienced improvements through investment have regressed due to subsequent and consistent growth. From the perspective of Mexico and Texas, there remains a significant need to improve water quality in the region.

The availability of funding over the years has fluctuated and has not necessarily always been secure. TWDB colonia funding was exhausted in 2005.[11] Available RUS funding for the next 3 years is expected to remain consistent with funding levels observed during 2005–2006.[12] The future of ORCA's funding stream is far from secure. The U.S. Congress did not consent to President Bush's reduction in CDBG funding for Fiscal Year 2006 and a proposed transfer to the Commerce Department. In Fiscal Year 2007, the White House budget called for a 25% reduction in ORCA. ORCA officials speculate that a decrease in CDBG funding would force them to lower the maximum grant level, require more matching funds, reduce grant amounts, or expand their low-interest loan program into new areas. On November 7, 2007, Texas voters approved Proposition 16 – SJR 20,[13] a "constitutional amendment providing for the issuance of additional general obligation bonds by the TWDB in an amount not to exceed $250 million to provide assistance to economically distressed areas."[14] It is not yet clear what fraction of their funds may be made available to Texan border communities for water or wastewater infrastructure investment. Recent debate has focused on ending BEIF funding, where the annual appropriation has dwindled since its inception. It is uncertain whether grant funds will be available in the future.[15]

[11] Interview by Marcel Dulay with Ignacio Madera, former Deputy Director and administrator of Economically Distressed Areas Program, Texas Water Development Program, Austin, Texas, May, 2006.

[12] Interview by Marcel Dulay with Brian Daniels, State Director, Texas USDA Rural Development Waco, Texas, April 16, 2006.

[13] Office of the Secretary of State, November 2007 Constitutional Amendment Election. http://www.sos.state.tx.us/elections/historical/index.shtml.

[14] Texas Senate, Joint Resolution 20, 80th Legislature (2007).

[15] Interview by Mike Myers with Technical Staff, North American Development Bank, Austin, Texas, March 21, 2006.

6. Conclusion

This paper has sought to integrate a large number of ambient water quality samples collected over time and space within the Rio Grande basin in order to determine if there has been improvement in the water quality. Prior to 1999, various agencies within Mexico and the U.S. reported that there were areas in the region with poor water quality and warned of the risk that NAFTA-induced economic growth could degrade the environment. Water quality data indicate that fecal coliform pollution increased with the growth in the region after 1994. These data show that in specific locations where BECC/NADB and other agencies have invested in water sector infrastructure, those efforts have reduced water quality degradation. Investment in sewers and wastewater treatment has improved ambient water quality. Although the details are complex and not easy to interpret, the ambient water quality measurements do indicate that in cases where there has been poor ambient water quality, the absence of investment leads to further degraded water quality. Degraded ambient water quality appears to result in sites where infrastructure investments have not collected and treated most or all the wastewater produced by sprawl and other regional growth.

Acknowledgements

This paper would not have been possible without the support of students, staff, faculty, and professionals throughout the region. The research was supported by grants from the U.S. Environmental Protection Agency, The North American Development Bank, the Institute for Innovation, Creativity and Capital of the University of Texas at Austin, the Policy Research Institute of the Lyndon B. Johnson School of Public Affairs, and the Bess Harris Jones Centennial Professorship in Natural Resource Policy Studies.

References

BECC (Border Environment Cooperation Commission), 2006. *Project Application Received for the BEIF/PDAP Prioritization Process,* 30 June (July 7, 2007); http://www.cocef.org/prior_formats?list_applications.pdf. Calculations by Marcel Dulay.

EPA (U.S. Environmental Protection Agency), 2003. *Border 2012: U.S.–Mexico Environmental Program*, Secretariat for the Environment and Natural Resources, 5 May (October 5, 2006); http://www.epa.gov/border2012/pdf/2012_english.pdf.

EPA (U.S. Environmental Protection Agency), *303 (d) List*. (May 5, 2005); http://www.epa.gov/reg3wapd/tmdl/303d.htm.

Government of the United States of America and the Government of the United Mexican States, *Agreement Between the Government of the United States of America and the Government of the United Mexican States Concerning the Establishment of a Border Environment*

Cooperation Commission and a North American Development Bank. (September 19, 2006); http://www.nadb.org/about/about_origins.html#

IBWC (International Boundary and Water Commission), 2004. *Third Phase of the Binational Study regarding the Presence of Toxic Substances Along the Rio Grande/Rio Bravo and Its Tributaries Along the Boundary Portion Between the United States and Mexico*, El Paso, TX, June (December 4, 2005); http://www.ibwc.state.gov/PAO/CURPRESS/2004/RGToxic Study.pdf.

Interview conducted by Marcel Dulay with BECC and NADB and mayors.

Interviews conducted by Marcel Dulay during a May 2005 field trip with various colonia residents.

Interviews conducted by Marcel Dulay during a May 2005 field trip with various municipal managers in Mexico.

Interview by Mike Myers with Technical Staff, North American Development Bank, Austin, TX, March 21, 2006.

Interview by Marcel Dulay with Brian Daniels: State Director, Texas USDA Rural Development, Waco, TX, April 16, 2006.

Interview by Marcel Dulay with Ignacio Madera: former Deputy Director and administrator of Economically Distressed Areas Program, Texas Water Development Program. Austin, TX, May 2006.

Interview by Marcel Dulay with Gorge Garcés: General Director, North American Development Bank. Austin, TX, October and November, 2006.

NADB (North American Development Bank), 2007. *Summary of Project Financing Activities*, San Antonio, TX, 31 March (May 7, 2007); http://www.nadb.org/news_updates/news_ updates.html.

North American Free Trade Agreement, 1994. Part 1, Chapter 1, Article 101.

Office of the Secretary of State, *November 2007 Constitutional Amendment Election.* (November 2007); http://www.sos.state.tx.us/elections/historical/index.shtml.

Secretaría de Medio Ambiente y Recursos Naturales, *Reglas de operación para los programas de infraestructura hidroagrícola, y de agua potable, alcantarillado y saneamiento*, 7 April (May 6, 2006); http://www.cna.gob.mx/eCNA/Espaniol/Programas/Infraestructura/DOF% 201oSep 03%20Modificaciones.pdf.

TCEQ (Texas Commission on Environmental Quality), 2003. *Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2004*, Austin, TX, 15 August (January 25, 2007); http://www.tceq.state.tx.us/assets/public/compliance/monops/water/04twqi/04_ guidance.pdf.

TCEQ (Texas Commission on Environmental Quality). *Sampling Data Query and Surface Water Quality Monitoring* (March 2, 2006); http://www.tceq.state.tx.us/compliance/monitoring/ crp/data/samplequery.html.

Texas Comptroller of Public Accounts, 1998. *Governance: Who Decides?* July (October 22, 2006); http://infinitepower.org/taxinfo/taxforms/96-599/chap12.pdf.

Texas Senate, 2007. Joint Resolution 20, 80th Legislature.

Texas Surface Water Quality Standards. 30 TAC §307.10. 17 August, 2000.

Warner, D. and Jahnke, L., 2003. U.S./Mexico Border Health Issues: The Texas Rio Grande Valley, April (January 31, 2008); www.uthscsa.edu/RCHWS/Reports/NAFTA2.pdf.

SECTION IV

ALTERNATIVES TO SAVING THE DEAD SEA: OPPORTUNITIES AND RISKS

WORKING WITHIN THE INTERNATIONAL COMMUNITY

SAVING THE DEAD SEA: THE MEDITERRANEAN–DEAD SEA OPTION

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Abstract: The Dead Sea Peace Project (DSPP) is a tunnel and hydroelectric power project that can produce between 1,500 to 2,500 MW of clean and renewable electric energy. The value of such electric energy will be maximized by power generation during peak demand times. In addition it can produce around 700 million cubic meters of desalinated water. Over a period of 7 years of planned operation, the DSPP will restore the Dead Sea to the desired level, and thereby reverse the erosion and subsistence that is presently destroying the area. The planned annual supply of Mediterranean Sea water through the DSPP will be 5 billion cubic meters, which, after desalination (using distillation to remove 90% as potable water) can provide a substantial amount of potable water for the ever growing population in an increasingly water scarce region. Maximum capacity of the project is for 12 billion cubic meters annual flow, which would provide enough water for 20 million people if suitable desalination capacity should be developed.

Keywords: Mediterranean Sea; Dead Sea; desalination; hydroelectric power; tunneling

1. Introduction

Many different proposals have been made over the last 150 years for connecting the Mediterranean Sea with the Dead Sea (www.mfa.gov.il "The Red Sea and the Mediterranean Dead Sea Canals", accessed March 10th, 2009). The most famous was written in Theodore Herzl's Old New Land (Altneuland in

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C. Lipchin et al. (eds.), *The Jordan River and Dead Sea Basin: Cooperation Amid Conflict*,

German) where he described the utopian modern Israel that generates energy for the State by connecting the Mediterranean Sea to the Dead Sea. The Dead Sea is the lowest point on the earth's surface, lying over 394 m below the level of the Mediterranean. To convert this tremendous difference in levels into a source of power was the simplest idea in the world. Herzl envisioned a canal, which was 10 m wide and 3 m deep, providing about 50,000 hp (Altneuland – Old New Land, English Internet edition, March 10th, 2009).

The shortest route for connecting directly with the Dead Sea is an alignment from Palmahim, south of Tel Aviv to the northern end of the Dead Sea, and the most efficient method is a below sea level tunnel constructed with tunnel boring machines, connected with a storage reservoir that will store the tunnel flow so that the available energy can be used when most needed.

Water introduced into the Dead Sea can be added in the shallow north end of the Dead Sea in a way that will float the Mediterranean Sea water on top of the Dead Sea, creating a non-mixing saline gradient layering that will prevent the harmful environmental effects of mixing of the introduced seawater with the Dead Sea water. The top layer of Mediterranean Sea water can be used to provide feed water for desalination plants located as needed around the Dead Sea, with water being removed from the top layer, and saline water from the desalination process being returned to an intermediate layer between the Mediterranean Sea water on top and the Dead Sea water on the bottom.

This most efficient proposal for saving the Dead Sea, providing desalinated water for the region, and for restoring the Jordan River flow, can be reviewed on the project website (http://www.deadseapower.com) The Dead Sea Power Project (DSPP) offers the most promising option, being the only plan to rehabilitate the Dead Sea to its optimal level (around 400 m below sea level) within 9 years of operation, and having economic benefits by the largest net energy generation capacity and the largest water desalination capacity, while having the minimal environmental risk.

Thorough economic and environmental impact assessments should be completed before the beginning of construction of the project. Planning and design would take 2 years, and construction would require 5 years, so that the project could be operational within 8 years after receiving governmental approval from Israel, the Palestinian Authority, and Jordan.

2. History

The idea of a Mediterranean Sea–Dead Sea connection has a rich history. From 1855 to the present, many different proposals have been advanced for utilizing the unique character of the Dead Sea (Table 1). The Med–Dead project promoted by the Med Sea Dead Sea Company came close to starting in 1984, but was blocked by objections from Jordan and by economic problems.

TABLE 1. Many Different Proposals Have Been Advanced for Utilizing the Unique Character of the Dead Sea. (Israeli Ministry of Foreign Affairs. 2002; Burke, S. 1998; Gavrieli, I. 2004; Wolf, A. 1994)

Date	Event	Goal	Advocate
1885	Med–Red–Dead canals	trade route to India	Brit William Allen[*]
1902	Med–Dead	hydropower	Theodore Herzl[**]
1955	Med–Dead or Red–Dead	regional water supply	US: Johnston Plan[***]
1973–1984	Med–Dead	hydropower	Med Sea Dead Sea Company[****]
1994	Peace Treaty	water supply	Israel and Jordan[*****]

In 1993, Mr. Randolph Gonce, manager of Dead Sea Vision LLC, developed a unique plan for a tunnel below sea level with sufficient capacity to supply the entire water needs of the region. It was to employ mechanical vapor compression (MVC) desalination for maximum utilization of water, thereby limiting the brine return to the Dead Sea. He made this proposal available to several Israeli experts who responded favorably to the idea.

On May 15, 2008, after 15 years of developing information and refining plans, interested parties consisting of water, engineering and environmental experts came together in Tel Aviv to pursue further development of what had become the Dead Sea Power Project (DSPP). The group decided to organize a company in the USA, to be named Dead Sea Vision LLC, to own intellectual property rights and progress for the DSPP. Subsequently the head of the Palestinian Water Authority signed a letter of support for consideration of the project as an alternative to the proposed Red Sea–Dead Sea conduit which is currently under study.

3. Overcoming Technical Obstacles with Advanced Technology

Tunneling technologies have progressed tremendously over the last 3 decades. Increased efficiency of tunnel boring machines (TBM) has lowered tunneling

[*] Israeli Ministry of Foreign Affairs. 2002. "The Red Sea and Mediterranean Dead Sea Canals Project." http://www.mfa.gov.il/MFA.

[**] Burke, S. 1998. "Dead Sea Canal, No. 429." Trade and Environment Database Case Studies. http://www. american.edu/projects/mandala//TED/deadsea.htm.

[***] Burke, S. 1998. "Dead Sea Canal, No. 429." Trade and Environment Database Case Studies. http://www. american.edu/projects/mandala//TED/deadsea.htm.

[****] Gavrieli, I. 2004. "Formulating a Regional Policy for the Future of the Dead Sea: The 'Peace Conduit' Alternative." Water for Life in the Middle East, Antalya, Turkey.

[*****] Wolf, A. 1994. "Treaty of Peace between the State of Israel and the Hashemite Kingdom of Jordan." Oregon State University Transboundary Freshwater Dispute Database. http://ocid.nacse.org/qml/research/tfdd/to TFDDdocs/168ENG.htm.

costs, and allows the installation of watertight tunnel lining during the boring process, inside the shielded TBM. This prevents disruption of overlying aquifers, and prevents the subsequent depletion of such aquifers. The tunneling will be done simultaneously, from three points – intake, end of the tunnel and a point in the middle, to optimize the construction efficiency.

The intake reservoir at Palmahim will be excavated in calcareous sandstone below sea level, so there is no possible risk of contamination of the coastal aquifer. Filtration of the Mediterranean Sea water is possible within the intake reservoir (Figure 1).

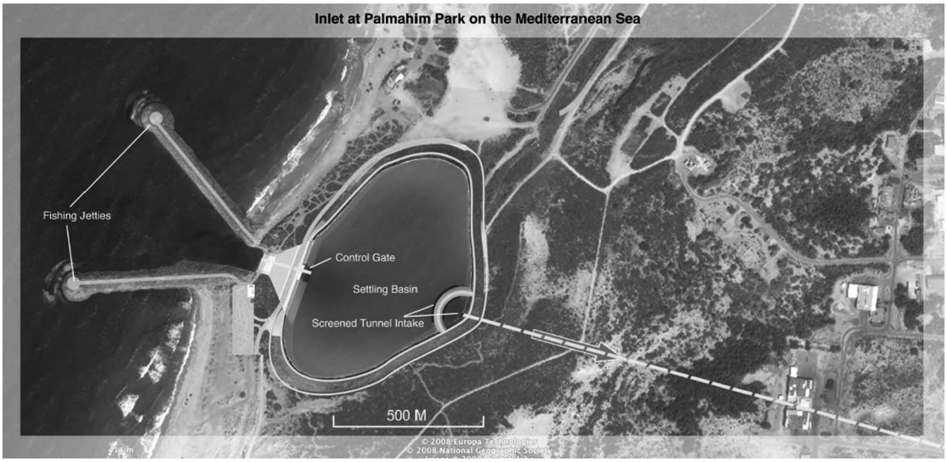

Figure 1. Proposed intake reservoir near Palmachim (Figure produced by Randolph Gonce)

The operative reservoir at the end of the tunnel, over the Dead Sea, is less sensitive, being within the Dead Sea drainage basin, with no underlying aquifer and no springs in this area. The soil of the reservoir area is heavy clay, and with compaction will have an extremely low percolation rate (Figure 2).

Recent developments in design of seawater hydro turbines will enable the efficient operation of the hydroelectric plant, utilizing about 90% of the available energy.

The Raccoon Mountain project is a pumped water energy generation, with similar capacity as the planned DSPP (Figure 3).

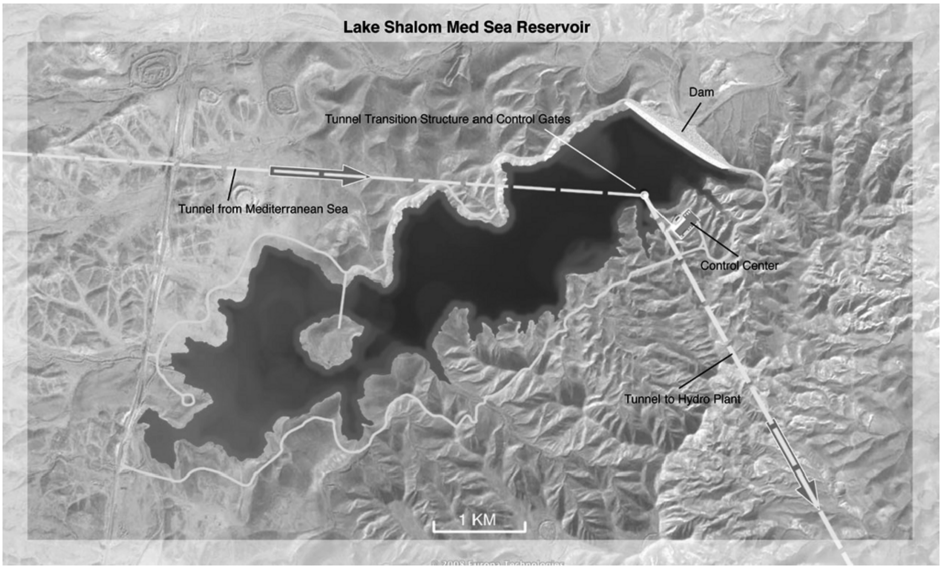

Figure 2. Proposed operative reservoir over the Dead Sea (Figure produced by Randolph Gonce)

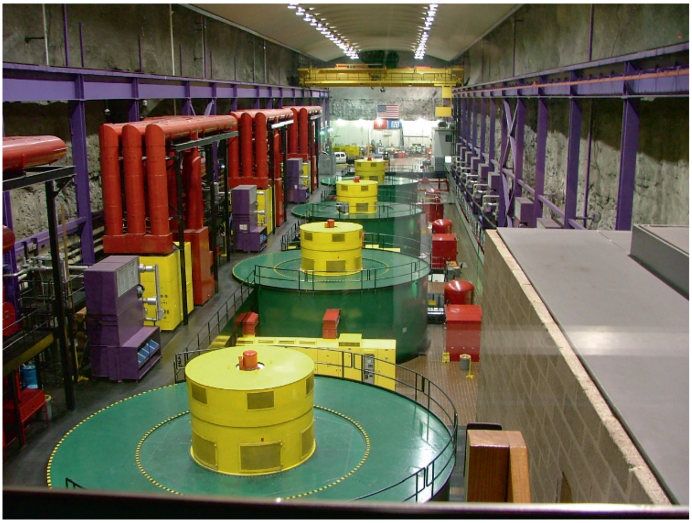

Figure 3. TVA Raccoon Mountain Turbines – 1,600 MW* (*Tennessee Valley Authority, Pumped energy project – 4 × 400 MW turbines)

4. Environmental Challenges

The main environmental challenge to be overcome is the impact of Mediterranean Sea water mixing with Dead Sea water. We believe that the problem of water mixing will be minimal due to the quick filling of the layer of Mediterranean Sea water over the Dead Sea water and the difference of densities between the two layers. A layer of 25–30 m will be stable and not be mixed by winds or streams. The brine from the desalination plants will be laid in between. However, to optimize the water discharge to the Dead Sea, we suggest a low current insertion of the water, as is described in Figure 4 above.

The proposal also plans restores the level of the Dead Sea quickly so as to limit the damage from subsistence and erosion that is quickly degrading the Dead Sea environment. Environmental risks of boring the 10 m diameter tunnel will be minimal, because the tunnel will be deep underground, below sea level, the entire distance, and be lined and grouted so as to prevent the inflow of water from the overlying aquifer.

Moreover, the project does not have the environmental baggage that attaches to the Red Sea–Dead Sea conduit project, including impact on Red Sea coral reefs, danger of contamination of fresh water aquifers along the route of

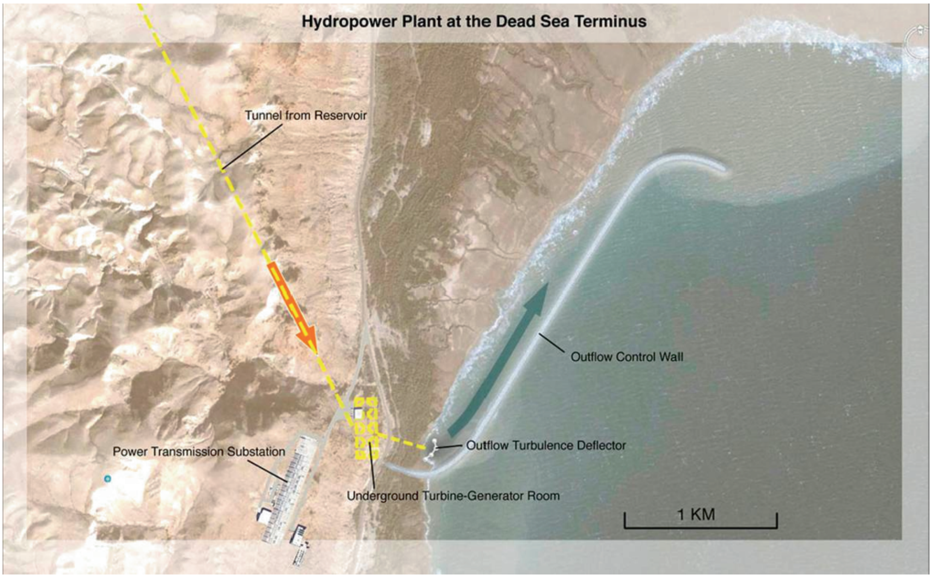

Figure 4. Proposed Mediterranean–Dead Sea terminus

the pipeline, discoloration of Dead Sea water by precipitation of gypsum, disturbance of archaeological sites, etc.

5. Economic Advantages

It seems that the DSPP plan is the only proposal that can become economically viable as compared to the Red Sea–Dead Sea conduit for example, due to the volume of water transferred to the Dead Sea, the capacity of energy generated

TABLE 2. Basic Economic Calculation (Energy Generation Only) and Sensitivity Analysis on Selling Price

	Amt	Hydraulic head (M)	Energy generation capacity (kWh)	$	Sensitivity analysis energy selling price		
Water (CM)	1	370	0.9				
Water (BCM)	5	370	4,500,000,000				
Selling price ($/kWh)				0.1	0.08	0.12	0.15
Annual income				450,000,000	360,000,000	540,000,000	675,000,000
Investment ($)				4,000,000,000	4,000,000,000	4,000,000,000	4,000,000,000
Annual payments (5%, 15 years) ($)				384,000,000	384,000,000	384,000,000	384,000,000
Annual operation costs ($)				20,000,000	20,000,000	20,000,000	20,000,000
Annual gross profit ($)				46,000,000	−44,000,000	136,000,000	271,000,000

and the desalinated water that can be produced. The DSPP, compared to the Red Sea–Dead Sea conduit, is one third as long, has 6 times greater capacity, delivers water 100 km closer to the target water market (Bethlehem, Jerusalem, Jericho, Amman, the upper Jordan valley and the Israeli Negev) and will cost about the same as the proposed Red Sea–Dead Sea conduit.

The DSPP projected costs are approx. $1.75 billion for the tunnel, $1 billion for the hydro power plant, and $1.5 billion for the desalination plant and contingent infrastructures (reservoir dam, inlet channel, filtration system, water carrier from reservoir to hydro power plant, and miscellaneous). The projected income from power sales to Israel Jordan and the Palestinian Authority are about $750 million annually. The project income should increase with expected increases in energy prices.

The figures in Table 2 were based on the following assumptions:

- Energy generation capacity enables the system to operate 8 h a day, at peak price hours, thus getting maximum value. Selling price of $0.10/kWh seems minimal since it is considered clean energy at peak demand.
- Operational cost is just an evaluation.
- Ten year Return of Investment gives the project annual gross profit from the first year.
- Water desalination needs energy – about 2.5 kWh/cm. The transfer price of the energy is an arbitrary decision. Price of the desalinated water would reflect the energy prices and will be sold accordingly.
- Desalination project can be operated (partly) at low rate energy prices.
- Pumping water from the Dead Sea to Amman, and other high level locations, would be done during low rate energy prices only.

Additional economic advantages are:

- Each cubic meter that passes through the turbines generates about 1 kWh of electric energy.
- Electric rates are assumed to be $0.3/kWh for the desalination project, and $0.9/kWh normal rate, and at $0.25/kWh priority rate (peak hours, subsidy for green energy).
- The planned fill rate of 5 billion cubic meters per year generates 5 billion kilowatt hours, at the average rate of $0.15/kWh, which is calculated as $750 million.
- The planned desalination plant, producing 1 billion cubic meters annually, will generate $200 million in profit, at $0.60/m^3.

- Property around the reservoir above the Dead Sea (Lake Shalom) can be developed for profit.
- Carbon credits can be sold for profit.

6. Political Dimensions

Given that this proposal is in the Middle East, politics complicates the picture as three countries are involved: Israel, Jordan and the Palestinian Authority. The current World Bank-sponsored feasibility study on the Red Sea–Dead Sea conduit is politically more acceptable as it meets Jordan's demand for control of the project in its territory, given that Jordan will be the primary benefactor of the project. The DSPP on the other hand, favors Israel and the Palestinians in that the project will traverse Israel and the West Bank. This can help to strengthen ties between the parties in terms of water and energy production. The disadvantage for Jordan is that it is at the "end of the pipe" and will be considered a consumer of water and energy. In order to allay Jordan's reservations, certain infrastructures, such as desalination plants, should be built within Jordanian territory and special terms can be negotiated on prices for water and energy that Jordan would purchase from the project. Finally, given that the project is proposed to be financed and built by the private sector, albeit with government approval, favorable terms for each country in terms of profit sharing from the company can be negotiated.

7. Summary

Increasing rates of unemployment, lower interest rates, the extreme condition of the Dead Sea, the opportunity to offset carbon release by utilizing renewable green energy, and the need to provide living area and employment to Palestinian refugees, all give reasons to move forward now with this very practical and economical project, the Dead Sea Power Project.

Technological advances in tunnel boring and electrical generation make this project more feasible today than at any previous time. The Dead Sea is heading toward 428 m below sea level by the year 2017, and this opens the way for placing a deep layer of Mediterranean Sea water on top of the Dead Sea, to be maintained by annual removal for desalination feed water and replacement by fresh inflow from the Mediterranean Sea. Imagine a sea with boating and fishing, like the Mediterranean Sea, but with Dead Sea preserves along the shore in strategic places for environmental protection and tourist attractions. Picture planned development of the region in ways that will preserve its unique beauty, and also allow development of fish and prawn production in marine ponds, and in fresh water ponds filled with desalinated water destined for irrigation after growing Tilapia fish for international commerce.

The use of water for agricultural production in the areas below sea level in the Jordan Valley will have an advantage in prices because of lower costs for pumping and distribution. Every cubic meter of water that flows into the Dead Sea will produce about $0.13 value of electric energy. Five billion cubic meters annual flow into the Dead Sea will produce an annual income of $650,000,000 for a project that will cost about $4 billion to build. Low cost desalinated water for irrigation, used at lower elevations in the Jordan Valley, will deliver full capacity flow through the hydroelectric plant even after the Dead Sea is filled to 400 m below sea level.

This project offers tremendous advantage to Jordan for supplying 1 billion cubic meters annual supply of water. This water can be desalinated at the North End of the Dead Sea in Jordanian territory, giving them complete control of their critical water supply. They can also desalinate near Potash City for distribution to the lower Jordan Valley. Other desalination plants can supply water to Jerusalem, the West Bank, and the Jordan Valley between the Sea of Galilee and the ridge near the southern end of the valley, about 280 km in length. Water can also be made available for renewing the Jordan River.

All of this is possible while insuring that the potash mining industry at the southern end of the Dead Sea is protected. Extension of the intake tubes for transferring water from the Dead Sea into the evaporation ponds of the mining industry will allow their continued operation, while lowering their cost of pumping the water.

Surely now is the time to move forward with this important project, for the healing of the region.

References

Burke, S. 1998. "Dead Sea Canal, No. 429." Trade and Environment Database Case Studies. http://www.american.edu/projects/mandala//TED/deadsea.htm.

Gavrieli, I. 2004. "Formulating a Regional Policy for the Future of the Dead Sea: The 'Peace Conduit' Alternative." Water for Life in the Middle East, Antalya, Turkey.

Herzl, T. Altneuland – Old New Land, English Internet edition http://www.hagshama.org.il/en/resources/view.asp?id=1603.

http://www.deadseapower.com.

http://www.mfa.gov.il/mfa/mfaarchive/2000_2009/2002/8/The Red Sea and the Mediterranean Dead Sea canals.

Wolf, A. 1994. "Treaty of Peace Between the State of Israel and the Hashemite Kingdom of Jordan." Oregon State University Transboundary Freshwater Dispute Database, http://ocid.nacse.org/qml/research/tfdd/toTFDDdocs/168ENG.htm.

THE FUTURE OF THE DEAD SEA: IS THE RED SEA–DEAD SEA CONDUIT THE RIGHT SOLUTION?

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Abstract: In the past, the Dead Sea's level fluctuated due to natural climatic changes. Today, however, the Dead Sea water balance is depleted by ~90%, mainly as a result of human intervention. The Jordan River, known globally for its historic value and once the Dead Sea's major water supplier, has been reduced to a poor sewage stream. The situation is a clear reflection of the regional potable water shortage. Over the past 78 years, this depletion has caused a 32 m drop in the lake's level, occurring at accelerating rate that exceeded 1 m/year on the average for last decade. Furthermore, he level's fall accompanied by environmental deterioration, including damages to the infrastructure, tourism, agriculture and ecosystems. The riparian parties of the Dead Sea have agreed to investigate the RSDSC (Red Sea–Dead Sea conduit) plan as a potential solution to stop the deterioration and to increase the potable water supply in the area. The World Bank is financing a 2-year feasibility study for the project, which is much too short a period to conduct sufficient research that bridges knowledge gaps, especially with regard to the environmental implications. A systemic approach that involves reviving the Jordan River–Dead Sea system is free of the various environmental threats involved in the RSDSC has not yet been fully considered. It is therefore offered herein for *simultaneous* feasibility study. The comparison of these alternatives should involve comprehensive environmental and economic cost–benefit analyses (free of political pressure) as the precondition for choosing the best way to achieve the declared goals. It is this generation's responsibility to ensure a healthy future for Dead Sea for the generations to come before the present window of opportunities shuts for good.

Keywords: Dead Sea; Jordan River; canals; water balance; human intervention; Environmental threats; coastal oases; systemic alternative

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1. Introduction

The Dead Sea sits at the world's lowest elevation and has various unique properties that make it downright strange. Together with its Biblical links, this has generated a rich folklore, a host of superstitions, and a mystical image. The dramatic crossing of the Jordan by the Israelites adjacent to the mouth of the Dead Sea, as recounted in Joshua 3, is a constitutional event in the national story of the People of Israel. The exact same spot is also accepted as the cradle of Christianity, where John baptized Jesus (Figure l) and "the spirit descended upon him as a dove" (Mark 1).

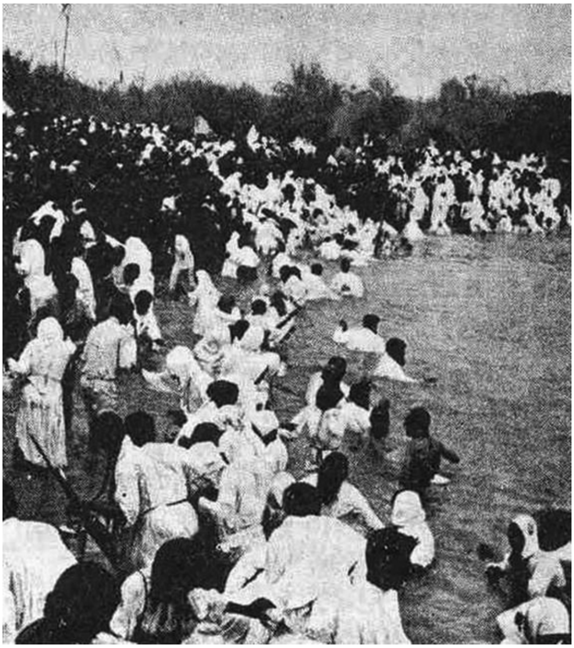


Figure 1. Pilgrims at the traditional baptism site of the southern Jordan River, in the 19th century (Source: Vilnai, 1976: 3049)

The Dead Sea has always held an economic significance as well. It holds various treasures that make it a profitable site and popular destination. In the past, salt production and natural asphalt (tar) floating block collection were very beneficial and well-documented economic activities. Furthermore, the healing springs and the beautiful surrounding oases were home to aromatic plants and exotic herbs that were sources of valuable essences whose outstanding qualities were praised remarkably by the classical historians (Stern, 1980). Of course, the astonishing features of the lake's water, such as the famous floating effect for swimmers and the absence of visible creatures, also added to its appeal. These properties have positioned the Dead Sea as a site of world interest since the dawn of time.

In 1930, a chemical industry based on mineral sedimentation in evaporation ponds began developing alongside the Dead Sea. This industry has had a formidable economic impact, but carries with it a heavy environmental price. On the other hand, the minor industry surrounding the production of Dead Sea salts is far less harmful to the environment. These salts have long been a popular trend in cosmetics and spa-related products and therefore represent a profitable source of business in the area.

Numerous tourism enterprises, including eco-tourism, medical tourism, historical-geographical tourism and religious tourism, are proving quite successful. These are signs that the area is establishing itself as a prosperous locus based on sustainable development unlike the industry.

Diversion projects in the Dead Sea watershed along with industrial evaporation ponds fed by pumped Dead Sea water have depleted over 90% of the lake's water balance. In turn, this depletion has caused a reduction in its water volume, a rise of the salinity, a steep drop in the level of the lake and the withdrawal of the coast line. These changes have host of negative environmental effects, threatening both the natural treasures the area has to offer and the infrastructure that supports their profitability.

The famous Jordan River was the main natural supplier of water to the Dead Sea. In the past (See Figure 2),the water inflow from the Jordan was roughly ~1,250 MCM/year (million cubic meters per year) out of the total ~1,750

TABLE 1. Annual Water Balance Estimations (MCM/year) (Raz, 1993; Lensky et al., 2005; Eidelman et al., 2006)

Total inflow in the past	~1,750
Recent total inflow (17%)	~300
Loss of water (brine) by evaporation (1/3 of which is from industrial evaporation ponds)	~1,050
Recent deficit balance	~750
Annual level drop due to evaporation	750 divided by 650 km^2 of surface = 1.15 m
Less 0.1 m of salt accumulation on the bottom	= 1.05 m (The calculated value is similar to the measurements average for the recent decade)
Amount of freshwater needed to compensate the loss of brine	~850 MCM/year

MCM/year. Over the years however, the Jordan's headwaters have been diverted on a massive scale for use by the various riparian nations and is nothing but a trickle, mainly of sewage and impure water. Today, the overall inflow into the Dead Sea is around 300 MCM/year (~17% of the original). In 1930, the Dead Sea reached its highest measured level in the 20th century at −390 m. A combination of the diminished replenishment and the evaporation from industrial ponds (which accounts for about one third of total ~1050 MCM/year brine loss by evaporation) caused the Dead Sea level to drop to −422 m by the end of 2008. The average rate of decline over the past decade has exceeded 1 m/year. Fresh water evaporation rate is higher than that of brine and hence, ~850 MCM/year of fresh water is needed to compensate the recent loss of Dead Sea brine by evaporation (Lensky et al., 2005) (see Table 1).

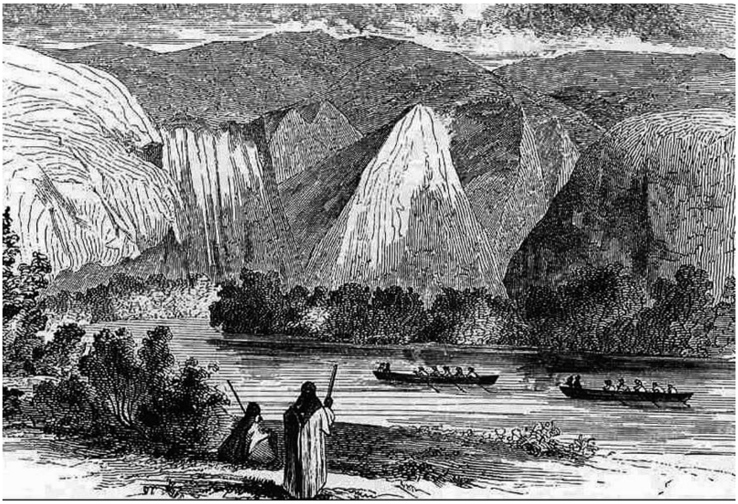


Figure 2. The natural Jordan River as was seen in 1849 by Lynch expedition (Source: Lynch, (1885) 1984: 158)

The Dead Sea's condition today reflects exploitation of its inflow in an unsustainable fashion rather than the influence of climatic change. Yet do the results of this human exploitation actually differ from natural cycles? Is not the price worth the gain derived, even if intervention is needed? Indeed, should the situation be altered? If so, how?

1.1. WHAT DETERMINES THE DEAD SEA'S WATER LEVEL?

The Dead Sea's water level expresses a dynamic equilibrium between the volume of incoming water and the volume of water flowing out therefrom. As a landlocked body of water, the Dead Sea has no natural outlet other than evaporation; therefore the natural water balance was strongly dictated by the climate.

A reduction in the quantities of inflow causes a drop in the water level. The drop will continue as long as a larger quantity of water is lost to evaporation from the surface area of the lake than the amount coming in. The drop in the water level and the sloping banks cause a reduction in the evaporating area and also increase the salinity which decreases the evaporation per a given area. Therefore, as the water level drops, the quantity of water lost to evaporation likewise drops until it equals the quantity of the inflow that has been reduced for climatic reasons. A new equilibrium is achieved at a lower level. Conversely, a reverse process occurs with the water level's rise as a result of a rise in the inflow, until a new balance is reached at a higher water level.

About two thirds of the Dead Sea's area is made up of the deep northern basin (~280 m deep), and one third is the shallow southern basin. The Lynch Straits linking the two basins has a sill at elevation of about −400 m. The northern basin collects most of the inflow, so that the very existence of the southern basin is dependent upon its link with the northern basin. The most significant changes in the lake's surface area are supposed to occur above and below this −400 m level, which means accordingly either maintaining or drying out of the southern basin water body.

According to geological and historical evidence, natural drops have occasionally occurred in the Dead Sea's water level below the Lynch Straits sill elevation, causing drying up of the southern basin (Bookman et al., 2006; Neev and Emery, 1967). Such drying events reduced the quantities of water evaporating by one third. In turn, this reduction offset the reduction in the inflow during dry periods, contributing to the halting of the ongoing drop in the northern basin. In this way, the southern basin historically served as a natural "shock absorber", and most of the changes in the water level in the past 2.5 millennia did not diverge much from the 10-m range above or below the sill elevation of the Lynch Straits. Further back in history, climate changes occurred on a wide scale, overcoming even the moderating influence of the southern basin.

Unlike in the past, and despite the separation of the two basins that occurred in 1975, the southern basin continues to lose large quantities of water to evaporation due to the fact that its entire area has been taken over by industrial evaporation ponds whose water is pumped out of the northern basin; thus the southern basin has lost its historic function of halting the drop in the northern basin's water level. Today, that level has dropped 22 m beneath the Lynch Straits sill elevation, and continues to fall.

The predicted equilibrium level for the present water balance of the Dead Sea is about −550 m. This will be achieved over a few centuries, during which the rate of the water level drop will be moderated (See Figure 3). In the event that the present deficit increases, the equilibrium water level will drop, and the period needed to reach it will lengthen.

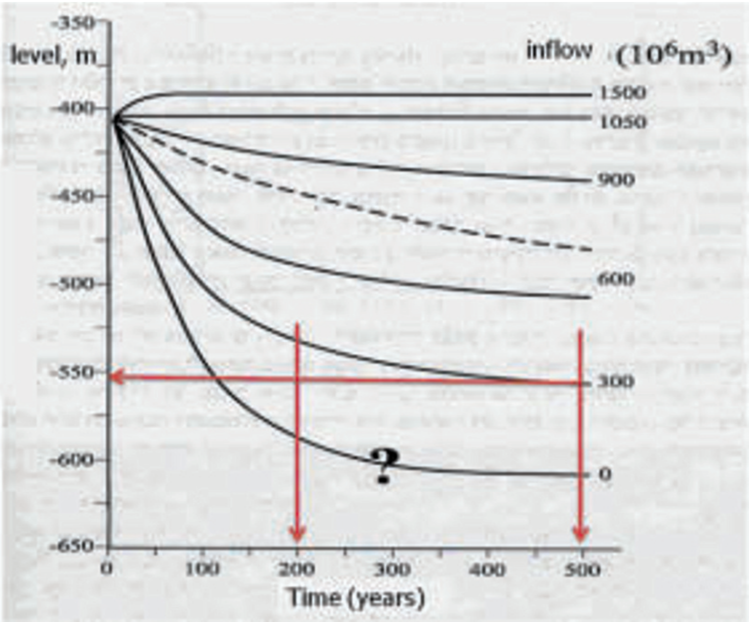


Figure 3. Prediction of future equilibrium levels versus different amounts of annual inflows (Yechieli et al., 1998). The present inflow is assumed to be ~300 MCM/year

1.2. IS HUMAN INTERVENTION DIVERTING NATURAL CYCLES?

The first series of direct measurements of fluctuations in the Dead Sea's water level began in 1900 when Macalister carved a reference line on a rock that juts out over the surface, and ended on the eve of World War I (Masterman, 1913). Measurements were reinstituted in 1929 and continued by the P.P.L. (Palestine Potash Limited) factory (later the Dead Sea Works). The highest measured level was −390 m in 1930. Since then and up to now (the end of 2008), the water level has dropped from 32 to −422 m.

The annual average drop in the Dead Sea's water level was 25 cm in the 1950s and 50 cm in the 1970s. In the past decade, it reached 1.05 m. Tangible evidence lies in the jetties to which boats were once tied but that today hang suspended and/or far from the coast line, as seen in Figures 4, 5a and 5b. New studies attempting to reconstruct the fluctuations in the water level show clearly that the drop in the past decades differs from the natural drops that occurred over the past millennia, both in their rate and in the levels reached. This trend is clearly depicted in Figure 6. These changes correspond with the intensified human intervention, both in water diversion from the Jordan River basin and Dead Sea – related industry, rather than to the natural cycles.

Figure 4. An abandoned jetty at a naval base (Ein-Gedi) and a sinkhole in the background

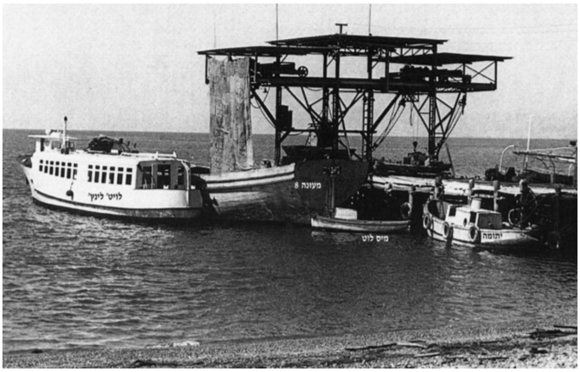


Figure 5a. The jetty of the Palestine Potash LTD factory at the northern tip of the Dead Sea, 1940 (DSW archive)

Figure 5b. The same jetty in 1992 (Photograph by Raz)

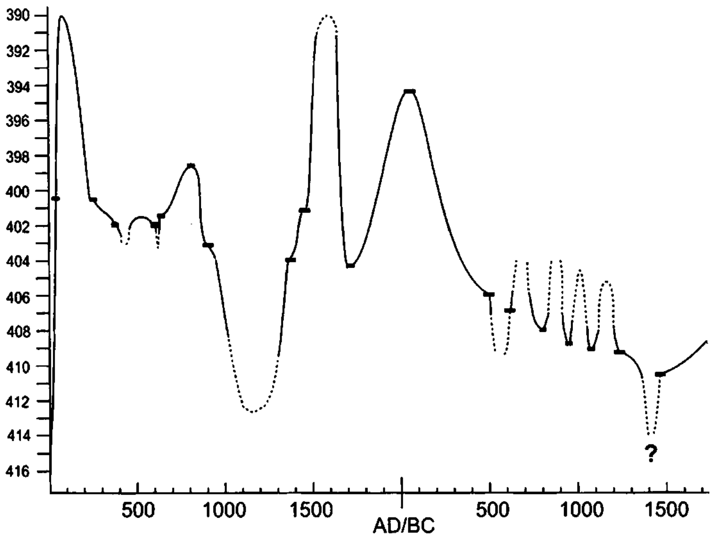


Figure 6. Dead Sea level fluctuations during the last three millennia (Bookman et al., 2006) show the outstanding amplitude and the steepness of curve over the last decades

1.3. ENVIRONMENTAL CHANGES RESULTING FROM THE DROP IN THE DEAD SEA'S WATER LEVEL

A rapid and continuous drop in a lake's water level throws the natural systems therein out of balance. The reduction in the inflow into the lake causes limnological changes and the disappearance of unique natural phenomena in the body of water and its surrounding area. Following are just a few examples:

1.4. CHANGES IN THE BODY OF WATER

Occasionally during the summer, the Dead Sea's water would turn white, generating curiosity and amazement. The "Whitening of the Dead Sea" phenomenon has been explained as being caused by aragonite ($CaCO_3$) and gypsum ($CaSO_4.2H_2O$) crystallization in the water body during intensified evaporation, causing supersaturation of the water in respect to these minerals (Neev and Emery, 1967). Following the whitenings, the crystals would sink down and coat objects lying on the lake's bottom. These would become partially exposed by seasonal drops in the water level, revealing a "natural sculpture garden" that lent further aesthetic value to the already distinguished the Dead Sea. This mineral crystallization was conditioned by bicarbonate (HCO_3^-) and sulfate (SO_4^-) ions supply in the inflowing water. With the reduction in the inflow, the "whitening" has become rare or disappeared altogether, with the last observed event in August 1974. The earliest "sculptures" on the upper beach are destroyed, and no new ones have formed since.

During rare heavy winter rains when the surface water's density has dropped beneath 1.21 g/ml, occasional growths of green algae have formed at densities of thousands of cells per milliliter coloring the water green. The algae bloom was often followed by bacteria bloom whose levels could rise to millions of cells per milliliter. This bacteria bloom would be fed by the algae and color the water red and purple (Oren, 1983a, b, 1985, 1993; Oren and Shilo, 1982). The growths and shifting hues attracted researchers, locals, and visitors. The last incidence thereof followed the outstanding winter of 1991/1992. Since then, even winters with heavy rains were not sufficient for diluting the increasing density of the water to the degree that allows for a microbial bloom.

1.5. CHANGES OUTSIDE OF THE BODY OF WATER

The recent drop in the water level has exposed salty mud flats that today run parallel to most of the western beach in a strip that fluctuates in width according to the topography (2.5 km along the Tze'elim Plain). This strip constitutes a widening band of marsh and sinkholes, threatening existing tourism and preventing further development at the Dead Sea. In turn, this is causing the suspension of the National Outline Plan (NOP) for developing the Dead Sea beaches.

Lagoons were always the scenery base of the coast line. They were also exploited for salt production, as hinted at in the Bible (Ezekiel, 47: 11), as described in ancient documents, and as documented in travelers' logs and photos from the beginning of the 20th century (Figure 7). Salt, of course, was extremely important to both economy and ritual. The lagoons were formed at the rear of an embankment of pebbles heaped by waves and currents. The existence of the mud flats in place of pebble beaches, along with the absence of inter-basin currents and the reduction of inflow from the Jordan has reduced the source of pebbles and the momentum needed to form the embankments. A rare opening of the Deganya Dam following the winter of 1991/1992 released larger quantities of water into the Dead Sea, generating strong, pebble-bearing tides that formed an embankment and caused a renewal of the lagoons' formation, as seen in Figure 8. This has not recurred since.

Figure 7. Salt production from lagoons near Ein-Gedi in 1918 (Source: Vilnai, 1964: 76)

Figure 8. Reappearance of lagoons along the coast line of the Dead Sea after opening the Deganya dam in the winter of 1991/1992 (Photograph by Raz)

1.6. DOES THE HUMAN-GENERATED BENEFIT JUSTIFY THE CHANGES IT CREATES?

The environmental changes that have accompanied the drop in the Dead Sea's water level, and the resulting disappearance of unique natural phenomena, did not arouse public attention to the Dead Sea's plight until the emergence of a sinkhole on the west Dead Sea Highway in 1989. The number of sinkholes reached 320 over a decade, not counting the Lynch Straits and the Dead Sea Works premises (Raz, 2000).

The sinkholes gave rise to a decision by the Ministry of Infrastructure to conduct a wide-ranging study of the phenomenon and how to deal with them. By the end of 2007, 2,000 sinkholes were documented in the area. They were responsible for property damage and injury, as well as the loss of livelihoods. Figures 9 and 10 illustrate some of the damage that caused various development projects to be abandoned. The study, which proved the linkage between the sinkholes and the drop in the Dead Sea's water level (Raz, 2000; Frumkin and Raz, 2001; Yechieli et al., 2003), along with the alarming rate of sinkhole generation, paved the way for a full-scale examination of the problems besetting the Dead Sea, and a foundation for national policy was formed to guard its future. This study was supposed to have answered the question: Is intervention at all needed to halt the drop in the Dead Sea's water level? If so, what intervention? In a Cabinet decision of January 2003, an inter-disciplinary team was formed to study three scenarios:

1. *The "default" scenario*: The negative recharge rate in the Dead Sea basin continues and even intensifies (likely to occur with the coming decades anyway).
2. *Seawater conduit*: Changing the water balance by significant contribution of seawater from the Mediterranean or the Red Sea, and/or "reject brine" from combined desalination plant on the Dead Sea beach.
3. *Freshwater supply*: A significant change in the recharge rate by restoring a considerably the natural sources of water that flowed into the Dead Sea, and/or exchanging them by desalinated water, thereby partially restoring previous conditions.

Figure 9. An abandoned tourism area (Source: Raz, 2001–2008)

Figure 10. An abandoned agricultural area (Source: Raz, 1993)

2. The Coastal Oases

The team completed its study of Scenario 1 (Eidelman et al., 2006), which summarized the damage and threats thus far, and the expectations for the near and middle future if no intervention is performed. In the course of this study among others, the possibility of a considerable threat to the coastal oases ecosystem was concluded. The coastal oases in the northwestern Dead Sea are fed by springs that are linked hydraulically to the Dead Sea, and are therefore affected by the drop in its water level. The output of the springs is 110–130 MCM/year, and is presently the Dead Sea's largest and most stable natural water source. The Tzukim Springs alone flow at a rate of 65–93 MCM/year (Roffe, 2003) at a wide range of salinities.

On the coastal oases, 162 species of plants have been documented (National Parks Authority Database and Reports; Eidelman et al., 2006), of which 15 are rare or very rare and classified as endangered species in Israel. For wildlife, including 110 species of birds on their migratory routes, the oases provide food, shelter and protected places to reproduce, and serve as a resting site and place to store fat. The Tzukim Springs are on the list of bodies of water with worldwide importance to birds (Evans, 1994), and 17 endangered species in particular.

A group of aquatic vertebrates (Goren and Ortal, 1999) and invertebrates in the Dead Sea's feeder springs has been held up as one example from among 11 such groups in the world that are endangered (Wells et al., 1980). This group contains the largest endemic concentration of species in Israel (Por et al., 2001; Dimentman and Por, 1991). These endemic species, as well as others, have considerable scientific importance to understanding evolutionary processes, environmental changes, and past linkages with various water systems throughout the history of the Dead Sea Rift.

The drop in the Dead Sea's water level has caused the shifting of springs and the lengthening of stream channels both underground and above ground, through a medium that was saturated in the Dead Sea's water and hence increased the springs' salinity. The water's potential wanders eastward through an interfingering zone between coarse-grain (gravel) sediments in the west to the fine-grain (clay) sediment in the east. The undermining of the stream channels on the mud flats causes drainage and drying of the high environment, as well as deepening stream channels with strong flow. As a result, ecological changes are occurring that affect species composition, distribution and bio-diversity, with the possibility of a chain effect both inside and outside the coastal oases ecosystem.

The continuous drop in the water level will exacerbate these trends, and is liable to release pressure above the deeper sub-aquifer outlets. In turn, this will by-pass the oases from below and, after a salting process, empty downstream into the newly exposed hyper saline swamp that can not support the coastal oases. If this undesirable scenario plays out, it will cause the disappearance of the coastal oases along with all of their natural treasures (Figure 11).

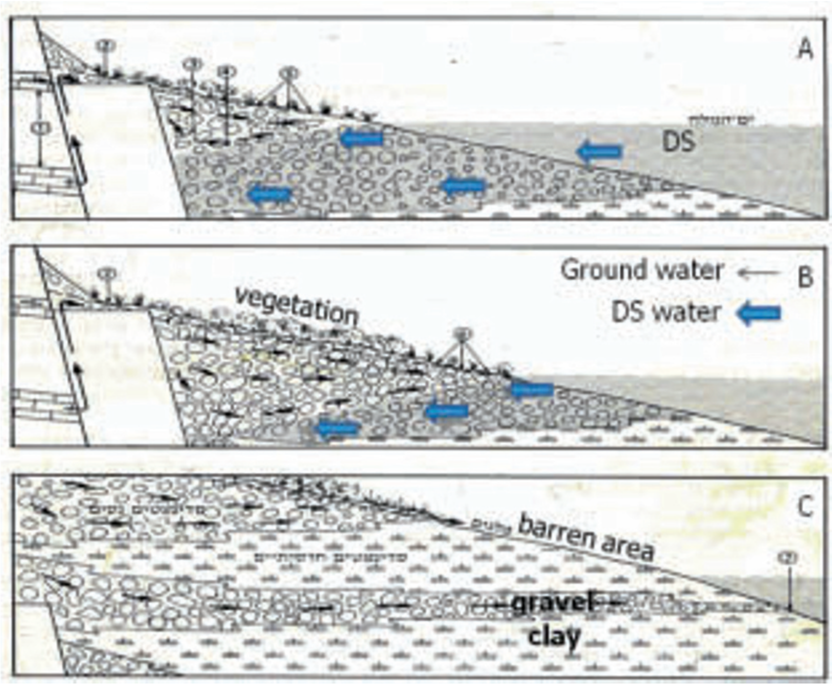


Figure 11. The effect of a water level drop on coastal zones (Raz, 1993). The drop in the level within the gravel range (A+B) advances the ground water front eastward and expanses the coastal oases. Farther drop to the clay rang (C) exposes hyper-saline and barren mud flats, releases pressure above the deeper sub-aquifer outlets which causes the water to by-pass the oases from below (after Raz, 1993)

These findings, although they do not represent existential threats to humans (or certainly not immediately so, in contrast to the sinkholes), do have ideological and scientific gravity in terms of human welfare. They are no less problematic than the phenomena that are visible to the human eye, which are mainly felt by local residents, and they should be added to other considerations in favor of halting the drop of the level.

Disappointingly, no continuation of the policy paper has been called for, and the questions underlying it have not been studied professionally.

2.1. HISTORY OF THE PROPOSED CANALS

2.1.1. Proposals prior to 1996

In the wake of the sensational discovery in the middle of the 19th century that the Dead Sea lies almost 400 m below the Mediterranean, a series of proposals popped up suggesting ways to exploit its low elevation, first for transportation purposes and later for producing hydroelectric energy. Proposals to dig a canal via the northern valleys of Israel and the Jordan Valley or a tunnel underneath the Judaean Hills, have undergone various reincarnations (Bourcart, 1899; Herzl, 1902; Lowdermilk, 1944; Vardi, 1990). See, for example, Figure 12.

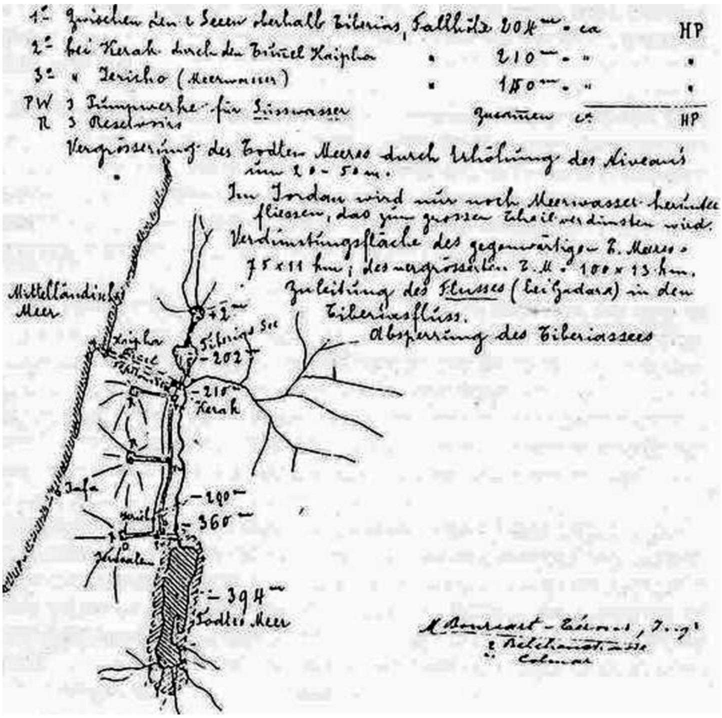


Figure 12. Bourcart's proposal for canal via the northern valleys of Israel and the Jordan Valley, combined with hydroelectric power generation (Bourcart, 1899) (Source: Raz, 1993)

The rising price of petroleum during the energy crisis of 1973 revived the idea of exploiting the difference in elevation between the two seas for producing alternative (hydroelectric) energy. After the oil embargo of 1974, the Israeli government appointed a committee to study the feasibility of the idea, headed by Professor Shlomo Eckstein. The positive conclusions of the committee led to progress on the subject. In November 1977, Professor Ne'eman headed another committee that studied six possible routes for a seawater conduit: five from the Mediterranean, and one in the Arava (Araba) from the Red Sea, as illustrated in Figure 13. The Ne'eman Committee chose the Katif Alignment as the best option for economic, environmental, and other reasons.

Figure 13. The six alternative routes for a seawater conduit that have been investigated by Ne'eman Committee (Source: Raz, 1993)

The government adopted the committee's recommendation and established a state company to undertake the project. In the end, however, it was suspended for lack of economic justification. The conclusion that exploiting the elevation difference for desalinating seawater on the Dead Sea beach is more worthwhile than producing electricity led in the 1990s to a reexamination three routes: from the southern coastal plane (Katif), from the northern coastal plane (Hadera) via Jordan Valley, and through the Arava (Araba) from the Red Sea. In 1996, another version of the Hadera–Jordan Valley alignment was proposed: to desalinate Mediterranean water by a plan attached to the Hadera power station (Ben-Meir et al., 1996). This project allocated 600 MCM/year of high-quality water for the Jordanians needs and the remaining 200 MCM/year to the Sea of Galilee.

2.1.2. Jordanian proposal

Jordan faces a rather grave domestic water scarcity situation, and is quite supportive of the idea of desalination by means of a sea-to-sea canal. The government pushed forward its version of the Arava Alignment (Harza JRV Group, 1996): the Read Sea–Dead Sea Canal (RSDSC) (shown here in Figure 14) to be built by foreign companies. The plan was submitted to Israel for review, as required by the 1995 peace accords. In 1996, the Israeli Foreign Ministry convened a large team of experts to examine and respond to the Jordanian plan. The team deemed it inferior to the proposed alternatives in all respects (summary of Foreign Ministry hearing of November 7, 1996). A massive project based on a low slope and a long route, requiring pumping at an elevation difference of 1,400 m, seemed preposterous. It would yield benefits only after all funds had been invested in a drawn-out construction process. The team was also concerned for the unfathomable environmental threats such an undertaking would create. They considered alternatives such as the Mediterranean Sea Dead Sea conduit or modular desalination on the Mediterranean coast as simpler and cheaper. After all, the distance between Hadera and the King Abdallah Canal is only 70 km and the distance from Haifa Bay to the Sea of Galilee is only 50 km.

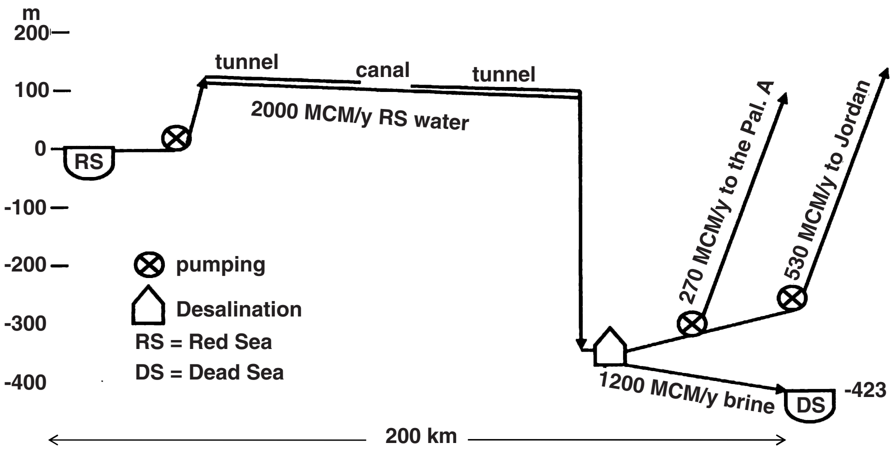


Figure 14. The Harza plan for RSDSC (Source: Beyth, 2007)

3. Environmental Concerns Over Proposed RSDSC Plan

Eventually, the government of Israel neglected its own decision (No. 2863 from Jan 5th 2003) to check various alternatives for saving the Dead Sea, and supported the RSDSC. Its declared vision is to save the DS from environmental degradation, to desalinate ~800 MCM/year water at affordable prices (2/3 for Jordan, 1/3 for the Palestinian Authority and Israel) and to build a symbol of peace and cooperation in the Middle East.

In light of the consensus, the World Bank is financing a feasibility study of the current proposal for the project. As it stands, the plan is to pump 2 BCM/year (billion cubic meters per year) of water from the Red Sea to the Dead Sea. This would generate 0.8 BCM/year of desalinated water on the Dead Sea shore, 0.27 of which is designated for the Palestinians. The byproduct, ~1.2 BCM/year of marine brine per year, would be used for the recovery of Dead Sea. The World Bank feasibility study will be completed in 2 years, which is much too short a period to conduct sufficient research that bridges knowledge gaps, especially with regard to the environmental implications. This plan would result in ~84 million tons of dissolved salts entering the Dead Sea every year. This is roughly 31.5 times more than the Jordan River salt supply in the past, and has a different chemical composition. Studies show that mixing sea (any sea) water with Dead Sea water might cause negative limnological and microbiological impacts (Gavrieli et al., 2002, 2005, 2006), resulting in considerable damage to industry and tourism.

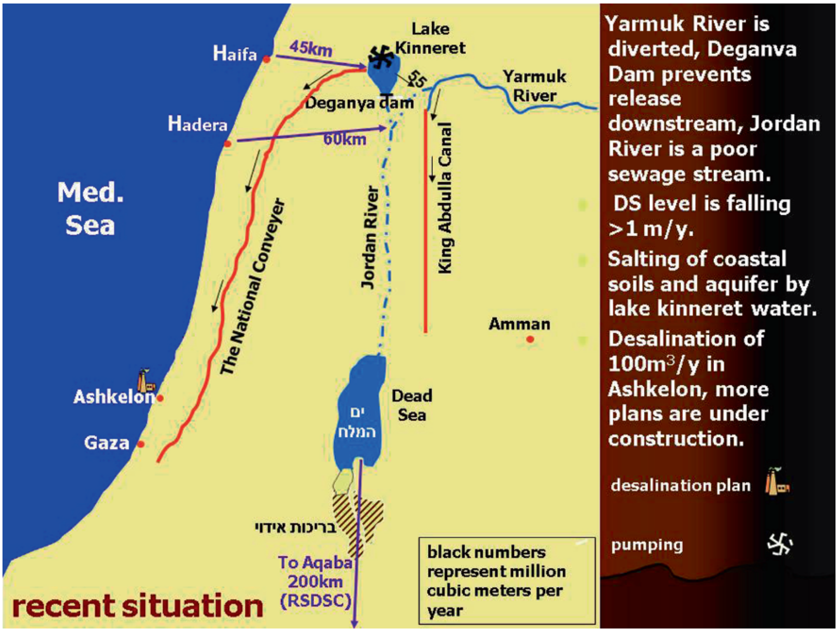
In addition to its direct impacts on the Dead Sea environment, the proposed RSDSC could affect the Gulf of Aqaba and the Arava Valley. Currents are a major factor of the marine ecosystem; pumping 2 BCM of water per year from the Gulf of Aqaba might drastically change the conditions of the vulnerable and unique ecosystem in the narrow edge of Gulf. The coastal tourism industries of Egypt, Israel and Jordan rely heavily on this natural wonder. Furthermore, the proposed path of the RSDSC would stretch along the most active seismic belt in the region and cross geological faults, some of which are probably active (Shirav-Schwartz et al., 2006). The possibility of an earthquake that damages the alignment and causes flooding, or even of simply small leakage, presents the threat of soil and aquifer contamination by sea water.

4. JRDS: The Systemic Alternative

In the light of threats and uncertainties in the marine alternatives, a systemic alternative – the JRDS (Jordan River–Dead Sea system) – has been put forth as a modular approach involving potable water. It involves replenishing the Jordan River using either water from massive desalination on the coastal plane (MD1), and/or shipping water from the Turkish Mediterranean coast (T2).

The first of these ideas, MD1, looks expensive due to the cost and amount of desalination needed (2.6 times more per year than in the RSDSC and MD2, see Table 2), but might be outweighed by the benefits of the systemic approach. Furthermore, although there are economic and environmental disadvantages of the heavy energy use required in desalination, significant changes are on the horizon in the realm of viable clean energy sources.

The second idea is T2. Every year, billions of cubic meters of potable water are flowing into the Turkish Mediterranean Sea, roughly 700 km north of Haifa. A contract for shipping this water to Israel has been signed but not implemented due to the high cost of conventional transportation by tankers. Recent experiments have yielded an appropriate material for producing giant tanks that have been dragged successfully this distance. Using this new technology, a fleet of about 22 relatively small sea crafts can supply 2 BCM/year of potable water, far beyond the amount expected from the RSDSC and the amount required for the recovery of the JRDS system. Furthermore, the developers claim that the cost of transportation to the Israeli coastal plane (Hadera) is just 75% of the desalination cost in the same place. This option is also free of negative impacts of the desalination and the allocation of expensive coastal land for projects. The cost is expected to decrease as the tanks' capacity increases, which is limited by the actual capacity of the means of transporting the tanks from the factory to the sea.



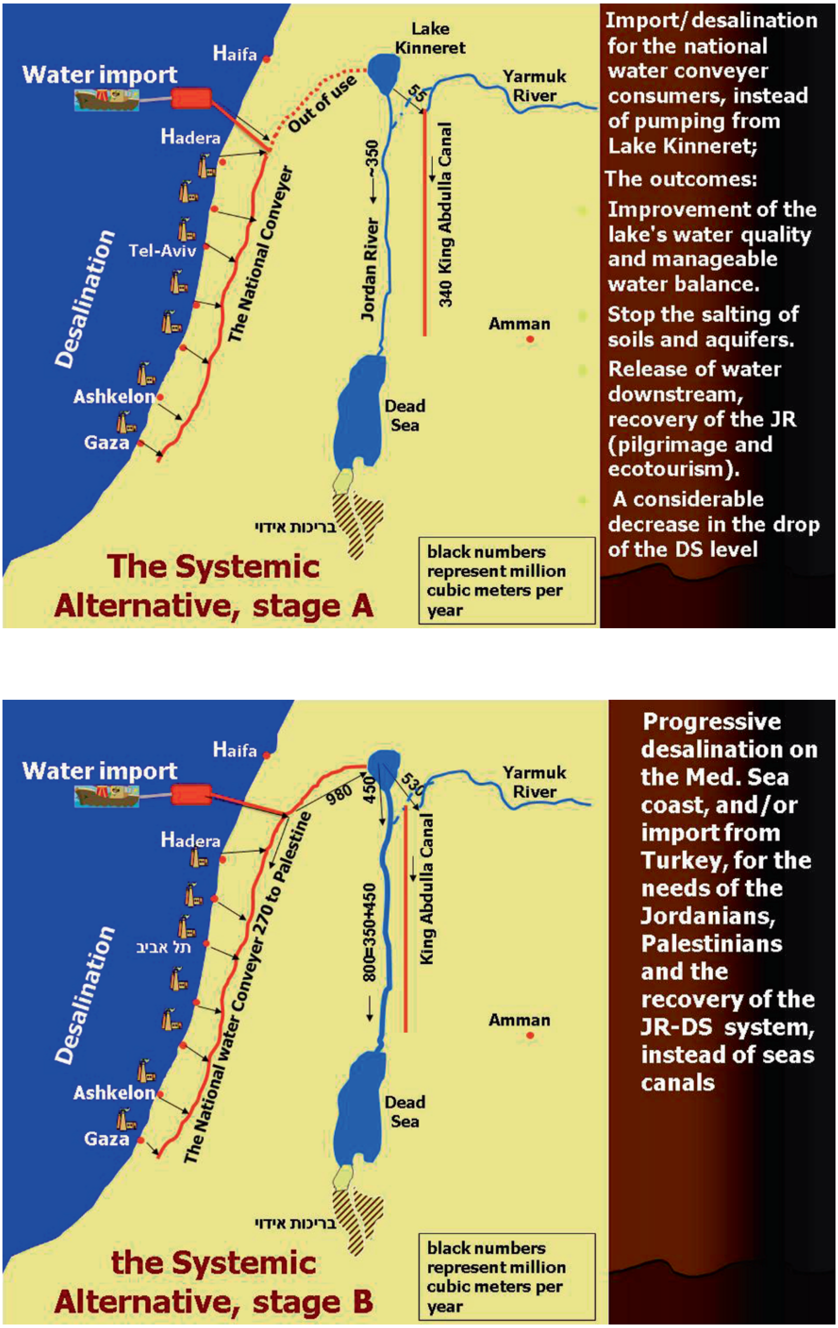


Figure 15. JRDS – The systemic alternative

The first stage of the JRDS plan (Stage A) is to import/desalinate ~0.35 BCM/year for the Israeli National Water Carrier (NWC) to replace the amount pumped from Lake Kinneret. This will improve the lake's water quality and manageable water balance (Gophen, 2007a, b), stop the salting of soils and aquifers by Lake Kinneret water and enable the release this portion downstream along its natural flow path (the Jordan River). This will help to achieve the restoration of Jordan River for immediate benefits and a considerable reduction in the rate of the drop in the Dead Sea's level into which it flows.

The second stage (Stage B) is to import/desalinate ~1.3, 0.27 BCM/year of which will be transferred to Palestine from altitude 0 (instead of pumping from Dead Sea at −400 m), and 1.03 BCM/year of which will flow by alignment to either the Jordan River Valley or to Lake Kinneret (possibility: in the route of the NWC with an option to gain energy downstream). Of this 1.03 BCM/year, 0.53 will flow to Jordan by the adjacent King Abdulla Canal, again instead of pumping it up from Dead Sea, and the remaining 0.5 BCM/year will be released to accomplish the recovery of JRDS system. (See Figure 15 below, three stages of the systemic alternative.)

The JRDS alternative is the closest to the original/natural situation and hence minimizes environmental risks and uncertainties, avoids seismic and sea water contamination threats and does not interfere in the Gulf of Aqaba

TABLE 2. Partial Comparison of Annual Costs* in Million Dollars, Excluding Maintenance

Plan	(Cost × volume) + additional cost	Annual price
RDSC desalination	($0.45/m^3 × 0.8 BCM/year) +$580M pumping and transport from Dead Sea	$940M
MD2 desalination	($0.45/m^3 × 0.8 BCM/year) +$195M pumping and transport from Jordan River Valley	$555M
MD1 desalination	($0.56/m^3 × 1.65 BCM/year) +$146M pumping and transport from Jordan River Valley −130 by gaining energy downstream	$940M
T2 import	($0.45/m^3 × 1.65 BCM/year) +$146M pumping and transport from JR Valley −130 by gaining energy downstream	$758.5M

* Costs are not up to date, due the changes in the global economy, but still proportional in respect to each other.

ecology. The conduit needed is not as large of an undertaking, given that it is 1/4 to 1/3 of the length and 1/2 of the capacity of the RSDSC. In addition, its modular nature is economically significant; implementation and benefits of Stage A are instant. The result of reviving the Jordan River as a most desired

TABLE 3. Partial Comparison of the Main Investments* in million dollars

	Canals	**Desalination plants**	**Pumping and transport system**	**Total investment**	**Annual desalination and transport**
RSDSC** 170 km for 2 BCM/year sea water + 30 km for 1.2 BCM/year of brine	4,450	3,600	800	8,850	940
MD2*** 60 km for 2 BCM/year sea water + 110 km for 1.2 BCM/year of brine	1,840	3,600	270	5,710	555
MD1** 60 km for 1.03 BCM/year desalinated water and no brine canal	900	5,000	224	6,124	940
T2 60 km for 1.03 BCM/year imported water and no brine canal	900	0000	224	1,124	759

* Costs are not up to date, due the changes in the global economy, but still proportional in respect to each other.

** Based on Neaman Institute report + corrections.

*** Accommodation from MD2 data.

N.B. Protections against environmental threats and uncertainties are not considered.

pilgrimage and ecotourism site is meaningful from both economic and heritage points of view and promises benefits for the communities on both sides. Including Lake Kinneret in the project offers Jordan a storage capacity that the country needs; as a bi-national reservoir it will carry a real message of peace and cross-border cooperation that fills the purpose of the international financiers and the declared vision of the project far beyond the RSDSC.

The RSDSC option doesn't link the water supply systems of Jordan and Israel and is currently preferred, not because of any stark advantages, but due to the consensus between Jordan and Israel (but not Egypt) based on mutual suspicion. This ambivalence has lead to opposition to any linkage between their water supply systems rather than adoption of such a linkage (and others) for enhancing the peace. Currently, Jordan accepts 55 MCM/year from Lake Kinneret; the precedent exists and the system is ready for further development. The T2 version of the scenario might be especially attractive, given that the water comes from an impartial body (no "made in Israel" water).

The apparent attractiveness of the JRDS alternative cannot make it preferable over RSDSC without a comprehensive feasibility study. Bearing much fewer uncertainties, such a study is expected to be considerably quicker and cheaper compared to the one currently underway for the RSDSC (Table 3). The World Bank is expected to declare its support for the "best alternative, which is not known yet", as the only option, whether the partners like it or not. Jordan's need for international financing for a potable water project, together with the recognition of the administration and the public in Israel of the need to save the Dead Sea in the most beneficial and least harmful way, in addition to international guaranties, might lower the barriers of suspicion.

5. Conclusion

The idea of using potable water instead of marine brine to save the Dead Sea is a fundamental one that has not yet been fully considered or properly examined. It is this generation's responsibility to ensure a healthy future for Dead Sea for the generations to come. That said, regional and international bodies involved in the problem-solving process are obliged to conduct *simultaneous* feasibility studies of the various alternatives and then to choose the best of them. The comparison of these alternatives should involve comprehensive environmental and economic cost–benefit analyses, free of political pressure. This is the precondition needed for choosing the best way to fulfill the declared vision, on which Israel, Jordan and the World Bank have agreed.

References

Ben-Meir, M., Kantor, S., and Shaham, G., 1996. Mediterranean Sea–Jordan River Basin Project, Highlights of study: 12 pp.

Beyth, M., 2007. The Red Sea and the Mediterranean Dead Sea canals project, *Desalination*, 214: 365–371.

Bookman, R., Bartov, Y., Enzel, Y., and Stein, M., 2006. Quaternary lake levels in the Dead Sea basin: two centuries of research. *New Frontiers in Dead Sea Paleoenvironmental Research*, The Geological Society of America, Special paper, pp. 155–170.

Bourcart, M., 1899. Kraftund bewaesserungsanglagen in Palaestina. Letters to T. Herzl, 1899–1901, preserved in the Central Zionist Archives, Jerusalem.

Dimentmam, Ch. and Por, F.D., 1991. The origin of the subterranean fauna of the Jordan–Dead Sea Rift Valley, *Stygology*, 6(3): 155–164.

Eidelman, A., Cohen, G., Bein, A., and Kaplan, M. (eds.), 2006. *Policy Document – The Dead Sea Basin*, Assessment of Current situation and Prospects for the Future under Continued Dead Sea Water-Level Decline, Ministry of National Infrastructures/Ministry of the Environment/The Jerusalem Institute for Israel Studies.

Evans, M.I. (comp.), 1994. Important Bird Areas in the Middle East, *BirdLife International*.

Frumkin, A. and Raz, E., 2001. Collapse and subsidence associated with salt karstification along the Dead Sea, *Carbonates and Evaporites*, 16(2): 117–130.

Gavrieli, I., Lensky, N., Gazit-Yaari, N., and Oren, A., 2002. The impact of the proposed "Peace Conduit" on the Dead Sea, evaluation of current knowledge on Dead Sea – seawater mixing, *GSI/23/2002*, Geological Survey of Israel, The ministry of National Infrastructure.

Gavrieli, I., Bein, A., and Oren, A., 2005. The expected impact of the "Peace Conduit" project (the Red Sea–Dead Sea pipeline) on the Dead Sea, *Mitigation and Adaptation Strategies for Global Change*, 10(1): 3–22.

Gavrieli, I., Lensky, N., Dvorkin, Y., Lyakhovsky, V., and Gertman, I., 2006. A multi-component chemistry-based model for the Dead Sea: Modeling to the 1D Princeton Oceanographic Model, *GSI/24/2006*, Geological Survey of Israel, Ministry of National Infrastructure. Including appendix V: Oren, A., Gavrieli, I., Gavrieli, J., Kohen, M., Lati, J., and Aharoni, M., Long-term field simulation of algal and archaeal bloom in the Dead Sea.

Gophen, M., 2007a. Lake Management Perspectives in Arid, Semi-Arid, Sub-Tropical and Tropical Dry climate. Proceedings of the 12th International Lake Conference, Jaipur, India. Invited paper.

Gophen, M., 2007b. Long-term (1970–2001) Eco – Hydrological Processes in Lake Kinneret and its Watershed., in: *Climatic Changes and Water Resources in the Middle East and in North Africa*. H. Zereini, ed.

Goren, M. and Ortal, R., 1999. Biodiversity of the inland water fishes of Israel. *Biological Conservation*. 89: 1–9.

Harza JRV Group, 1996. Red Sea–Dead Sea Canal Project, Draft Prefeasibility Report, Main Report. Jordan Rift Valley Steering Committee of the Trilateral Economic Committee.

Herzl, T., 1902. *Altneuland* (German), Seemann Nachf pub, Leipzig.

Lensky, N.G., Dvorkin, Y., Lyakhovsky, V., Gertman, I., and Gavrieli, I., 2005. Water, salt and energy balances of the Dead Sea, *Water Resources Research*, vol. 41, W12418, doi: 10.1029/2005WROO4O84.

Lowdermilk, W.C., 1944. *Palestine, Land of Promise*, Harper & Row, New York.

Lynch, W.F., 1984. Narrative of the U.S.'s expedition to the River Jordan and the Dead Sea. Hebrew edition, the Ministry of Defense Pub, p. 158.

Masterman, E.W.G., 1913. Summary of observations on the rise end fall of the level of the Dead Sea. 1900–1913, *P.E.F. Quarterly Statement*, pp. 192–197.

Neev, D. and Emery, K.O., 1967. The Dead Sea depositional processes and environment of evaporates*, Geolog. Surv. Isr.*, Bull. 41.

Oren, A. and Shilo, M., 1982. Population dynamics of *Dunaliella parva* in the Dead Sea, *Limnology and Oceanography*. 27(2): 201–211.

Oren, A., 1983a. Bacteriorhodopsin mediated CO_2 photo assimilation in the Dead Sea, *Limnology and Oceanography*. 28(1): 33–41.

Oren, A., 1983b. Population dynamics of Halobacteria in the Dead Sea water column, *Limnology and Oceanography*. 28(6): 1094–1103.

Oren, A., 1985. The rise and decline of a bloom Halobacteria in the Dead Sea, *Limnology and Oceanography*. 30(4): 911–915.

Oren, A., 1993. The Dead Sea alive again. *Experienta*, 49: 518–522.

Por, F.D., Dimentman, Ch. and Frumkin, A., 2001. Israel. *Encyclopedia Biospeologica*, C. Juberthie, and V. Decu, eds., Vol. 3. Soc. Biospeologie, Moulis (C.N.R.S.) – Bucarest (Acad. Roumaine), Imprimerie Fabbro, Saint-Girons, France. 4 pp.

Raz, E., 1993. *The Dead Sea Book* (Hebrew), Nature Reserves Authority & Tamar Regional council.

Raz, E., 2000. Study of sinkholes formation along the Dead Sea short, second report (Hebrew), GSI/31/2000, Geological Survey of Israel, Jerusalem.

Raz, E., 2001–2008. Sinkholes follow-up reports, engineering department, Tamar Regional Council.

Roffe, B., 2003. The output of Einot-Tzukim summer 2003, the Water commissionership and the Hydrological service.

Samuel Neaman Institute, 2007. Reclaiming the Dead Sea Alternative for action, Technion, Israel Institute of Technology.

Shirav-Schwartz, M., Calvo, R., Bein, A., Burg, A., Novitsky, R., and Baer, G., 2006. Red Sea–Dead Sea Conduit, geo-environment study along the Arava Valley, *GSI/24/200*6, Geological Survey of Israel, the Ministry of National Infrastructure.

Stern, M., 1980. *Greek and Latin Authors on Jews and Judaism*, Vol. 2, The Israel Academy of Science and Humanities, Jerusalem.

Vardi, J., 1990. Mediterranean–Dead Sea Project: Historical Review: in *Mediterranean–Dead Sea Project*; Arad, V., Beyth, M: *GSI/9/1990*: 31–50.

Vilnai, Z., 1964. *The Dead Sea and its Israeli Beach* (Hebrew), Tamar Regional Council.

Yechieli, Y., Gavrieli, I., Ronen, D., and Berkovitz, B., 1998. Will the Dead Sea die? *Geology*. 26: 755–758.

Yechieli, Y., Wachs, D., Abelson, M., Crouvi, O., Shtivelman, V., Raz, E., and Baer, G., 2003. Formation of sinkholes along the shore of the Dead Sea/Summary of the first stage of investigation, *GSI Current Researches I*, Vol. 13: 1–6.

Wells, S.M., Pyle, R.M., and Collins, N.M., 1980. *The Invertebrate Red Data Book*, International Union for the Conservation of Nature (IUCN).

GREENING THE RED SEA–DEAD SEA WATER CONVEYANCE PROJECT

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Abstract: This paper outlines the proposed regional Red Sea–Dead Sea Conveyance Project ("the Project") in its current design, as conceived by a group of engineering companies headed by the Harza Jordan River Valley Group from 1995 to 1997. It explores the various concerns of those who stand in opposition to the Project, as expressed in recent public meetings held by the World Bank. Finally, it details a host of suggestions to improve the Project's performance and public acceptability. Overall, these proposed ideas involve "greening" modifications.

Keywords: Red Sea; Dead Sea; the Project; World Bank; Harza Group design; greening

1. Introduction

A few months ago, the World Bank announced the winners of its international tender for the preparation of two separate, but inter-related, feasibility studies for the well-publicized Red Sea–Dead Sea (RSDS) Conveyance Project. The objectives, scopes and lists of tasks for these studies – one relating to its technical, economic and financial feasibility and the other to its environmental and social impacts – were set out in a lengthy terms of reference (TOR) document published in April of 2005.

The two groups of engineering and consulting companies chosen – one headed by Coyne et Bellier of France, and the other by ERM of Britain – will have to satisfy a long list of opponents to both the Project and the World Bank's study programme. These include several environmental protection groups, Red Sea and Dead Sea coasts tourist industry organizations, Wadi Araba/Arava agricultural settlements, and the Potash and other Dead Sea-derived chemicals' companies in Israel and Jordan.

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The current design for the Project can and should be improved, not only from the critical environmental point of view, but also economically. In other words, as the title of the paper suggests, the Project can and must be "greened" further. It also needs to be packaged and presented better to the public.

2. The Current Project Design

Right now, the reference point for the Project's design is the one adopted in the Harza JRV Group's Prefeasibility Report which was commissioned by the Jordan Rift Valley Joint Steering Committee in 1995 and completed in 1997 (Harza JRV Group, 1998). The key elements of this design are:

- Abstraction of about 1.86 billion cubic meters per year of seawater from the Gulf of Aqaba/Eilat at a point located on the border between Jordan and Israel.
- Conveyance of this seawater, after *minimal pretreatment* (only settling of sand and chlorination, "as significant treatment is envisaged immediately upstream of the desalination plant at the Dead Sea") for about 11 km, by an open canal, to a pumping station within Jordan, where it will be raised to balancing tank at an elevation of about 125 m above sea level.
- Conveyance of the seawater over a distance of about 142 km, in two free-flow drilled tunnels (121 km) and an intermediate open canal (21 km), all located entirely within Jordanian territory, to a point nearby the Dead Sea, at an elevation of 107 m.
- Pretreatment of the seawater, by deep-bed filtration, de-chlorination, pH adjustment and micro-screening, to make it suitable for desalination by reverse osmosis.
- Delivery of the pretreated seawater through a pressure shaft and tunnel (15 km) to the desalination facility, located near the Dead Sea at the lowest possible elevation (365 m below sea level).
- Production of up to 2.3 million cubic meters per day (851 million cubic meters per year) of 300 ppm TDS (Total Dissolved Solids) desalinated water, in a reverse osmosis plant operating at a recovery ratio (product to seawater feed ratio) of 45%. Due to the beneficial contribution of the hydrostatic head of the feed and the use of energy recovery turbines, the energy consumption of the desalination plant, *excluding* the seawater intake pumping, will be only 140 GWh/year, or 0.16 kWh/m^3 of product, and 970 GWh/year, or 1.14 kWh/m^3 of product, *including* seawater intake pumping energy.

- Transmission of the desalinated water – 570 million cubic meters per year to Amman and 280 million cubic meters per year to Hebron/Jerusalem – by pipes, pumping stations and terminal reservoirs. The energy requirements for these transmissions are 2,640 GWh/year, or 4.63 kWh/m^3, for Amman, and 1,320 GWh/year, or 4.71 kWh/m^3, for Hebron/Jerusalem.
- Discharge of the desalination plant brine along with any un-desalinated seawater in a 7 km long canal leading to the Truce Line Channel, where it will join and mix with the Israeli and Jordanian Potash works' end-brines and flow with them, by gravity, for about 20 km, into the northern basin of the Dead Sea.

This design resulted in a total required investment of almost $5 billion at 1996 values, or about 6.85 billion including cost escalations during the 10 year construction period. The desalinated water costs at their final delivery points in Amman and Hebron/Jerusalem, would be \$1.34/m^3 and \$1.15/m^3, respectively.

3. Opponents to the Project and Their Concerns

On August 12, 2007, a well-attended public meeting was held by the World Bank, in Neve Ilan, near Jerusalem (other meetings were held later also in Ramallah, Jericho and Amman). The objectives of the meeting(s) were defined by the Bank as:

- To inform the public about the Bank's proposed and recently revitalized Study Program for the Red Sea–Dead Sea (RSDS) Water Conveyance project and
- To obtain the views of all interested parties on the Study Program's Terms of Reference published 2 years earlier (on April 19, 2005)

Those attending the meeting witnessed a 3-h parade of Israeli opponents to the Project, each voicing, in differing degrees of eloquence and vehemence, their criticisms to both the Project and the Study Program as currently defined and specified. The speakers included mainly representatives from environmental protection groups (the "Greens"), Wadi Araba/Arava agricultural settlements, Red Sea and Dead Sea coasts tourist industry and the two Potash and other chemical-producing companies in Israel and Jordan, who expressed strong concerns about the potential environmental risks and threats to their various forms of livelihood. Others expressed opposition based on religious and cultural grounds. Almost all speakers complained bitterly and forcefully that the World Bank's Terms of Reference did not include the examination of alternative schemes for saving the Dead Sea.

The main points and concerns raised by these groups, divided into the three zones to be affected by the Project, were:

1. Gulf of Aqaba/Eilat

- The large quantity of seawater to be sucked and pumped out (almost 2 billion cubic meters per year) will impact seawater level and circulation over a wide stretch of the Gulf (FoEME, 2007) and could have a negative influence on the sensitive coral reef (SNIASST, 2007).
- The huge pumping station that will be required will occupy a significant area of land at a site where the shore line is limited and short (SNIASST, 2007).
- Construction activities at the seawater intake will destroy benthic habitat at the site (FoEME, 2007).

2. Wadi Araba/Arava

- The groundwater in the Araba/Arava Valley (currently exploited at a rate of 40–55 million cubic meters per year) will be vulnerable to salinization due to constant seawater leakage from the conveyance facilities and/or large spills resulting from catastrophic damages thereto from flashfloods, tectonic activities and earthquakes (frequent along this section of the Syrian–African fault line) (FoEME, 2007; SNIASST, 2007).

3. Dead Sea

- The Dead Sea water column will become stratified with a relatively diluted upper water layer (FoEME, 2007). This will result in an increased rate of evaporation. Furthermore, given the northern wind regime over the Dead Sea, it can be expected that the new humidity in the air above the northern section of the Dead Sea will be transported southward, where it will reduce the rate of evaporation from the commercial solar ponds that produce Potash and other chemicals (DSW, 2007).
- Dilution of the surface water, combined with the introduction of nutrients resulting from polyphosphate anti-scaling chemicals present in the desalination plant's brine, will result in microbial blooming (FoEME, 2007).
- The mixing of the calcium-rich Dead Sea water and sulfate-rich Red Sea water will result in gypsum precipitation that could lead to the whitening of the surface water (FoEME, 2007). The gypsum may also float on the surface of the water, acting as a suspension that damages evaporation rates in the chemicals producing solar ponds (DSW, 2007).
- The lower water layers will likely develop reducing conditions that will result in the release of hydrogen sulfide (H_2S). The hydrogen sulfide will increase the solubility and concentration of trace metals in the Dead Sea water and blanket it with a malodorous toxic H_2S gas (FoEME, 2007).

- The inflow of Red Sea water could introduce oil and petroleum pollution, as well as micro-elements and other contaminants that are not found currently in the Dead Sea. These, together with the chemical additives used to pretreat this seawater prior to its use as feed in the desalination plant and discharged with its brine will adversely affect the purity of the chemicals produced from the Dead Sea (DSW, 2007).

Many of the speakers present also pointed to alternative schemes, including rehabilitating the Jordan River and a Med–Dead conduit. The Jordan River alternative would involve stopping or limiting the diversion of water from the Sea of Galilee water to Israel through the Israeli National Carrier. This water would then resume its natural flow down the Jordan River to the Dead Sea, revitalizing en route the section of the River connecting the two Seas. To compensate for the loss of this potable water supply to the Israeli water system, new large seawater desalination plants would be constructed along the Mediterranean Sea (FoEME, 2007; SNIASST, 2007). The Med–Dead alternative looks like a smaller and less regionally cooperative project than the Red–Dead. It would replenish the Dead Sea with Mediterranean Sea water through several alternative routes and desalination schemes (SNIASST, 2007).

If the World Bank's representatives were surprised and/or frustrated by the strong opposition to the Project exhibited at the Neve Ilan public meeting, they didn't show it publicly. They certainly had every reason to be frustrated: They had already redefined the Project (in the Overview Section of the Study Program's Terms of Reference [TOR]) from an *economic* project – meant primarily to take advantage of and utilize the potential energy difference between the two Seas to generate power and/or desalinated water (while restoring the rapidly decreasing Dead Sea water level) – into an *environmental* "Saving the Dead Sea" project, with potential ancillary water and power supply benefits (WB, 2005). Furthermore, they had also given the ecological issues of the Project independence and extra weight by separating them, along with the social aspects of the Project, from the main technical and economic feasibility study, and providing them with a separate, detailed TOR, which calls for a comprehensive and critical review by a different, specialized team of experts. This shift in emphasis was well placed, but, as shown in Neve Ilan, it was insufficient. Also, the Bank's response to the call for examining alternative schemes turned out to be inadequate and unconvincing.

4. Greening the Project: Improving its Performance and Acceptance

It is the contention of this paper that to win all the nay-sayers support or even only acquiescence, it will be necessary to go *further* and present the Project not only as a "Saving the Dead Sea" project with potential positive implications to the Sea and the stakeholders that surround it in comparison to the "no action alternative" and all the alternative schemes promoted by the critics, but as a *comprehensive environmental project* that will have profound positive ecological and economic benefits to *all* stakeholders, including those along the route of the water conveyance system and even those north of the Dead Sea.

Right now, even after the shift in emphasis in the 2005 TOR, the goals of Project's environmental and social feasibility study appear defensive, trying mainly to identify, address and find ways to mitigate risks, e.g. how to minimize damage to the coral reefs in the Gulf of Aqaba/Eilat, how to minimize the risks of leakage and contamination of the ground water along the Wadi Araba, etc. For the Project to succeed in winning the hearts and minds of all its current opponents, its designers and feasibility assessors must take an imaginative and creative approach and, besides performing all the tasks listed in the World Bank's TOR, suggest and examine several new, bold yet practical ideas and elements that have the potential to enhance the ecological, economic and social dimensions of the Project. In other words, as the title of this paper suggests, they must "green" the Project further.

To do this, the environmental and social issues will have to lead rather than follow the Project's goals and resultant systems designs. The conventional thinking and practice ("wisdom") is that environmental assessments and impact analyses should commence only when a project's design has been optimized and finalized on the basis of a value analysis and cost–benefit studies. However, just like in modern reliability engineering practice, where reliability considerations do not wait for the system's design to be established on the basis of desired performance figures and cost–benefit analyses, and then, through a design review, changes are introduced to improve reliability, it is my opinion that dealing with the environmental issues should not be postponed until the Project's design is finalized, but, from the start, be an integral and critical part of the design process.

The Harza JRV Group's design can be significantly improved, both economically and environmentally. The new ideas and elements that should be considered in the new World Bank Study include:

(a) Applying Nanofiltration (NF) on part of the seawater at a site alongside its Red Sea intake point in order to soften the total conveyed seawater stream and to remove various contaminants

(b) Designing the seawater intake system so that it will maximize the removal of pollutants of concern from Red Sea, transforming the act of seawater extraction from a cause of concern to a positive clean-up operation with ecological benefits to the gulf of Aqaba

(c) Increasing the social and economic benefits to the settlements along the Wadi Araba/Arava through enhancement of tourist projects

(d) Splitting and relocating the desalination plant(s) and generating hydro-electric power during peak power demand periods

(e) Taking advantage of the Dead Sea's clean solar energy potential and utilizing the Project's resultant density stratification to create salinity gradient solar ponds for both power and desalinated water generation

(f) Introducing the brine derived from the desalination plants at the northern end of the Dead Sea

(g) Expanding the Project to include the rehabilitation and revitalization of the Jordan River through a minimal flow of Sea of Galilee water, without it reaching the Dead Sea

4.1. PRETREATMENT OF RED SEA WATER WITH NANOFILTRATION (NF)

Nanofiltration (NF) is a membrane desalination process that utilizes membranes with a higher molecular weight cut-off point than brackish water and seawater reverse osmosis (BWRO and SWRO) membranes. The NF membranes reject bivalent elements, such as calcium, magnesium, sulfates, almost as well as BWRO and SWRO membranes, but to a much lesser extent mono-valent ions, such as sodium and chloride (the rejection figures for the better NF membranes are 98% for sulfate ions, 85–90% for calcium and 94–98% for magnesium). They will also block the passage of heavy metals, nutrients and other contaminants.

NF has therefore been used often, particularly in the USA (Florida), on hard and contaminated groundwater, to soften municipal water supplies and/or to remove organic and inorganic contaminants, such as tri-halo-methanes, heavy metals, color, etc. Recently it has also gained favor, particularly in Saudi Arabia, Kuwait and the Emirates, as pretreatment to seawater desalination plants with difficult (i.e. contaminated) feed water and/or where long seawater intake lines are required – essentially, where the costs of supplying the seawater feed to the plants are relatively high. In these plants, the NF pretreatment of *only a fraction of the feed* (the exact fraction has to be optimized) has removed 96–98% of this fraction's total hardness and reduced its TDS by 55–65%. The resultant blended seawater feed has enabled the desalination plants, both thermal and membrane (SWRO), to operate at considerably higher conversion ratios, up to 65% compared to 40–45%, with no operational and maintenance problems and considerable savings in antiscalant chemicals' costs.

The RSDS Water Conveyance Project could certainly qualify as potentially the longest and most expensive raw water supply system to any inland desalination plant site worldwide. The cost figures developed by the Harza JRV Group for the investment in the seawater conveyance system to the desalination plant (including the intake sub-system, contingencies and engineering and administration) were $1.66 billion in 1996 prices, and about $2.28 billion if the cost escalations during construction are taking into account. These escalation calculations were based on a 3% per annum inflation rate, and if we assume that this rate has continued during the 11 years since they were made (a conservative assumption considering the 50% depreciation of the US dollar since 1997), then today's seawater conveyance system costs, in dollar terms, should be at least a third higher, or on the order of $3 billion.

Using the Harza JRV Group's capital discount rate of 8% and 40 year Project lifetime (i.e. a 0.08386 capital recovery factor), the capital cost component of the total seawater delivery cost to the desalination plant's battery limits should be today about 13.7 cents/m^3 of seawater. Pumping energy costs, at 830 GWh/year and today's electric power cost of 8–9 cents/KWh, will be in the range of 3.6–4.0 cents/m^3. Other conveyance system operating costs, at 2.5% of the capital cost of the conveyance system per year, should add about 4 cents/m^3, for a total of about 21.5 cents/m^3.

The Harza JRV Group's study established the seawater optimal conveyance flow rate (60 m^3/s, or about 1.86 billion cubic meters per year) and the resulting sizes and costs of all the Project's works and items of equipment based on an optimization process and various design concepts and assumptions. Based on a conventional and conservative recovery ratio of 45%, 851 million cubic meters per year of desalinated water could be produced from this seawater feed. A second option that increases the recovery ratio of this same desalination plant to, say, 65%, will enable either allow for downsizing of the project, or for more production of water (about 1,225 million cubic meters per year).

Both options will reduce the rates of flow of seawater and/or desalination plant brine into the Dead Sea, thereby slowing the pace of water level restoration. They will also slow the pace of Dead Sea water dilution and its effects on the chemical industries. In any case, these industries prefer restoring the Dead Sea's level to only −407 m, rather than to the Harza JRV Group's Study's target level of −395 m.

The Harza JRV Group's Study projected (on the basis of the Dead Sea level, surface area, density, evaporation rate, chemical industries water withdrawal rate and other parameters that existed at the time [1995], and an algorithm developed by it) that with a seawater abstraction of 60 m^3/s and a 45% desalination plant conversion ratio (its base design), i.e. a brine inflow to the Dead Sea of 1,040 million cubic meters per year, the sea's level will rise by about 16 m after 40 years of Project operation.

On the basis of the same study algorithm and data, if we maintain the seawater flow and conveyance system size but increase the desalination plant's recovery ratio to 65% (the second option), the situation will be more or less

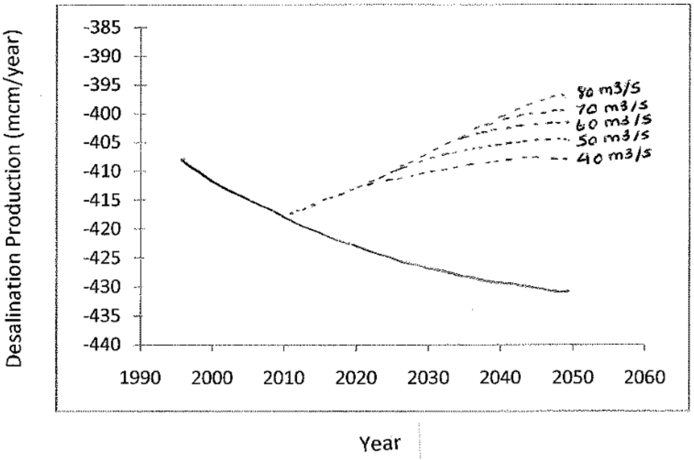

Figure 1. Dead sea filling regime (base case scenario assuming viable groundwater inflow into the Dead Sea). Based on data from Exhibit 7-2 in the Harza Group's study (Harza, 1998)

equivalent to a project with only a 40 m^3/s seawater abstraction rate and a 45% recovery, i.e. an inflow of about 660 million cubic meters per year. As can be seen from Figure 1, the sea level in this case will rise by about 9 m in 40 years.

However, since it is probable that the full desalination plant's capacity with this second option, 1,225 million cubic meters per year, will be built up in stages, to meet the developing demand, there will be an initial stage where excess seawater, and not only desalination plants brine, will be introduced into the Dead Sea, raising its level at a much faster rate. The 660 million cubic meters per year of brine rejected from the desalination plants when they reach their final, full capacity, will then be sufficient to raise the Sea level to its final desired level within a reasonable time and to maintain it there, by matching the steady-state rate of surface evaporation.

Reducing the size of the conveyance system so that the same amount of desalinated water is generated at a 65% conversion ratio from only 40 m^3/s of abstracted seawater (the first option) will result in only about 440 million cubic meters per year of brine entering the Dead Sea. This is well below the minimal quantity of inflow required, according to the Study, to avoid a further drop in the level of the sea, let alone raise it to the target level.

For this reason, and also since the water shortages in all three beneficiary entities – Jordan, Israel and the Palestinian Authority – have only increased since the Study was made, i.e. more desalinated water from the Project would be welcome, the second option (or may be an option with even higher rates of flow) should be chosen.

Using the above developed seawater supply cost figure (21.5 cents/m^3) to quantify the benefits of the increased recovery ratio, we see that, at 45% recovery, 2.2 m^3 of seawater feed are required per 1 m^3 of desalinated water compared to only 1.5 m^3 at 65% recovery. At 45% recovery, therefore, the seawater supply adds 47.8 cents to cost each cubic meters of desalinated water, compared to only 33.1 cents at 65% recovery, a saving of 14.7 cents/m^3. The cost of the NF treatment per 1 m^3 of desalinated water will depend on the fraction of the feed that will be pretreated, but we can estimate it. The cost per cubic meters of seawater filtrate (at, say, 70% NF system recovery) should be on the order of 25–30 cents, and if, say, 30% of the seawater is treated, the cost of the softer and lower salinity feed to the desalination plant will be increased by 7.5–9 cents/1 m^3, and the cost of the desalinated water (at 65% recovery ratio) will increase by 11.5–13.8 cents/1 m^3. The net savings will be 0.9–2.2 cents/1 m^3 of desalinated water or, for 1,225 million cubic meters per year, $11–27 million annually.

Nanofiltration will also bring a host of additional benefits. Firstly, the softening of the conveyed seawater will decrease the quantities of sulfate introduced into the Dead Sea and the precipitation of Gypsum, which could result in “whitening”. It will also eliminate the need to add polyphosphate based anti-scaling chemicals to the desalination plant’s feed. These normally contribute 1–2 cents to the cost of each cubic meters of desalinated water. The annual savings, for 1,225 million cubic meters per year, would be $12–24 million. Equally important is the fact that the elimination of these additives will allay the fear that, as nutrients, they will induce algae and microbial blooming in the upper layers of the Dead Sea. At a 65% desalination plant recovery rate, the concentration of the brine which would be introduced into the Dead Sea from the 3.6% TDS feed and would form the top layer in any density stratification, will be higher, about 10.2% TDS instead of about 7.6% (from 4.2% feed). This will reduce both algae and bacterial growth and evaporation rates at the surface. The NF system will also reduce the concentration of organic matter and nutrients in the seawater delivered in the conveyance system. This will increase the effectiveness of its chlorination, thereby reducing marine organism growths on all conveyance structures and equipment and the risk of subsequent algae and bacteria blooms in the Dead Sea. Marine organism growth within seawater supply lines has always been a major problem for desalination plants utilizing open sea intake systems, with and without chlorination (both continuous and shock treatments). In Israel’s Ashkelon and Palmachim large SWRO plants, for example, this growth has led to the need to continuously carry out maintenance work on their seawater supply lines, including periodic scraping of pipe surfaces. The Harza JRV Group’s study ignored this potential but real problem, yet it exists nonetheless, and will have to be dealt with in the current World Bank study. Finally, the generation of higher concentration brine in the desalination plant, with lower levels of calcium, magnesium and sulfates, will improve the economics and purity of table salt production at the Dead Sea.

4.2. MODIFYING THE SEAWATER INTAKE

Whereas, normally, intakes to seawater desalination plants are situated in areas of minimal pollution, in order to protect the desalination plants and minimize their feed pre-treatment costs, I believe that the act of abstracting seawater for the Project could and should be transformed from a cause of concern to the ecology of the Eilat-Aqaba into a positive "cleaning up the Gulf" operation.

Therefore, he Study should opt, for a submerged intake system (with intake heads that include coarse filters to prevent suction of fish, algae and large floating objects; see Figure 2) for large seawater desalination plants rather than a surface configuration as typically utilized in large coastal power stations and as called for in the Harza JRV Group's design. Figure 3 depicts the surface intake system at one of Israel's Mediterranean Sea coast power stations. To put the Project's seawater abstraction rate in its proper proportions, it should be noted that this intake system provides 340,000 m^3/h of seawater coolant to the power station, i.e. almost 60% more than the Project's 60 m^3/s, or 216,000 m^3/h, abstraction rate. Some of these submerged intake points should be specifically be placed at sites where they will be able to suck up and withdraw as much pollution as possible (i.e. at the highest concentration point within any contaminant plume, as is done for contaminated groundwater pump and treat remediation). These sites should include not only known and identified day to day sources of pollution (ports, fish cages, etc.), but also likely, though random, potential oil spill locations, where skimming equipment could be used.

Figure 2. A submerged type of intake used to supply seawater feed to a desalination plant in Cyprus (Photograph courtesy of IDE Technologies)

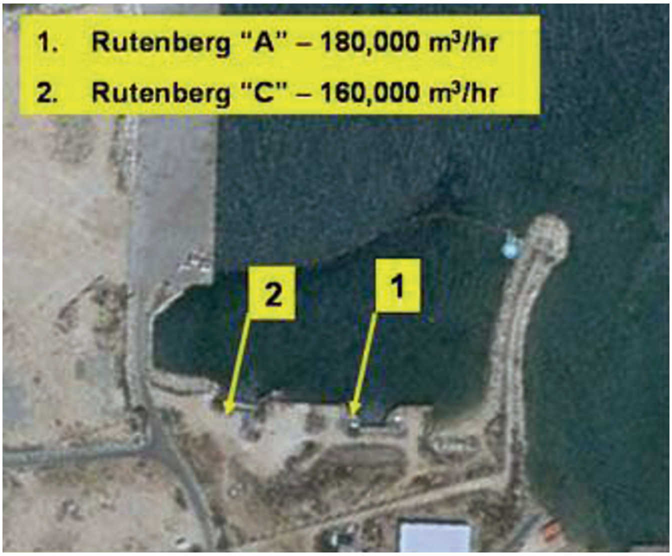

Figure 3. A satellite view of surface intakes delivering 60% more seawater coolant to a power station than the total Red Sea intake flow (Source: Google Earth)

This polluted stream would probably comprise only a small fraction of the total required seawater intake capacity and should be separated from the (non-polluted) balance of the seawater intake. The pollutants collected by it will be removed on shore, utilizing suitable facilities (beyond the minimal facilities envisaged in the Harza JRV Group's study), including sand filters and the NF system suggested above, and discharged to a suitable, approved disposal site (e.g. coastal infiltration basins, similar in design to the Soil Aquifer Treatment basins used in Israel to filter treated municipal effluents). The NF system would concentrate the polluted stream to 30% of its original volume, reducing the volume to be disposed of.

The Gulf seawater flow pattern resulting from the proposed layout of all submerged intake suction points will have to be modeled and optimized to benefit ecologically in the most cost-efficient and effective manner from the Project's total seawater abstraction. It should aim to change the Aqaba/Eilat area from being the dead-end of a long and narrow gulf that continuously collects and accumulates pollution from cargo ships, tourist activities and commercial aquaculture into a body of water that is continuously "vacuum-cleaned" to remove both suspended matter and stagnant water, which is replaced by a steady inflow of fresh seawater, as clean and clear as that enjoyed by tourists in their favorite Sinai Red Sea coast beaches.

If this clean-up concept proves feasible, i.e. its benefits (as well as the mitigating effect of reduced total seawater abstraction if the Project is down-scaled as a result of the NF scheme) will outweigh the added costs of the submerged intake system (vis-à-vis a surface intake system), it should be well-publicized by the World Bank and the Project's sponsors.

4.3. INCREASING THE BENEFITS TO THE ARABA/ARAVA VALLEY

The conveyance of the seawater through the Araba/Arava Valley should be treated and, more importantly, presented to the public not as something dictated by the need to "Save the Dead Sea", a necessary evil whose potential threats and risks to the current livelihood of the Valley's residents will be mitigated by the best possible engineering, but as an *opportunity* to develop the region and boost its economy. The residents of the Valley must be offered strong economic incentives to accept and support the Project, regardless of the risks that will, no doubt, remain even after all precautions have been taken and fault and failure events and consequences have been minimized.

The fact is that there is a strong potential market for new seaside and aquatic sports recreation sites by vacationers, locals and foreign tourists, from both Israel and Jordan. The two countries are currently short of free coastlines for such recreational activities. Jordan has only about 26.5 km of Red Sea coast and the Israeli Mediterranean and Sea of Galilee coasts are already overbuilt and cramped. The tens of thousands of Israeli tourists, who are eager for such recreation, far from the crowds and tumult of these limited stretches of beach, and who cross every year into Sinai, could and should be lured into closer, safer and equally attractive newly developed sites along the Valley.

To create these there must be some diversion of seawater from the main conveyance system along the Jordanian highlands to the Valley. Some of this water should also be desalinated locally, at various points along the Valley, to support the tourist population and its service personnel without drawing from and even supplementing the meager natural water resources which are utilized fully to support existing agriculture.

To allay fears that leakage and catastrophic events could contaminate the groundwater currently used for agriculture in the Valley, it would not be unrealistic to include in the Project provisions for installing, in a worse case scenario, a desalination plant that will be capable of supplying, at a significantly better quality, the entire 40–55 million cubic meters per year of groundwater currently in use. This quantity is less than 5% of the total Project desalinated water potential.

Jordan can allow this seawater diversion without detracting from its insistence that the main conveyance system, supplying the "raw material" for its vital new potable water source, lie, for security reasons, entirely within its borders. Most of the seawater will continue to flow in its territory and its own Valley citizens will also benefit from the diversion and its touristic projects.

Such projects will draw the residents of the Valley, on both sides of the border, as they did the agricultural settlements in the northern Jordan Valley, into the tourism trade, which is immensely more profitable than agriculture. One of the key attractions of the northern Jordan tourism trade is rafting. The Project might consider the seawater conveyance system as a means to sculpture lengthy and challenging rafting courses along the Wadi Araba that will compete with the best rafting courses in the world (e.g. the Colorado River in the U.S.) and make them a global attraction for all rafting lovers.

4.4. STAGING HYDROPOWER AND DESALINATION PLANTS

The hydrostatic height difference between the northern terminal point of the conveyance system and the Dead Sea should be used to generate electricity through hydraulic turbines at the Dead Sea level, rather than to provide an initial head for the reverse osmosis desalination process.

Furthermore, the Project's total desalinated water capacity should be broken up into two or more staged plants. This will allow the upstream plants to operate at lower conversion ratios and operating pressures, reducing total energy consumption. An overall recovery of 65% in one plant will anyway require its staging, for the sake of energy efficiency, since higher operating pressures than in a 45% recovery plant will be required.

The first plant should be sized to provide only the Jordanian share of the Project's total desalinated water output, and be located at the conveyance system terminal, near its planned pretreatment facilities. The Israeli and Palestinian shares of the desalinated water should be produced in separate downstream plants located on the western side of the international border, closer to their main product using population centers, and operated by their nationals. At the large desalinated water capacities envisaged for the Project, all plants will continue to benefit from economies of scale.

If the same formula for dividing the Project's total desalinated water output adopted in the Harza JRV Group's study, 60% to Jordan and 40% to the Israelis and Palestinians, will apply, the Jordanian desalination plant will be able to operate at a 39% recovery, producing 725 million cubic meters per year of product from 1.86 billion cubic meters per year of NF treated seawater feed and discharging about 1,135 million cubic meters per year of brine.

The Jordanian desalination plant will include operational seawater, product and discharge brine reservoirs. It, as well as the Israeli–Palestinian desalination plants, will be operated continuously, but their outputs will be maximized when low valley Time of Use (TOU) power tariff rates apply and reduced somewhat when high peak TOU tariffs apply. Likewise, the stored product will be pumped to its destinations as much as possible when valley TOU power tariff rates apply and the stored brine (and excess seawater if the desalination plants' capacities will be built up in stages) will be discharged through hydraulic turbines, located at the Dead Sea level, to generate electricity, only when peak TOU tariffs apply.

This will minimize the Project's energy costs, that, at today's fuel and energy costs (which are considerably higher than those when the Harza JRV Group's study and optimizations were carried out), will weigh heavier on the Project's profitability.

It will also simplify and reduce the size of the pressure shaft, tunnel and penstock in the Harza JRV Group's design, and, if the Israeli and Palestinian desalination plants are sited by the Dead Sea shore, somewhere between Hebron and Jerusalem, will shorten the pressurized fresh water supply pipelines to these cities, at the "expense" of a lower cost unlined, open canal along side or even within the Dead Sea, which will deliver the seawater by gravity to the plants, like the canal bringing Dead Sea water from the north to the Dead Sea Works evaporation ponds.

More importantly, as will be discussed shortly, this will enable utilizing clean, renewable solar-energy desalination, using salinity gradient solar ponds and low-temperature Multi Effect Distillation (LT-MED) plants, and introducing the brine into the Dead Sea at its northern end, thereby minimizing and postponing its effects on the chemicals producing industries.

The fresh water lines to Amman from the Jordanian desalination plant will, likewise, be shortened, and the added energy consumption of this plant, due to its not being assisted by the seawater's hydrostatic head as in the Harza JRV Group's selected location, will be compensated by the saving in its product pumping, from an elevation of +107 m rather than −365 m (using their Study's figures). This will allow for eliminating several of the nine pumping stations envisaged in the Study for the fresh water transmission line to Amman.

4.5. USING THE TWO SEAS' SALINITY DIFFERENCE TO CREATE SALINITY GRADIENT SOLAR PONDS

Further innovation lies in the use of salinity (and density) gradient solar ponds These trap solar energy by suppressing convection-induced mixing and heat dissipation at the surface, and generate a brine stream with temperatures as high as 95°C. Most importantly, they possess, by virtue of the heated pool's depth and volume, a heat capacitance that enables continuous operation also during nighttime and cloudy weather.

The salinity gradient ponds were developed commercially in the early 1980s. Several demonstration ponds were built and operated along side the Dead Sea and within it ("floating ponds"), where solar insolation values are high (1,900–2,100 kWh/m^2/year). The largest pond, with an area of 250,000 m^2, generated 2–2.5 MW of clean energy using a low temperature, Organic Rankine

Cycle (ORC) secondary fluid turbo-generator (See Figures 4 and 5). The project was suspended, however, since it was found that the generated electric energy was competitive with fossil fuel power only when the cost of oil was higher than $40/barrel, and the fuel costs at the time were considerably lower. Needless to say, fuel costs, even after taking into account the depreciation of the dollars, are considerably higher today and are expected to remain so throughout the life of the Project. Moreover, this $40/barrel economic breakeven point was calculated for ponds built along-side of the Dead Sea, where the laying of insulating and leak protecting double-layer plastic sheets was necessary. If the

Figure 4. The large solar pond and ORC station (Photograph courtesy of Ormat Industries Ltd.)

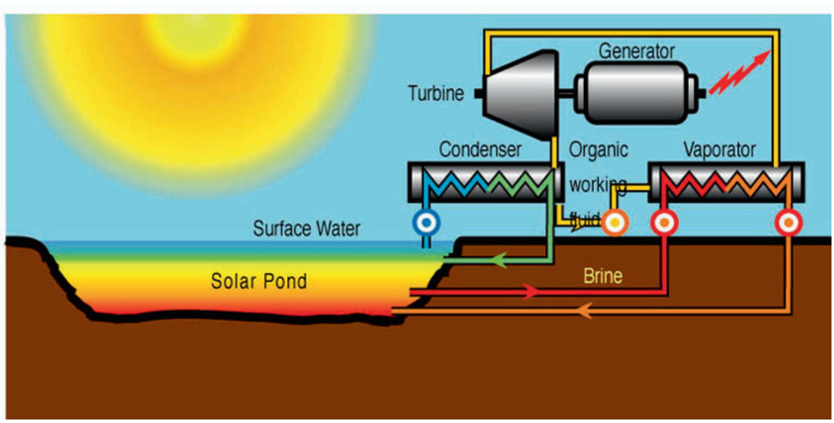

Figure 5. Schematic of a solar pond-driven ORC power plant (Image courtesy of Ormat Industries Ltd.)

ponds are built within the Dead Sea, on its shallow, currently exposed beds, it will be possible to save on this major investment cost. The ORC turbo-generators, which are the most efficient method of generating power from low grade heat sources, have been scaled up and improved efficiency-wise since the 1980s and today are used extensively throughout the world for geothermal energy production.

Another potential application for the 95°C heat generated by the salinity gradient solar ponds' hottest, highest density bottom layer is seawater desalination utilizing Low Temperature Multi-Effect Distillation (LT-MED) plants. These are the most efficient low grade heat input thermal seawater desalination plants in the world and recently larger scale single units have been developed. Figure 6 shows an early prototype test unit.

Figure 6. An LT-MED seawater desalination plant prototype (Photograph courtesy of IDE Technologies Ltd.)

In a study performed for the Israeli Ministry of Energy and Infrastructures (today the Ministry of National Infrastructures) and published in Desalination Journal (Hoffman, 1992), it was found that the cost of desalinated water from LT-MED plants utilizing solar pond generated heat was lower than the cost of any other solar desalination system and was competitive with the cost of desalinated water produced with energy from conventional fossil fuel power plants when the cost of oil was \$20–25/barrel (\$2.7–3.8/MBtu). More importantly, solar desalination using solar ponds was the only solar desalination system that could operate continuously (to minimize the fixed costs of desalinated water) including during night-times and cloudy periods, without fossil fuel backup.

With all other solar energy collectors (that do not have such a built-in heat storage capacitance) up to 65–77% of their energy inputs, if continuous operation is desired, are derived through fossil fuel firing – definitely not a totally "clean" process.

Also important is the fact that the designers of the solar ponds have developed techniques for dealing with the microbial blooming concern. Transparency is critical for the solar rays' penetration of the upper (lower salinity) layers to the heat accumulating higher density bottom layers. These techniques should be studied and adopted.

Similarly, other techniques developed for maintaining the integrity and effectiveness of the solar ponds, techniques that are relevant also to maintaining the stratification of Red Sea water and rejected desalination plant brine on top of the mineral rich Dead Sea water, should be examined and adopted. This stratification is important to both the Dead Sea Works and the Arab Potash Company in that it delays and minimizes the expected decline in Potash production rates due to the effects of introducing water with a lower concentration and a different composition of minerals into the Dead Sea.

The first of these techniques is one that reduces or eliminates mixing of the top, low-salinity gradient layers by wind-induced currents, waves and turbulence. Floating nets which attenuate and dampen these dynamics were developed for this purpose. They can calm the surface layers, and trap most of the solar energy within the lower, higher-salinity bottom layers, both making energy available for subsequent utilization, and considerably reducing the evaporation rates on pond surfaces.

The second technique involves drawing water from the hot bottom layer, recovering its heat for energy, and reintroducing it at an appropriate intermediate layer. Properly designed suction and discharge schemes and devices are critical to avoid turbulence and mixing that would destroy the sensitive temperature and salinity gradients in the pond. Needless to say, these techniques are also critical in drawing undisturbed mineral-rich bottom layers for the production of Potash and other chemicals by the DSW and APC.

The solar ponds would be installed on the shallow north-western shores of the Dead Sea that have been extensively exposed due to the drop in sea level and the receding coastline (see Figure 7) and partially in the sea itself ("floating ponds"). Figure 8, which shows the Israeli and Jordanian Potash companies' evaporation ponds on the southern end of the Dead Sea, illustrates what the solar ponds at its northern end would look like.

Figure 7. The shallow coastal areas exposed by the sea level drop (Photograph courtesy of Gundi Shachal of Kibbutz Ein Gedi)

Figure 8. The potash companies' solar evaporation ponds (Photograph courtesy of Gundi Shachal of Kibbutz Ein Gedi)

4.6. DISCHARGING BRINE AT THE DEAD SEA'S NORTHERN END

According to the Harza JRV Group's design, the Red Sea water, prior to and/or after its desalination by a Reverse Osmosis plant, would be introduced into the Dead Sea at its southern edge (or just north of the chemical-producing evaporation ponds) via the Truce Line Canal. If the Israeli and Palestinian desalination plants (including any thermal desalination units operating on heat derived from the above-noted salinity gradient solar ponds scheme) are located along the northwestern shores of the Dead Sea near the population centers that will benefit from their desalinated water, it will be possible to have their brine discharged either to the salinity gradient solar ponds or directly into the Sea via relatively short open canals much further north. Such northern points of entry, as requested by the Dead Sea Works, will delay and minimize effects on the economically important chemicals production.

4.7. EXPANDING THE PROJECT TO REHABILITATE THE JORDAN RIVER

The proponents of "the Jordan River Alternative" are the most vocal opponents of the RSDS Water Conveyance Project. To neutralize their criticism, I propose examining and possibly including, as an annex to or as an integral part of the Project, a miniature scale version of this scheme that will achieve the same ecological benefits for the Jordan River and Valley, without the loss of 400–500 million cubic meters per year of valuable fresh water. A loss of this magnitude would require an equivalent increase in the scale of seawater desalination along the Mediterranean Sea, at an incomprehensible annual cost of $260–350 million (a Present Value of $5.2–7.0 billion over 40 years at 4% interest), and the increase of air pollution from the 180–230 MW fossil-fuelled power plants providing the energy required for this desalination.

Under the proposed alternative scheme, an additional, but still relatively small amount of Sea of Galilee water, the minimum required to rehabilitate and revitalize the Jordan River, will be released and allowed to flow through it southward. This water, however, will not be released into the Dead Sea and lost, but will be dammed at the northern end of the Sea and diverted, perhaps also at several other points downstream of the Sea of Galilee, for irrigation (both agricultural and landscaping) and other economic development projects (e.g. tourism). If the quality of this water will be compromised by other (current) discharges upstream it will be used for domestic and tourist consumers only after pretreatment by gravity, micro or ultra filtration, as warranted. The salinity of this water can, in any case, be reduced by blending with high purity product from the nearby seawater desalination plants, avoiding the need for additional brackish water desalination plants.

This scheme is not meant to and will not raise the Dead Sea's water level (this will be done by the Red Sea water, through the RSDS Water Conveyance Project), but to provide all the *other* features and benefits claimed by the Jordan River Alternative. Israel will be compensated for the reduction in flow through the National Water Carrier by additional desalinated seawater.

5. Conclusion

To summarize, this paper proposes to modify and expand the Red Sea to Dead Sea Water Conveyance Project, as envisaged by the Harza JRV Group, and to transform it from a "Save the Dead Sea" project into a larger Jordan Rift Valley project that will be environmentally superior and will expand its benefits to all the stakeholders from the Sea of Galilee to the Gulf of Aqaba/Eilat. The new ideas and elements that are proposed in order to improve the Project's economics and make it more acceptable ecologically include:

1. Changing the composition of the Red Sea water at its source (reducing the levels of sulfates, contaminants and nutrients) so as to make it more acceptable ecologically and commercially (to the chemicals producing industries) for mixing with the Dead Sea water.
2. Increasing the amount of desalinated water that can be produced with the same amount of seawater abstraction and conveyance by 30%.
3. Using the abstraction of this water to remove excess nutrients and accumulations of pollutants from the Gulf of Aqaba/Eilat.
4. Diverting some of the conveyed seawater to the Araba/Arava Valley and utilizing it to create large-scale recreational and aquatic tourist attractions.
5. Desalinating some of this diverted seawater also at one or more points along the Araba/Arava Valley, to support these new activities and economic development, in general, including making up for any loss of ground water resources that may result due to leakage or catastrophic events, thereby assuring the continuation the Valley's current hi-tech agriculture.
6. Reducing the Project's energy costs by dividing its total desalinating capacity into several plants that will operate in series. The first plant, which will be situated at the higher elevation terminal conveyance point, above the Dead Sea, will provide only Jordan's share of the water and will include seawater and brine storage capacity. It will be operated in a regime which would minimize its output and electric energy consumption and maximize electric power production from the brine and excess seawater passing through a hydro-electric turbine located at the Dead Sea's level, when high peak demand Time of Use (TOU) tariffs apply, and increase its output when low valley TOU tariffs apply. This location and operating regime will also reduce the costs of the product delivery system and product pumping energy to Amman (shorter high pressure lines, less pumping stations and maximum use of valley TOU tariffs).
7. Locating the downstream desalination plants which will supply the Israeli and Palestinian shares of the Project's water output at the northwestern shores of the Dead Sea, nearer to the population centers which will be served by this water (Hebron and Jerusalem). This will shorten and reduce

the costs of their high-pressure product transmission pipelines. The plants will be operated by Israeli and Palestinian nationals in a regime that, like the Jordanian plant, benefits from the existing TOU tariff structure.

8. Including within these desalination plants not only electricity consuming reverse osmosis units but, in a hybrid scheme, also high-efficiency, low-temperature thermal desalination units that will derive their energy from nearby salinity gradient solar ponds. The northern entry of these plants' brine into the Dead Sea will postpone and reduce the Project's effects on the chemicals industries in the north.
9. Utilizing the salinity gradient solar ponds to generate heat not only for the thermal desalination plants but also for generating electricity, mostly during peak power demand hours, by Organic Rankine Cycle power plants.
10. Achieving all the features and benefits claimed by the Jordan River Alternative, without paying for them through the loss (to the Dead Sea) of large quantities of fresh water, by releasing a relatively small amount of Sea of Galilee water into the Jordan River, as required to revitalize the Jordan Valley. This water will be dammed at the northern end of the Sea and used there for agricultural and landscaping irrigation and other economic development projects. Israel will be compensated for this water, on a one for one basis or by a larger share of desalinated water.

Even if only some of these proposals are adopted, they will help overcome the objections raised by the Project's opponents and their benefits will contribute decisively to turning the whole Jordan Rift Valley into a valley of peace, cooperation and prosperity.

References

FoEME, 2007. An Analysis of the Latest Research Commissioned by EcoPeace – FoEME on the Red Sea to Dead Sea Conduit and Its Relevance to the World Bank Led Study. Friends of the Earth Middle East (FoEME), May.

DSW, 2007. *The Possible Impact of the Red–Dead Water Conveyance Project on the Dead Sea Industry*. Dead Sea Works Ltd. (DSW), 2 September.

Harza JRV, 1998. *Jordan Rift Valley Integrated Development Study – Red Sea Dead Sea Canal Project Prefeasibility Report*. Prepared for The Jordan Rift Valley Steering Committee of the Trilateral Economic Committee by the Harza JRV Group, February.

Hoffman, D., 1992. *The application of solar energy for large-scale seawater desalination*. ADAN Technical & Economic Services Ltd., a study performed under Contract No. 75.05.02.01 of the Israel Ministry of Energy and Infrastructure and published in *Desalination*. 89: 115–184.

SNIASST, 2007. *Reclaiming the Dead Sea – Alternatives for Action*. Samuel Neaman Institute for Advanced Studies in Science and Technology (SNIASST), August.

World Bank, 2005. Red Sea–Dead Sea Water Conveyance Project, Feasibility Study Terms of Reference. World Bank (WB). 19 April.

THE "PEACE CANAL ON THE GOLAN" PROPOSAL: BENEFITS AND RISKS TO REGIONAL WATER COOPERATION IN THE MIDDLE EAST

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Abstract: Peace and water are interlinked existential variables in very short supply in the Middle East. 'The Peace Canal on the Golan Heights Plan' (1991) welds these two variables together in a project that provides mechanisms for peace and confidence-building measures, additional water supplies to the countries sharing the Jordan River watershed (excluding Lebanon) and a way to restore the Sea of Galilee, Jordan River and Dead Sea with potable water. Other alternatives to augment the regional water supplies and save the Dead Sea do not show the same promise. For example, the proposed Red–Dead conduit project is likely to cause irreversible damage to the chemical composition of the Dead Sea, and desalination projects on the Mediterranean coast are insufficient to make the required regional impact due to high cost of water, economic and geographic disparities among the parties and the severity of the regional water crisis. The Peace Canal plan is a win–win, conflict resolution proposal designed to address both the regional water scarcity problem and support the attainment of an Israeli–Syrian and Israeli–Palestinian peace agreements. This chapter describes: (1) the Peace Canal Plan, (2) the history of the Plan in a political and hydrological context, (3) The positions of the parties on Turkish water exports to the M.E and their feedback on the Plan, and (4) the risks and benefits of the Plan.

Keywords: Water; peace; the Peace Canal on the Golan Heights Plan ("the Peace Canal Plan" or "the Plan"); Turkey; Syria; Israel; Jordan, Palestinian Authority; water imports; regional water plan

1. Overview of the Proposed Peace Canal Plan

The Peace Canal Plan was initially conceived and formulated after the Madrid Peace Conference (1991) by Boaz Wachtel, an autodidactic Israeli water expert,

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later affiliated with Freedom House.[1] The original author's version has since been modified to include constructive feedback from the relevant parties, most notably from the Turkish government.

The revised 'Plan' is relevant now as ever. Its aim is multifold:

- Help Syria and Israel sign a simultaneous peace and water agreement with additional water from Turkey, backed by international guarantees.
- Stabilize and increase water inventories in northern Jordan, western Syria, Israel and Palestine (the project does not include Lebanon).
- Produce hydroelectric power on the slopes of the Heights.
- Restore the Sea of Galilee, Jordan River and the Dead Sea's past qualities.
- Facilitate a safe Israeli withdrawal from and the demilitarization of the Golan Heights.
- Influence the Israeli public to support a Syrian–Israeli peace/water agreement.
- Create and sustain regional, transboundary water and economic cooperation to support and preserve peace and hydrological stability.

The "Peace Canal Plan" is based on the purchase from Turkey of about 3–4 billion cubic meters (BCM) of water per year for an even and flexible distribution between Syria, Jordan, Israel and the Palestinian Authority.

The water would be diverted from the Ceyhan and Seyhan rivers, then distributed (about 500 million cubic meters [MCM] per year) via western Syria in two underground pipelines and closed canals between each of the buying parties (Figure 1).

In Syria, the water could be used in western cities that lack adequate water of good quality, as well as on the Golan Heights, where Syria plans to resettle thousands of people following peace. The Jordanian share could be pumped from the canal on the Golan Heights to cities on the elevated Jordanian plateau and for agricultural and domestic use in the Jordan Valley. Israeli and Palestinian shares could be used to recharge the Coastal, Mountain and Gaza aquifers and support an equitable water sharing agreement. Additional quantity of water (about 1.6 BCM/year for 20 years and 1.2 BCM/year thereafter) could be purchased from Turkey by the Israeli/Jordanian governments and Potash industries and conveyed through the Peace Canal to revitalize the Jordan River and slow the rapid decline of the Dead Sea level with potable water. The water is also designated to foster more Palestinian/Israeli/Jordanian agricultural production in the Jordan Valley.

[1] Freedom House is a US-based international NGO that conducts research and advocacy on democracy, political freedom and human rights. See website www.freedomhouse.org.

The Peace Canal Project is also designed to produce a few dozen megawatts of hydroelectricity on the western and southern slopes of the Golan Heights that would offset the energy required to convey the water over 700 km. Estimates suggest that the project would indeed be self sufficient, and excess power generated would be distributed among the parties.

The section of the project that runs 40 km north–south along the current Syrian–Israeli border on the Heights should be built as a wide and deep open water canal (Figure 2). This canal would have 2 adjunct smaller canals, one on either side to allow the continuity of the water flow while performing maintenance on the main canal. The main canal could serve as a shared reservoir for the Syrians and Jordanians on the Golan Heights and as a pumped storage reservoir vis-à-vis the Sea of Galilee, used in electricity production during peak and off-peak hours.

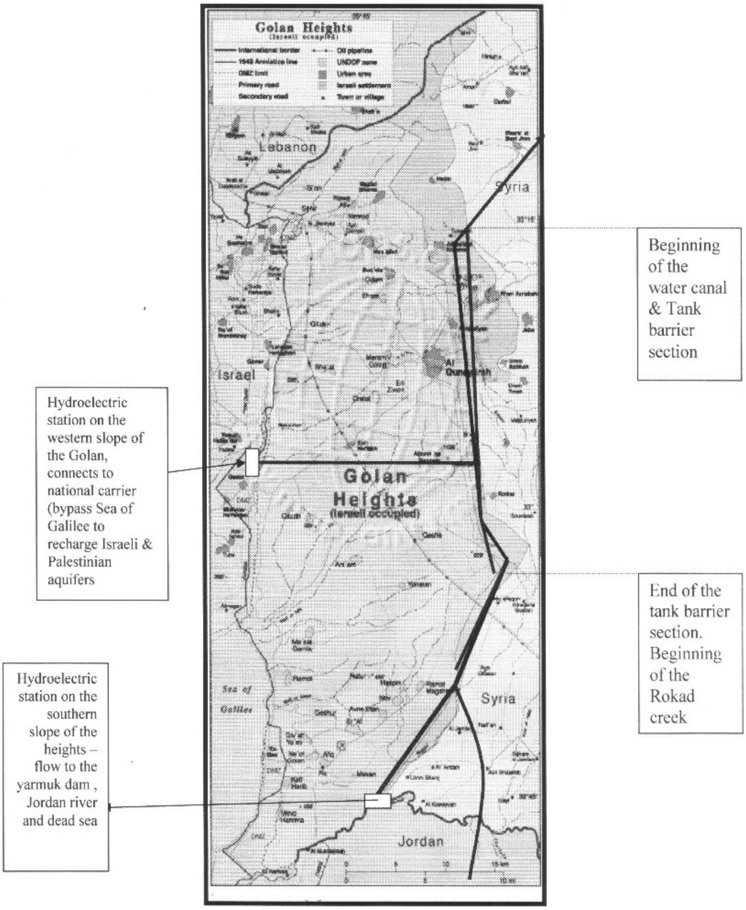

Figure 1. Map of Proposed Peace Canal on the Golan Heights

Additional benefit of the canals is that they could also serve as a tank barrier to deter and delay surprise armored attacks from either side into a future demilitarized Golan Heights and help reduce Israeli public resistance to a military withdrawal from the Golan. Together, these elements add water, energy and physical security for all parties without infringing upon the territorial integrity or the water inventory of either side.

The project could be constructed within 3–4 years with standard technologies, using local firms, materials and labor from each country, as well as private or international institutional capital (Hydroelectric stations will be bought from or donated by donor countries). The project requires G8 countries and International (UN) guarantees to provide the necessary level of security for the parties. Due to the large economies of scale and the self production of energy needed to transfer the water from Turkey to recipients, the price per centimeter for final users is estimated at under $0.60.

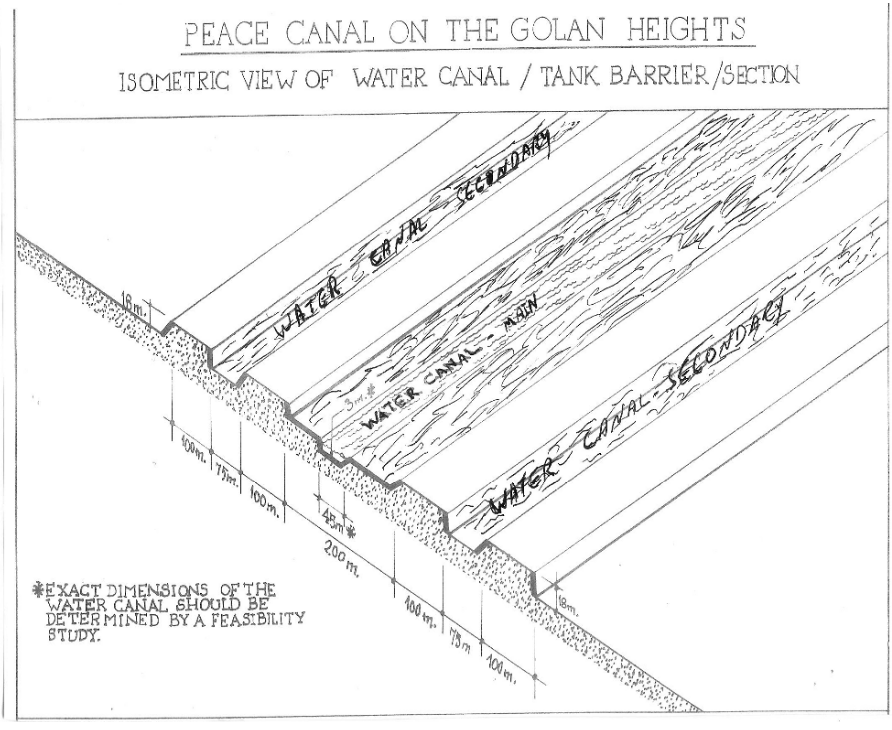

Figure 2. Water Canal on current Syrian–Israeli border

2. The Peace Canal Plan: Historical Background

The Peace Canal Plan was conceived after the October 1991 Madrid Peace Conference with the realization that, without a large additional quantity of water produced or delivered to Jordan River Basin countries, stability of current and future hydrological and political agreements is in grave danger. It became obvious that the regional water problem requires a regional solution. The period of study and analysis that followed reviewed existing options to relieve Middle Eastern water scarcity and reverse the damage to the rapidly declining Dead Sea and Jordan River. The conclusion was that no one option was enough to address the problem on a regional scale, but rather that multiple, coordinated water use efficiency, management and augmentation approaches were necessary to make a regional impact. It also became evident that Turkey held the key for a regional impact for two reasons. Firstly, it enjoys water surplus in the south central part of the country. Secondly, it expressed the political will to export some of that surplus to the Middle East.

After the Peace Canal Plan was put into writing, various respected figures were contacted for initial response. The Office of the Former US President Carter responded, saying: "The idea is unique since it combines alternative solutions to the problem of water with security considerations" (Mitchell, 1992). Later, Wachtel published a series of articles describing the project in US, Israeli, and Turkish media (e.g. Wachtel, 1991a, b, 1992a, b). In the following years, he presented the Peace Canal Initiative at various international water and conflict resolution conferences. In early 1992, Bruce McColm, Executive Director of Freedom House, invited the first author to work as a guest researcher. He stated: "Access to water is a basic human rights issue," and fully recognized the Plan's potential for enhancing human rights and conflict resolution in the Middle East.

In September of 1992, the United Nations sponsored a conflict-resolution conference among various NGOs in New York. The Peace Canal Plan was one of 13 proposed conflict resolution agendas selected for presentation from over 400 of those from NGOs in attendance. Consecutively, numerous meetings took place between a host of decision-makers, including the Jordanian Ambassador to the UN, Turkish officials in Washington and Ankara, officials from the Israeli Ministry of Agriculture and Foreign Affairs, Palestinian officials, and representatives from Middle East-related institutions in the US, including the State Department and the Middle East Institute. These efforts led the United States Senate Committee on Foreign Relations to add the following amendment to the 1993 US Foreign Operations, Export Financing and Related Programs Appropriation Bill:

> In addition, the Committee recommends that AID (Agency for International Development) and the Department of State, in conjunction with other appropriate U.S. and international agencies and institutions, review a series of innovative proposals to divert water from Turkey to the Middle East via a pipeline or through a series of canals and conduits running through the region. The Committee believes these ideas could both advance the Middle East peace process and bring new level of economic prosperity to depressed parts of the region.

In the end, however, the Committee of Appropriations did not include the amendment in the final bill for unknown reasons.

Sources, including the most senior Israeli negotiator to the talks suggest that these and other efforts led to the introduction by Israel of the Peace Canal Plan in the multilateral Syrian–Israeli peace negotiations on water in 1993.[2] A year and a half later, the Israeli Minister of Agriculture, Yaakov Zur, and the late Water Commissioner, Gideon Zur, ordered Mekorot (Israel's National Water Company) to start conducting a pre-feasibility study of the project. The work began in 1995, but Mekorot – a politically sensitive organization – stopped the study after a series of suicide bomb attacks in Israel in February of 1996 prompted Shimon Peres to halt talks with Syria. A few months later, when Likud came to power in Israel, all work on the Plan was halted under the assumption that this right wing political party would not withdraw from the Golan Heights.

With each new round of negotiations between Israel and Syria, and especially during December 1999, Wachtel tried to promote the Peace Canal Plan as an integrated water and peace plan, meeting with Turkish Ambassadors in Israel during this time. After Turkey agreed to act as a mediator in September of 2007, a senior Israeli politician contacted Wachtel and asked that the Plan be translated to Hebrew for distribution to members of the Knesset's Security and Foreign Relations Committee. Dr. Alon Liel – former Director General of the Israeli Foreign Ministry and the leader of track II (the unofficial and secret track of negotiations between Israel and Syria) – then handed the plan to the relevant negotiators and to the highest level Turkish officials.[3]

In 2008, *Syria Comment*, a website dedicated to promoting dialogue surrounding Syrian and regional issues, posted the Peace Canal Plan.[4] Reactions posted by Syrians were mostly favorable, but some took issue with the idea of a tank barrier on either side of the water canal on the Golan Heights. Some argued that this is a sign of distrust, especially after a peace agreement, and that the deep and wide water canal itself can serf as an obstacle for crossing over by armored vehicles.

Turkish reaction to the Peace Canal Plan followed a changing trajectory. Initially, when the Ataturk Barji Lake on the Euphrates in Turkey was proposed as an intelligent source that could use its 500+ m elevation for gravitational conveyance of the water to the Jordan River basin countries, the reception was interested but somewhat cool. Turkish officials and press pointed to the already

[2] Personal letter (1993) from Alon Pinkas at the Ministry of Foreign Affairs, reading: "The Peace Canal was passed on to the Director General of the Ministry of Foreign affairs to be handed over to the Israeli negotiators to be discussed/raised during the peace talks."

[3] Dr. Alon Liel handed over to the highest levels of the Turkish establishment the details of the "Peace Canal on the Golan Heights Plan" that was written by Boaz Wachtel. (Translated from Hebrew) http://www.is-peace.org/wnDispPage.asp?Item=433.

[4] Syria Comment - Blog discussion board: "The Peace Canal Plan – Peace plan/water import project from Turkey to the Middle East"; Saturday, March 22nd, 2008 http://joshualandis.com/blog/?p=638 (Accessed 23 March 2008).

excessive demands placed for Euphrates water by Syria and Iraq, emphasizing that additional commitment to provide water from the Euphrates to the Middle East countries was unacceptable. However, the initial plan had also proposed the Ceyhan and Seyhan rivers as fallback source options. Once the Euphrates option was dropped, Turks gradually warmed up to the plan. The Turkish Attaché in Jerusalem wrote to Wachtel: "we are in the belief that our authorities are interested in your project and would perhaps like to be in contact with you directly and/or through our office in Jerusalem" (Aaya, 1994). Meetings were held at the Turkish Foreign Ministry in Ankara in 1999, and DSI, the Turkish National Water Authority, invited the first author and the Technical Advisor Eng. Burton Most to tour the rivers for a briefing on local water use, future plans, water quality etc.

In 2008, the Turkish Ambassador to Israel pointed to the 'Infrastructure Corridor' or 'Med-Stream' as a competing proposal to the Peace Canal Plan. According to the Israeli Ministry of Infrastructure, it called for an undersea project, designed to deliver oil (20–50 million tons per year), natural gas (4–10 BCM/year), water (400–1,000 MCM/year), electricity (4,200 MW/year) and communication lines across 460 km, from a hub near the Seyhan River in south central Turkey to Haifa in Israel, at a cost of $2.5–4 billion (IMI, 2007).

The complexity of the project, partially stemming from the underwater pressure on pipes lying on sea bed at 800–900 m, technically limits the quantities of water that could be delivered to Israel and is therefore only marginally sufficient to stabilize the regional water inventory. It will have no direct impact on the rejuvenation of the Jordan River and the Dead Sea, but could have an indirect effect by substituting Sea of Galilee water pumped to the Israeli National Carrier with water from Turkey through the Med Stream, to allow the release of few hundred million cubic meters per year of water from the Sea of Galilee to the Jordan river and the Dead Sea. In the end, the idea is not sufficient to make the impact needed to save the drying Dead Sea or provide substantial quantities of water to Israel's neighbors. Free from any cross border political constraints, the project primarily adheres to Israeli water and some Far-East country's energy needs and neglect to address Palestinian and Jordanian hydrological crisis.

3. Views on Turkish Water Exports, Transboundary Cooperation in the Middle East and the Peace Canal on the Golan Heights Plan

Beyond the internal, multi-faceted impacts on societies and nature across the Middle East, water scarcity and climate change put quite a strain on the political and peace dynamics in the region. A former Israeli water commissioner and prominent expert, Meir Ben-Meir, alluded to this connection in an interview in Tel Aviv. "I cannot promise that sufficient water will prevent war," he said, "but poverty and scarcity of water will cause war – no doubt about that" (Cowell, 1989). In theory, the Peace Canal Plan works to heal this scarcity in a way that fair and beneficial for all stakeholders in the region. As Ben-Meir suggests, however, it is not a panacea for peace. This section describes the various points of view that have come from the parties involved in the Plan.

3.1. TURKEY'S POSITIONS

Turkey certainly possesses adequate quantities of water to export and reverse the negative hydrological and related political dynamics caused by water scarcity in the Middle East, and has expressed the political will to do so a number of times. From Turkey's perspective, however, Syria seems to be the major obstacle in the way of doing so. During the lengthy dispute on the water sharing of the Euphrates (until 1987) the Turkish Foreign Ministry described Syrian positions on Turkish water export in the following way:

> "Syrian officials maintain that the Peace Pipeline Project and other water selling schemes can be interpreted as a product of Turkey's dream of gaining a leadership position in the Middle East. Syria further argues that the secret ideal of Turkey is to dominate the countries of the region economically and politically by making them dependent on water. Besides, Turkey's effort to export water by pipeline, while not releasing a sufficient amount to its neighbors, is itself as a contradiction". (Turkey Ministry of Foreign Affairs, 1996)

Thus, in Turkish eyes, Syria seems to be using her geographic location, between Turkey's water and the rest of the Middle East, as a "blocking bargaining chip" to receive more water from Turkey. Syria understands very well that the proposed plan for overland water export through southern Syria is a financial and political panacea that could foster many positive dynamics both for Turkey and the Jordan River Basin countries. Syrian officials also know that all other technical delivery options for Turkish water exports, such as an underwater pipe between Turkey and Israel, or delivery by boats, cannot produce the same balanced and substantial regional impact on the water inventories of Jordan, Israel and Palestine. Essentially, Syria is fully aware of its integral role in the overall scheme, and the bargaining leverage it affords.

In the face of such hostile Syrian positions during the 1980s and later, Turkey set about developing alternative water resource export schemes. The first idea was to export water to Israel and other Mediterranean Sea countries via water tankers. To that end, Turkey invested $150 million to build the Manavgat water terminal to unload the water to tanker ships. At a rate of 50 million centimeters per year to Israel and a price tag of 16–18 cents/cm (Free On Board) Manavgat, the price at final destination, i.e. Israel, was close to a dollar (Gruen, 2007). At the time, the deal was considered far too expensive compared to alternatives like desalination, and faced considerable opposition in Israel. Then Finance Minister Benjamin Netanyahu was particularly adamant in his disapproval, but his stance was more likely based on right wing ideology, opposing the idea of Turkish water exports to Israel in any form. Furthermore, rising and fluctuating oil price seem to make the desalination option a substantially more expensive proposition than these proposed water imports.

While it is obvious that Turkey "owns the tap", so to speak, both on the Euphrates flow to Syria and on any future water export project to the Middle East, it is clear that Syria plays a crucial role in any effort to export water to the Middle East. From the geopolitical and Israeli water security points of view, it is reassuring that Turkey has a leverage over Syria (Euphrates flow) in order to "help" Syria keep it's future commitment to the safety of a Turkish water export project to the area. In that context, Turkey's former Foreign Minister, Hikmet Cetin said in 1994:

> "As part of the peace process, Turkey is prepared to supply water to Israel and its Arab neighbors from sources on the Southern coast of Anatolia, such as the Manavgat, Ceyhan and Seyhan Rivers." He doubted that "lasting peace between Israel and Syria, Jordan and the Palestinians could be achieved without the addition of Turkish water supplies". (Gruen, 2000)

The issue of Israel's water use from the Golan Heights after a withdrawal presents yet another water-related challenge in the negotiations. According to recent press report quoting Dr. Alon Liel of the Syrian–Israeli Peace Society, the Syrians see future Israeli water use from Golan sources (that now stands at approx. 300 MCM/year), after a withdrawal and peace agreement, as conditional upon greater allocation of water from Turkey and on international funding for a major desalination plant on the Syrian coast of the Mediterranean (Bendar, 2008). This marks the first time that the Syrians are directly tying the Israeli–Syrian water agreement to greater allocation of water from Turkey. A senior Turkish Diplomat (who wishes to remain anonymous) stated that Syria has not yet submitted a direct request for greater water allocation, but that Turkey will consider it once they do so (Personal verbal communication, 2008). However, a 2008 press report suggests that Turkey will not "open" the 1987 water sharing agreement between it and Syria to supply more water in the future to Syria from the Euphrates (AFP, 2008).

What could be inferred from the Turkish positions is that any future increase of Turkish water supply to Syria, in the context of a Syrian–Israeli peace agreement, could come as part of a regional water export project from Turkey to the Middle East (and not from the Euphrates). It is safe to assume that the amount of water Turkey would allocate to Syria would be similar to the amount of water used by Israel after a withdrawal from the Golan Heights (i.e. approximately 300 MCM/year). These facts support the hypothesis that the

Peace Canal on the Golan Heights project could satisfy the stated positions of the Syrian–Israeli–Turkish triangle and should be used to cement a simultaneous peace *and* water agreement between Israel, Syria and Turkey.

3.2. SYRIAN STANCE

Now may be the time for the hydrological chips fall in place. In 1994, after few rounds of talks with Israel, Dr. Nabil Saman (a Syrian expert for Middle East water) spoke with the London-based Arab newspaper Asharq Alawsad. He said: “The question of water: This question is even more important than the settlements issue and requires the involvement of regional and international players considering the large water needs of both sides.” When asked whether Israel would be willing to sacrifice its critical water supply from the Golan, Dr. Saman told the reporter that “Israel’s holding of the Golan stems from water needs and not security needs, and that its withdrawal is tied to agreements on water sharing and quota fixing.” He expressed his belief that Israel would not give up on this water. He said: “Israel received the principal of ‘land for peace’ and not ‘water for peace’…the Israeli efforts are based on the transfer of the problem to areas which most of them give an advantage, through offering suggestions like the Turkish Peace Pipeline. *Israel has already suggested during its talks with Syria the creation of a water barrier from north to south to prevent a possible Syrian advancement*” (Amid, 1994).

Here, Dr. Saman presents a Syrian interpretation of an Israeli stance and an important historical fact. First he pointed Israel seems to see the resolution of the Syrian–Israeli water issue [as] tied somehow to Turkish water, and maintains that this position or linkage may be advantageous to Israel. Second, he reveals that Israel has tossed the Peace Canal Plan onto the negotiation table before 1994. This could be inferred because the Peace Canal Plan is the only water export project from Turkey that incorporates a north–south water barrier along the current Syrian–Israeli border.

While some official Syrian statements expressed support for the idea of a Turkish water export project running through Syrian territory, they came with various conditions. Syrian Ambassador to Turkey Abd-Al-Aziz al Rifa’I stressed that “his country is not against Turkey’s selling water to Israel, but it prefers that Ankara play the water card in putting pressure on Israel to withdraw from Arab territories” (FBIS, 1994). Here, Ambassador Al Rifa, creates a clear linkage between Syria’s approval of Turkish water export plan to Israel and the return of the Golan Heights. This position was expressed during Hafez Al- Assad’s tenure, and continued to stand during the 2008 peace negotiations under his son, President Bashar Al-Assad.

3.3. ISRAELI POSITIONS

During the past 2 decades, Israeli officials were careful not to overstate Israel's desire to receive Turkish water through an over-land project via Syria, knowing full well that Syria might take advantage of the situation to make various demands. Nevertheless, senior officials did indeed make the connection between peace and water. The late Israeli Prime Minister, Izhak Rabin, said: "Turkey has abundant water. I believe in regional peace…The water in Turkey can be transported to Syria, Lebanon and Israel via pipelines. The problem at this stage consists of the impossibility to include Syria and Lebanon in such a reasonable project" (BBC radio, 1994). Major General (Ret.) Uri Sagi, the official Israeli representative to the negotiations with Syria, offered an insight on the importance of water issues during the 1999 negotiations, saying: "The water problem is the most important issue in the Syrian–Israeli peace negotiations. The security arrangements issue is a much lighter problem…The [water] problem cannot be solved independently of the Turkey, Syria and Israel triangle" (Haaretz, 1999).

The fact that Israel introduced the Peace Canal Plan during the Syrian Israeli multilateral talks during the early 1990s is very significant for the future of the peace negotiations between the two. The fact that the plan was introduced at this point is substantiated from two other sources. The first is Uri Nir's article in Ha'aretz' entitled "Israel will propose during the multilateral talks the construction of a water canal as a strategic barrier in the Golan" (Nir, 1993). The second is a US State Department document from 1992 revealing American positions on (and possible preferences toward) Turkish water export options to the Middle East. It lists only two land-based options to export water from Turkey to the Jordan River Basin countries: the Mini-Peace Pipeline and the Peace Canal Plan (US State Department, 1992). It may be that this State Department document gave Israel the confidence in a unified American and Israeli position to raise the Plan during the negotiations.

On May 26, 2008, the Israeli daily Maariv published an article entitled 'Pipeline at the end of the tunnel', which cited Dr Alon Liel, former director general of the Foreign Ministry and chairman of the Israel–Syria Peace Movement who has been involved in various peace initiatives between the states. It claimed that he "takes an enthusiastic view of the 'Golan Canal'," and he was quoted saying:

> It's an excellent idea that could be worked into peace settlements between Israel and Syria. Only recently, the Syrians officially told the Turks that they are prepared to let Israel continue to use the water sources on the Golan Heights after a withdrawal on condition that the Turks compensate them with water supplies and assistance in setting up desalination plants. I visited Turkey a few weeks ago, and I know from my talks with senior officials there that the subject

> is on the agenda. In question would be a significant increase in Turkey's water supply to Syria, and a Turkish readiness to sell us a large quantity of water as well.

The article said that, according to Dr Liel, the Golan Canal project will deepen Syria's involvement in the peace process and strengthen its foundations. "A few months ago, Boaz Wachtel presented the plan to me, and I suggested that he should pass it on to the Syrians to look at. I know that the plan reached Syrian hands, and that he received encouraging, unofficial responses from the Syrian side," he said (Bendar, 2008).

The article also cited Member of Knesset (MK) Hanegbi, the chairman of the Foreign Relations and Security Committee, as someone who supports the plan. He is quoted saying: "I received the document and studied it. I am not a water expert, but it is a very interesting plan, and I think that it needs to be looked at seriously." According to Hanegbi, a situation needs to be created in which peace is beneficial for both sides if the negotiations between Israel and Syria are to succeed. "The negotiations between Israel and Syria have failed 3 times in the past. If it transpires to the Syrians and Israelis that peace can also have economic benefits, it will reduce the chances of another failure" (Bendar, 2008).

Another voice in support for the Peace Canal Plan came from MK Roman Bronfman a few years before, when he spoke at a NATO conference 'Environmental Security and Environmental Regulations in Israel': He said:

> The final, and in my view, the most interesting solution is that of the Peace canal. This plan, drawn up by Mr. Boaz Wachtel, speaks of laying a 700 km canal from the Sihan and Jihan[5] rivers in Turkey to the region and thus supplying the water needs of Syria, Israel, Jordan, Palestine as well as solving the ever growing problem of the dropping level of the Dead Sea… It does, however, require reaching a peace agreement between Israel and Syria. (Bronfman, 2007: 81)

Israeli points of view regarding the Plan reflect a dilemma with regards to water security and political sustainability – on one hand Israel is acting unilaterally with desalination and other measures, but on the other hand, there is support and yearning for a steady supply of large quantities of water from Turkey if security of the flow can be assured. Senior Israeli decision makers are increasingly aware but reluctant to express that the only way to save the Dead Sea and the Jordan River and stabilize the Sea of Galilee is with potable water; the only source with sufficient quantities in the area is in Turkey.

[5] Refers to Seyhan and Ceyhan. Spelling error from pronunciation.

3.4. JORDANIAN POSITIONS

Professor George Gruen from Columbia University has dedicated much of his academic career to the analysis of water issues in the Middle East. He wrote: "Given the projected population growth and economic development, demand for water over the next 50 years in Israel, Jordan and Palestine will exceed supply, because demand is expected to reach 6.5 BCM/year while quantity of existing sources at that time is estimated to supply only 3 BCM/year. This means a severe water deficit that requires new water supplies" (Gruen, 2005). Another estimate by the University of Vienna, reads: "The projected supply, demand and deficit are as follows – despite the huge investment in the water sector, a considerable water deficit will still be facing Jordan. The water deficit for all uses is projected at 360 MCM/year in the year 2020" (UV, 2004). As a particularly water scarce nation in the Middle East, Jordan has an extremely limited ability to regulate its arid level water supplies between summers and winters and has been consistent in its support of the Turkish water export options. In 1993, Jordan's UN Ambassador Adnan Abu Odeh told Dr. Gruen that "Turkish supply of water is imperative to Israel, Palestine and Jordan" (Gruen, 2005).

In response to a letter from Wachtel, Crown Prince of the Hashemite Kingdom of Jordan, El Hassan Bin Talal, wrote back the following on July 12th, 1993:

> Thank you for your letter dated May 28th, 1993 in which you introduced the 'Peace Canal Plan'. The water issue is a very sensitive one, to which Jordan attaches great importance. To arrive at amicable short and long term solutions in this regard would, in our view, eliminate potential future disputes. Water issues should be considered as major component of a comprehensive peace package that would also include energy, environmental concerns and security aspects. A balanced approach that addresses the various demographic and economic needs is required. Innovative ideas are needed and welcome. We very much appreciate your keen interest in water issues in our area, and look forward to cooperating in any meaningful plan that would contribute to solidifying a peaceful settlement built on justice and fairness. (Crown Prince of Jordan, El Hassan Bin Talal, 1993)

On February 13, 1996, Jordan signed the Oslo Accord, agreeing to cooperate with Israel and the Palestinian Authority on many fronts, including water. Article 9.1 – "Declaration on Principles for Cooperation on Water-Related Matters and New and Additional Water Resources" – stipulates that the parties will study in order to determine their feasibility on "acquisition and import of water including the possibility of carrying such waters through existing or new supply systems." As a result of increased water stress on Jordan, King Abdullah visited Ankara during 2000 to discuss the various water import options from Turkey to the Middle East (Gruen, 2005). Jordan's support for water imports from Turkey has not diminished even slightly since. The severity of water scarcity in Jordan is such that it has no choice but to harness every available capacity. Professor Salameh of the University of Jordan explained: "We have to develop every drop…We can't look at just one aspect or one resource, every option deserves consideration" (de Chatel, 2007: 169). These facts point to a Jordanian commitment to work with its neighbors towards a regional solution to water scarcity, and specifically through water imports, most probably from Turkey.

3.5. PALESTINIAN POSITIONS

One of the most contentious issues in the Palestinian–Israeli peace negotiations is that of water allocation. The Palestinians demand a greater share of water from the aquifers under the West Bank, from which Israel currently pumps a substantial supply inside the Green-Line (pre-1967 borders). At the same time, Israel restricts Palestinian access to water under the occupied West Bank which has caused a severe water shortage among Palestinian farmers and city dwellers. Additional water from Turkey could help redistribute the trans-boundary water and provide more water to meet Palestinian demands, facilitating an easier compromise on the water sharing issue during the almost endless negotiations. In theory, additional water from any source could alleviate the security-driven competition for existing fresh water resources.

The Israel/Palestine Center for Research and information (IPCRI), an extremely influential Israeli–Palestinian bilateral cooperation organization, wrote the following in its landmark publication the 'Trilateral Confederation, A New Political Vision for Peace – The Just Way to Peaceful Co-Existence on Both Sides of the Jordan River':

> Another design that has captured much interest, proposed by the Israeli Boaz Wachtel, suggests building a waterway from Turkey to the Dead Sea, through Damascus and the Golan Heights. Such a waterway would provide an ample supply of water to Israel, Palestine, Jordan and Syria, and run through the Golan Heights, providing a buffer in case of a sudden Syrian tank attack against Israel. A comprehensive peace settlement with Syria and Lebanon would be necessary to implement such a proposal. As negotiations progress, we will be able to focus more attention on this proposal. (Hess, 1999)

In a recent statement sent to the authors by the Palestinian Negotiation Affairs Department, an updated position[6] based on Palestinian interest and experience was forwarded:

> The Palestinian Negotiations Affairs Department's position reflecting Palestinian interest in achieving a viable state is that the Palestinian's must secure its rightful share of all trans-boundary waters in accordance with customary international water law prior to or concomitant with any projects increasing the

[6] The following comment is not for personal attribution as it reflects a Palestinian position.

> overall supply among the Jordan River Basin riparian (Israel, Jordan, Lebanon, Palestine and Syria). Although the Palestinian side recognizes the importance of studying and developing new water proposals, there is a concern based on years of experience that Israel is likely to politically exploit any project which extends Israel's control over water supply to the Palestinians (i.e. Palestinian access to water sources and its ability to manage those water sources). The Palestinians recognize the opportunity in the Turkish water export idea for the region, but have witnessed numerous "cooperative" ventures where the Palestinians have received little or no benefit because of the impact of the occupation to diminish or expropriate any benefits. Nevertheless, the Peace Canal proposal deserves further consideration among other new water supply ideas to encourage the respective constituencies of the Jordan River Basin riparians that new supply creates the opportunity to reallocate existing trans-boundary freshwater in an equitable and reasonable manner by increasing the water pie.[7]

Much like Jordan, the severity of the water crisis in the occupied territories is such that Palestinians support the serious examination of realistic options to boost water supplies. Nevertheless, past events seem to have taught them to be suspicious.

4. Risks and Benefits of the Peace Canal Regional Water Project

The number one issue raised by the opposition to water exports from Turkey to the Jordan River basin countries is that of *dependency*. The idea, opponents say, that Israel, Jordan and the Palestinians will be reliant on Turkish water passing through Syria is a risky proposition, enough to reject the project altogether. The reality, however, is far more complicated than this simplistic, isolationistic, nationalistic view.

In fact, in the Middle East, as in some other places in the world, controlling territory does not necessarily mean controlling ones water resources. Most of Syria's water originates in Turkey. A third of Israel's water comes from the Golan, and another large portion from under the West Bank. Jordan is downstream from Syria along the Yarmouk River, which contributes a substantial amount to its national water supply. Clearly, water sharing across borders and entrenched interdependency is an existing fact. One could argue that changing the status quo unilaterally is, by itself, a cause for a new war. That said, it can be assumed that same logic could be applied to the Peace Canal on the Golan Heights.

Furthermore, no one side is expected to give up a drop of water as a condition to join the project. The added quantities are only boosting existing

[7] Statement by Palestinian Negotiations Affairs Department sent to author (Wachtel) on December 25th, 2008 via email.

inventories of each side. If Syria chooses to block the flow after an agreement is signed, it would be in clear contrast to its self interests, and the following could occur based on pre-determined contract:

- Syria would be cut off from its share from the Peace Canal Project.
- Turkey would be able to penalize Syria by reducing flow in the Euphrates.
- A possible casus belli with Israel (identical to an event disrupting the natural flow from the Golan after an Israeli withdrawal).
- The Arab League might impose sanctions in response to an act that hurts Arab brothers in Jordan and Palestine.

The agreement between the five countries involved in the Peace Canal Plan should clearly stipulate the automatic threat of international sanctions for those parties that infringe on the flow of water. Such international guarantees by the UN and G8 are crucial in keeping the parties' confidence level high while signing an agreement, especially as part of an Israeli–Syrian peace agreement. The same is true for Israeli–Palestinian agreement, also dependent on redistribution of water under the West Bank. Added water from Turkey that expands both the regional water pie and shares to each of the four recipients will boost the chances of reaching stable and lasting water and political agreements.

The key benefits of the Peace Canal Plan include:

- The facilitation of a peace agreement between Israel and Syria through a safe Israeli withdrawal from the Golan Heights and the resolution of the territorial and water disputes.
- Clear economic viability considering the self-sufficient energy production, as well as the economic benefits of peace. Energy produced is used to transfer the potable water from Turkey and for pumping from the Central Golan Heights at (+) 500 to Jordanian cities. (This advantage is in contrast to Red–Dead Canal that requires lifting of desalinated water from [−] 400 to [+] 1,000 m to Jordanian cities).
- Political balance and fairness due to an even distribution of benefits between the four recipients.
- A win–win conflict resolution formula for peace and water accords between Israel, Syria and Palestine.
- An environmentally safe potable water solution for the stabilization of the Sea of Galilee, revitalization of the Jordan River and reversal of the rapid decline of the Dead Sea (without altering the mineral composition of the Dead Sea).

- Enhance and stabilize recipients' water inventories in a time of scarcity.
- Helps Turkey earn hard currency for the sale of water and supports its geopolitical importance.
- Access to additional water could help increase the standard of living of the agrarian sectors in Arab countries; reduce poverty and hopefully, the religious radicalization of the poor.
- International guarantees, even distribution of benefits and fulfillment of major hydrological, economic and political interests of each side helps secure the flow of water for years to come.
- The new water is in addition to existing water inventories and does not require giving up a single drop of water from each of the participants.

The following is the basic criteria for successful regional water projects in the Middle East that address the regional water problem:

- Reduces resource and political conflicts in the region.
- Stresses equitable and balanced sharing of water and benefits.
- Is affordable, profitable and durable.
- Has no significant redirected negative impact, especially environmental impact.
- Has a significant positive impact on the Sea of Galilee, Jordan River and Dead Sea problems and on the water inventories of the four countries.
- Passes various feasibility tests: Environmental, Economic, Political, Technical and Social.

If integrated in an Israeli-Syrian peace accord, the Peace Canal on the Golan Heights Plan could fulfill these criteria, including the political criteria. The Plan could make a substantial contribution to the hydrological and political stability of this tumultuous region, ensuring a peaceful and prosperous existence of future generations.

5. Conclusion

The positions of the relevant parties with regard to the Peace Canal Plan seem positive as it fits major stated interests. The parties understand the risk involved with such water import project from Turkey through Syria, but think that the accumulative and multi-faceted benefits outweigh the possible risks. This is especially true when considering that no party is expected to give up a single drop of water in return for their agreement to participate in the project. The Peace Canal Plan is not a zero sum proposition but rather a win–win option for all involved. That said, the authors feel that the future of this Plan is bright.

References

Aava, Z., 1994. Personal verbal communication with the author (Wachtel).

AFP, 2008. Syria presses Turkey over Euphrates water supplies. *Agence France-Presse Agency (AFP)*. 2 January 2008. Terra Daily (November 10, 2008); http://www.terradaily.com/reports/Syria_presses_Turkey_over_Euphrates_water_supplies_agency_999.html.

Amid, I., 1994. Sahara. *Asharq Alawsat*, 7 February, 1994. London. (Published in Arabic).

BBC, 1994. Summary of World Broadcasts, British Broadcasting Corporation (BBC) Radio. 5 November 1994.

Bendar, A., 2008. Pipeline at end of tunnel, *Maariv*, 26 May, Tel Aviv.

Bin Talal, El Hassan, Crown Prince of Jordan, 1993. Personal letter to the author (Wachtel).

Bronfman, R., 2007. Environmental Security and Environmental Regulation in Israel, in: *Environmental Security in Harbors and Coastal Areas*, I. Linkov et al., eds., Springer, Dordrecht, The Netherlands.

Cowell, A., 1989. Recipe for Middle East Conflict: Add Water, *New York Times*, 16 April 1989.

de Chatel, F. 2007. *Water Sheikhs & Dam Builders: Stories of People and Water in the Middle East*, Transaction, New Brunswick, NJ.

FBIS, 1994. Foreign Broadcasting Information Services (FBIS), Washington, DC, 16 April.

Gruen, G.E., 2000. Turkish Waters: Source of Regional Conflict or Catalyst for Peace? *Water, Air & Soil Pollution*,123(1–4): 565–579.

Gruen, G.E., 2005. *Turkish Water Exports: A Model for Regional Cooperation in the Development of Water Resources*, Columbia University Press, New York.

Gruen, G.E., 2007. *Turkish Water Exports: A Model for Regional Cooperation in the Development of Water Resources*, Springer, Berlin/Heidelberg.

Haaretz, 1999. 3 October.

Hess, A., 1999. *Trilateral Confederation, A New Political Vision for Peace – The Just Way to Peaceful Co-existence on Both Sides of the Jordan River*, Israel/Palestine Center for Research and Information (IPCRI), A Final Status Series Publication, Supported by the Commission of the European Communities and the Swedish International Development Cooperation Agency (SIDA), January 1999.

Israel Foreign Ministry, 1997. Declaration on Principles for Cooperation on Water-Related Matters and New and Additional Water Resources, Israeli Ministry of Foreign Affairs: Information Division, Jerusalem (January 27 2008); http://www.mfa.gov.il/MFA/Peace%20Process/Guide%20to%20the%20Peace%20Process/Declaration%20on%20Principles%20for%20Cooperation%20on%20Water.

IMI, 2007. Israeli Ministry of Infrastructure, Press release, 24 October 2007. (January 27 2008); http://www.energy.gov.il/NR/exeres/8478470B-E4A5-4BCA-98C5-EB3904135ECC.htm.

Landis, J., 2008. Discussion Posting: The Peace Canal Plan – Peace plan/water import project from Turkey to the Middle East, *Syria Comment* (blog), posted 22 March, 2008 (22 March 2008); http://joshualandis.com/blog/?p=638.

Mitchell, C., 1992. Personal letter to the author (Wachtel). Director of Correspondence for the Office of Jimmy Carter, 21 January.

Nir, U., 1993. Israel will propose in the multilateral talks the construction of a water canal as a strategic barrier on the Golan’ 1995, *Haaretz*, 25 August.

Pinkas, A., 1993. Personal letter to the author (Wachtel) from Shimon Peres’ Advisor in the Israeli Ministry of Foreign Affairs.

Turkish Ministry of Foreign Affairs, 1996. *Water issues between Turkey, Syria and Iraq*. A Study by the Department of Regional and Trans-boundary Waters in the Turkish Ministry of Foreign Affairs.

US Senate, 1992. Calendar No. 700, Report 102–419, 102nd Congress, 2nd Session, *Foreign Operations, Export Financing, and Related Programs Appropriation Bill, 1993*. 23 September.

US State Department, 1992. *Grand Schemes for Middle East Water Development,* unpublished.

UV, 2004. Water Sector Challenges in Jordan. (27 January 2008); www.oosa.unvienna.org/pdf/sap/2004/graz/10.pdf.

Wachtel, B., 1991a. Water: the ultimate frontier, *Journal of Commerce*, 18 December, USA.

Wachtel, B., 1991b. Water – Mideast peace option, *Miami Herald*, 26 January, USA.

Wachtel, B., 1992a. The Peace Canal in the Golan, *Haaretz*, 14 February, Israel.

Wachtel, B., 1992b. The Peace Canal on the Golan, *Turkish Times*, 1 March 1, USA, Turkey.

SOCIO-ECONOMIC PERSPECTIVES

USING STAKEHOLDER ENGAGEMENT AND VISUALIZATION TO AID DECISION-MAKING ABOUT WATER USE IN THE MIDDLE EAST

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Abstract: Making decisions about water allocation in arid environments is inherently contentious. The uncertainty of climate change and projections of a warmer and drier future for arid regions raises the stakes further. When mixed with politically-charged questions about sovereignty, the locations of international borders, agricultural production and population growth, as is the case in the Middle East, these issues can become explosive. In this paper we explore whether methods developed for resolving questions related to how water is distributed in central Arizona, USA, can be applied to situations involving Israel and its neighbors. We describe a suite of approaches that includes a system dynamic program for exploring alternative future scenarios, along with high-resolution, three-dimensional representations of aquifer geometry, and decision-support tools like immersive visualization and secret voting on policy choices. Used collectively, this framework could strengthen the existing dialogue that has taken place over the past 2 decades among Israeli, Palestinian and Jordanian water managers and help reduce long-term water conflicts.

Keywords: Water; conflict; Middle East; decision-making; Israel; Palestine

1. Introduction

Amid the persistent conflicts of the past half century between Israel and its neighbors, one of the few hopeful signs has been the unwillingness of the belligerents to sabotage each other's water supplies. Mostly hidden from public

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view, diplomats and water experts have quietly established professional relationships and built pragmatic agreements designed to achieve results like sharing the flow of the Jordan River, slowing the drop in water level of the Dead Sea, maintaining aquifers beneath the Arava Valley, and piping desalinated seawater from Israel to Gaza.

This relatively optimistic backdrop contrasts with the challenging realities of rapid population growth, accelerating climate change, competing economic development paths, and ongoing political disagreements, any one of which can derail longstanding cooperative arrangements. Goodwill alone will not be sufficient to avoid serious differences in the future about how scarce resources can be allocated throughout the region; the players need to see tangible benefits and a clear roadmap to achieving an equitable distribution of water.

In this chapter, we describe some of the water-planning experiences of cities and private water providers in Metropolitan Phoenix, Arizona, a rapidly-growing desert city of over 4 million people (U.S. Census 2008). Most climate models forecast declining rainfall, rising temperatures, and reduced runoff throughout this southwestern part of the U.S. over the next century, while population is projected to increase markedly (Milly et al., 2005; Christensen and Lettenmaier, 2007; Seager et al., 2007). Like many arid regions around the world, central Arizona's water issues involve multiple jurisdictions that share common aquifers, reservoirs and canal systems for surface water distribution.

Phoenix-area water managers have several policy options to prevent shortage, including pricing and other forms of demand management, incentives for conservation, supply augmentation, interstate and international negotiation, public education and changes in land use ordinances and practices. Choosing among this wide array of alternatives is a highly complex process that requires the direct engagement of the public, elected officials, government agencies the business community, and scientific experts. Arizona State University, the only research university in the region (and the largest by student count in the U.S.) has been able to serve as an "honest broker," providing ideas and scientific tools to help water managers decide among contrasting future choices. Here we explore how Arizona's approach might be applied to the resolution of present and future water conflicts in the Middle East.

2. Water Issues in Central Arizona

Sometime between 1300 and 1450 A.D., the Hohokam people abandoned their agrarian settlements and over 200 km of irrigation canals in the Salt River Valley, where Phoenix is located today. Five hundred years later, the region was rediscovered by Anglo-European farmers and named "Phoenix" to commemorate the rise of a new civilization from the ashes of the prehistoric Hohokam. Private individuals and the U.S. Government rebuilt the canal system, connecting it to a series of reservoirs, which collectively allowed the expansion of what had been a small agricultural community numbering only 20,000 at the turn of the last century. The city's population grew steadily through the first half of the 20th Century and then accelerated in the 1950s, partly spurred by technological advances like air conditioning, which made summers more tolerable, and as World War II veterans who trained in the region decided to settle there upon returning from their War service (Gammage, 1999; Gober, 2006). In the 1970s, 1980s and 1990s the urbanization accelerated, and the metropolitan region is now the second fastest-growing large (>1 million) metropolis in the U.S. (U.S. Census, 2008).

It is commonly assumed that population increases in desert cities should be constrained by water supply. However, in the case of Phoenix there are several natural and man-made factors causing that supply to be surprisingly resilient. First, the deep gravels that underlie the Phoenix Basin contain a number of extensive perched lenses of fresh or brackish water. Although some of these have been partly contaminated by pollution from electronic manufacturing processes, the resource is still relatively large. Second, Phoenix sits at the base of the Salt and Verde River Basins. Dryland rivers flowing through Phoenix are fed by more humid upstream watersheds. The flows on these rivers were dammed as part of the Salt River Project (SRP) reclamation effort in the early 20th Century; six reservoirs within a 100 km radius of downtown Phoenix now provide a buffer against droughts.. Third, the Central Arizona Project (CAP) canal brings large volumes of Colorado River water 560 km across the desert to Phoenix and Tucson. Fourth, water-intensive cotton farming is still common in parts of the Phoenix metropolitan area; as this land is converted to residential use there can actually be a net increase in available water.

These water resources are managed by man-made regulations and laws that have evolved to promote growth and ensure a stable and secure water supply. Most notable among them is Arizona's Groundwater Management Act, passed in 1980, which requires that the state's urban areas achieve "safe yield" by 2025, a condition in which the water withdrawn from a basin is balanced by natural and artificial recharge and requires evidence of a 100-year assured supply in order for new development to occur (Jacobs and Holway, 2004). As a result, mandatory groundwater recharge is widespread in the region.

Forecasting future water supply and demand in this arid environment is complicated by uncertainties in these geophysical and political factors. Compounding the uncertainty is the fact that there is no single authority responsible for allocating water in Arizona. The roughly two dozen municipalities and Native American tribes that make up Greater Phoenix and the dozens of private water companies all share the same three sources of water: groundwater aquifers, the six nearby reservoirs on the Salt and Verde Rivers, and Colorado River water transported through the CAP (Figure 1). They function generally in an “every-man-for-himself” mode with operating rules that seek maximum flexibility to respond to drought, accommodate future growth, and assure a secure supply at all cost. The conflicts that inevitably result require novel types of adjudication.

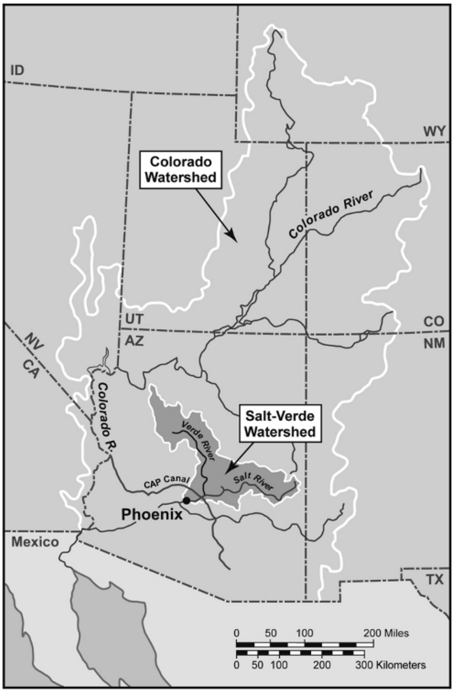

Figure 1. Map of southwest US showing primary surface water sources for central Arizona (Source: Google Maps)

The inherently complex challenges faced by water managers in Phoenix are shared by many other professionals dealing with long-term administration of environmental services. Partly in recognition of this common set of problems, the U.S. National Science Foundation in 2004 funded a $7M research program based at Arizona State University called “Decision Center for a Desert City: The Science and Policy of Climate Uncertainty” (DCDC). DCDC studies how water managers make decisions in the face of persistent uncertainty about drought, population growth and climate change. Atypically for this kind of academic program, the original grant proposal was based in part on input provided by community stakeholders like the municipal water administrators, a local utility, and the Arizona Department of Water Resources. As a consequence, the results of the university-based research have been more readily accepted by the managers than would normally be the case.

3. Decision Theater and WaterSim: Decision-Support Tools

The most critical ambiguities facing Phoenix-area water managers involve the volume and location of available supply, and the likely future demand. From a policy perspective, finding the ideal combination of well locations, pumping rates, surface supplies, and pricing is complicated by the competitive nature of individual jurisdictions. This creates a classic case of the "tragedy of the commons" (Hardin, 1968), where the outcomes of most benefit to the most people are bypassed in order to preserve local interests of the few. Yet if all of the players could actually see what the implications of their individual decisions were common resource base, they might come to different conclusions and make different decisions.. The uncertainty of climate change further argues for such an approach in which players would share certain surface supplies in plentiful years and share the deficits in lean years.

In order to facilitate this type of understanding, the DCDC team developed a tool called "WaterSim" which allows water experts, politicians, and the general public to explore alternative future scenarios. WaterSim is a software application developed using a commercial program called Powersim.[1] It integrates as many as several dozen different quantitative relationships and equations into a system dynamic framework (Forrester, 1987), connecting the output of one decision into the input options for another. It can be thought of as a large flow chart linking as many components as possible of a given decision tree. Results can be displayed through a variety of graphical means including charts, maps and three-dimensional representations. An online version of WaterSim[2] lets users create and compare alternative future scenarios (Gober et al., in review). A similar approach has been developed for Las Vegas (Stave, 2003).

WaterSim takes advantage of a facility called the Decision Theater (DT),[3] an immersive visualization environment used by Arizona State University's Global Institute of Sustainability[4] to bridge the gap between technical research and policy needs of various public and private sector stakeholder groups (Fink et al., 2003). The DT (Figure 2) offers a neutral space in which up to 30 people can interact with a wide variety of digital media, on seven large, high resolution, wrap-around, floor-to-ceiling, rear-projection screens all linked to a high performance computing cluster. The visual appeal of the room tends to focus the attention on critical variables, encourage discussion among participants, and facilitate the exploration of "what if" scenarios of the future. It moves discussion away from simple projections of the future and assessments of potential outcomes to a more activist mode in which participants see that the decisions they make today will chart the future and that some decisions work better than others,

[1] http://www.powersim.com.
[2] http://watersim.asu.edu.
[3] http://dt.asu.edu.
[4] http://sustainability.asu.edu.

given the uncertainty of climate change and rapid growth.. Of equal value is the collective experience of the staff members in facilitating decision making. In its 4 years of operation, the DT has hosted several dozen projects on topics including public health, school redistricting, transportation planning, air pollution mitigation, municipal zoning, architectural design, civil defense, and planetary exploration. Clients include city, state, and federal agencies, real estate companies, multi-national corporations, non-government organizations, and university faculty members and students.

In a typical WaterSim session, a dozen managers sit around a U-shaped table, using laptop computers to adjust variables displayed graphically on up to seven screens of the DT (Figure 3). By sequentially manipulating a series of slider bars, alternative situations can be designed that account for different climatic, economic, and policy conditions (Figure 4). In accordance with standard hydrologic methods, WaterSim assumes that future precipitation variations will replicate past trends. Thus creation of a scenario might begin with the assumption that a specific 25-year historical record (for instance, 1950–1975) will be reproduced in the next 25 years (2009–2034) (Figure 4a). On top of this starting base, the managers can then superimpose a drought of a particular duration and intensity, beginning in a specific year in a specific watershed, under temperature and precipitation conditions consistent with one of several dozen global climate models. In addition, users can define urban population growth rates (Figure 4b), rates of conversion of agricultural to residential land use (Figure 4c), and policy options such as how quickly the water table is allowed to decline, or whether agricultural or residential users will have priority access to restricted future water supplies (Figure 4d). The model's output could then show the combination of underground and surface sources required to meet future water demand, the

Figure 2. The seven screens of the Decision Theater were used by the Tempe City Council to derive a scheme for building height restrictions; members of the public participated from a large nearby meeting room. *Figures 2–4 courtesy of the DT and the DCDC project

rate at which the water table would fall, as well as household per capita allotments. Results can be shown for the entire region or for individual cities, water districts, or other relevant subdivisions.

Figure 3. "WaterSim" being displayed on five screens of the Decision Theater. Stakeholders can vote on policy options using networked laptop computers

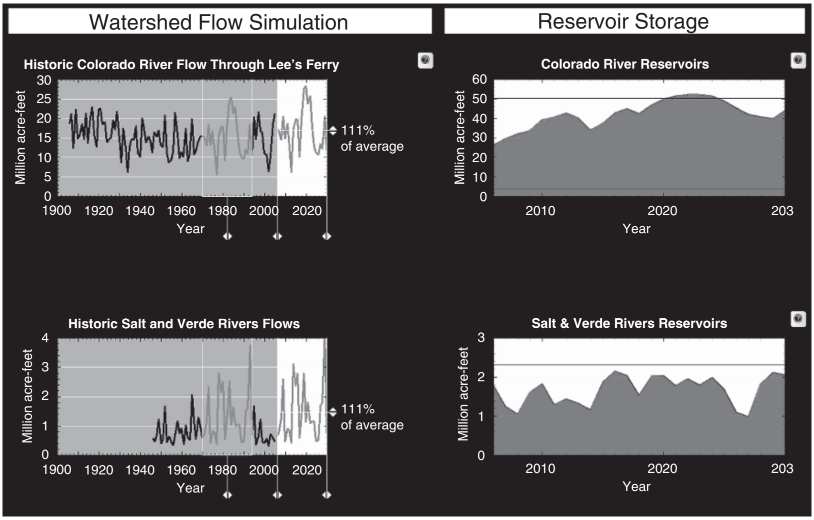

Figure 4a. Top left shows a 100-year historic record of Colorado River flow from which the 25-year period from 1970–1995 (lighter line) has been selected to project into the future. The *top right* shows derived storage levels in reservoirs along the Colorado River for the next 25 years, based on assumed river flow associated with the historic time period selected at left. *Lower left and right* show similar relations for the Salt-Verde River system

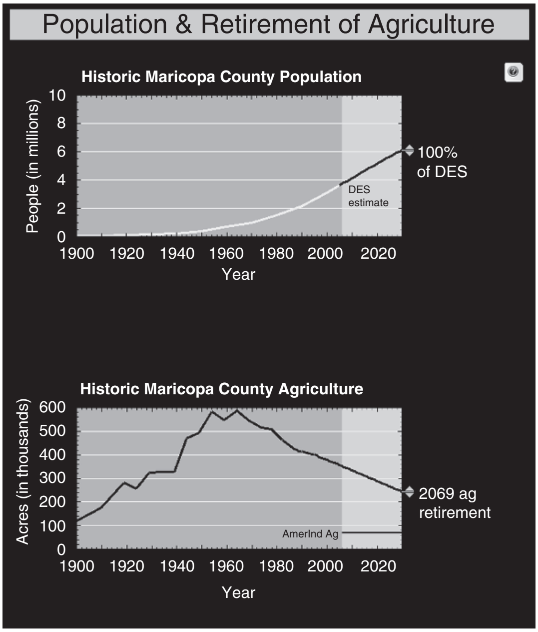

Figure 4b. Population growth rate (*top*) and percentage of land used for agriculture (*bottom*). Participants in the Decision Theater can adjust these two (and many other) variables in order to see how they affect long-term water supply

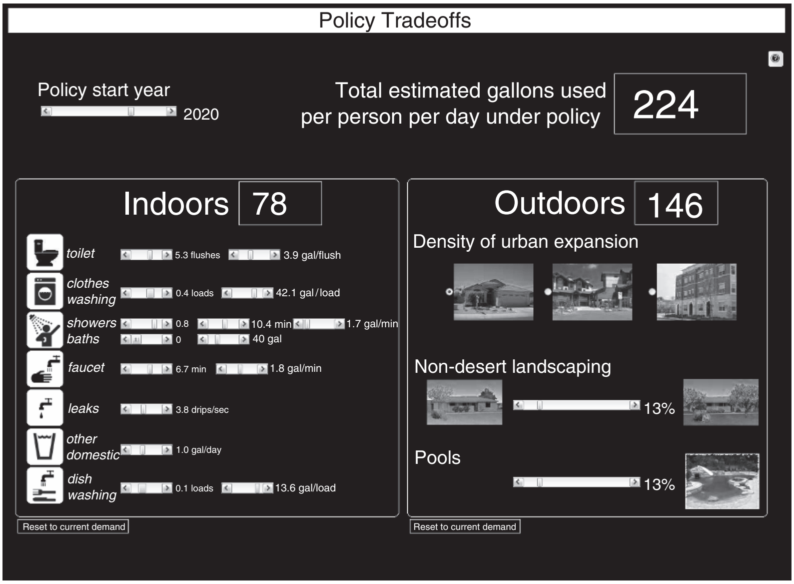

Figure 4c. Viewer-adjustable water-use policy options for indoor (e.g., low-flow toilets, shorter showers; repair leaks) and outdoor (landscaping style; fewer swimming pools) settings

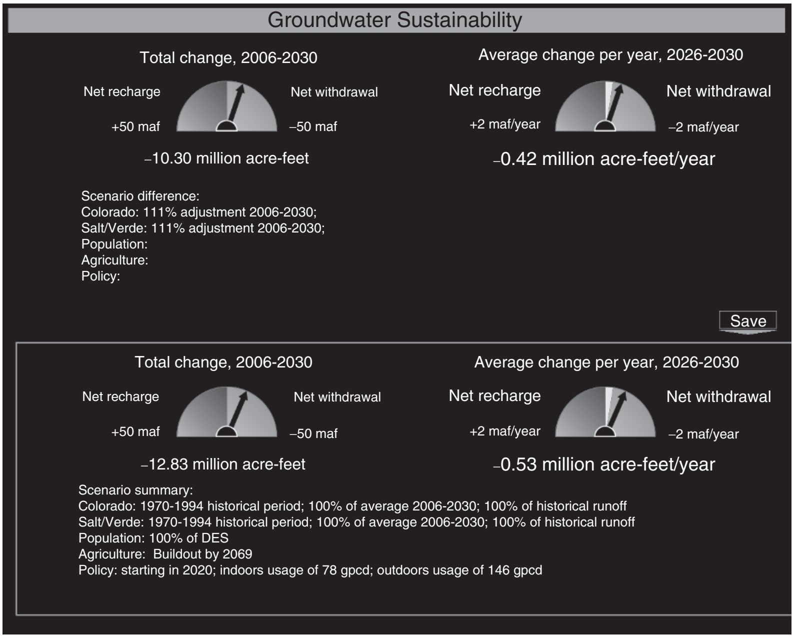

Figure 4d. Simplified conclusion about groundwater sustainability for a given scenario (for time frames of 2006–2030 and 2026–2030); complex information has been reduced to a very simple summary graphics showing net change of the water table

A second visualization approach that complements WaterSim's graphical interface involves three-dimensional depictions of the underground aquifer system, constructed using geophysical data or historical information from hundreds of wells distributed around the region (Figure 5). The Decision Theater allows participants to then "fly" around or through these subsurface representations, viewing them from any vantage point, and at different times in the past, or projected into the future. In addition, the flow paths of known pollution plumes can be shown, and projections can be derived that take into account the gradient of the water table, and pumping rates and cones of depression associated with different wells. Salinity and other measures of water quality can also be shown as a function of position and time throughout the region and for the entire available historical record. Proposed new treatment facilities can also be shown.

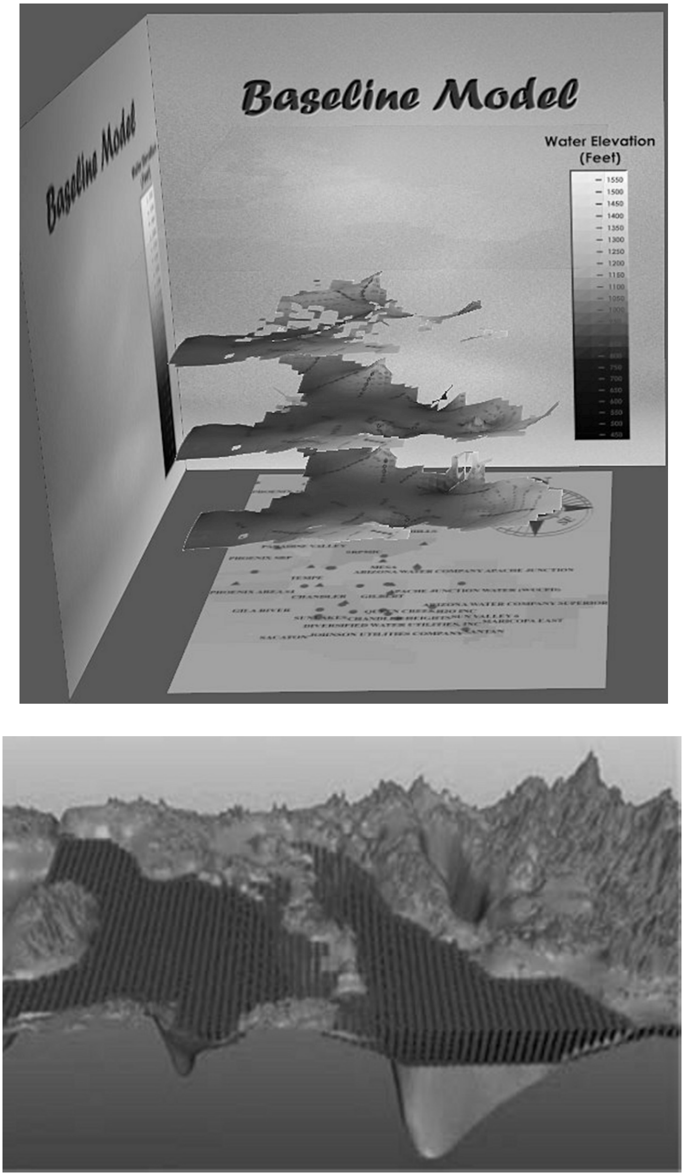

Figure 5. Two different three-dimensional representations of aquifers beneath the eastern portion of Metropolitan Phoenix, Arizona. Figures are based on data provided by the East Valley Water Forum for planning purposes only

(5a) Three perched layers extracted from geologic cross sections and superimposed over a map showing the geographic boundaries of the different jurisdictions in the region; shading and arrows depict the surface gradients on the water table lenses
(5b) Cross sectional view of the depth of the water table, superimposed on the region's surface topography; shown with 5 times vertical exaggeration

Certain urban sustainability goals have large implications for water use, like reducing the impact of the urban heat island effect by planting large numbers of trees, expanding the state's reliance on nuclear power in order to reduce greenhouse gas emissions, or spraying water on construction sites in order to reduce particulate air pollution. This is another case where the Decision Theater can help with evaluations of some of these unintended consequences and tradeoffs prior to investments being made in specific new infrastructure or policies.

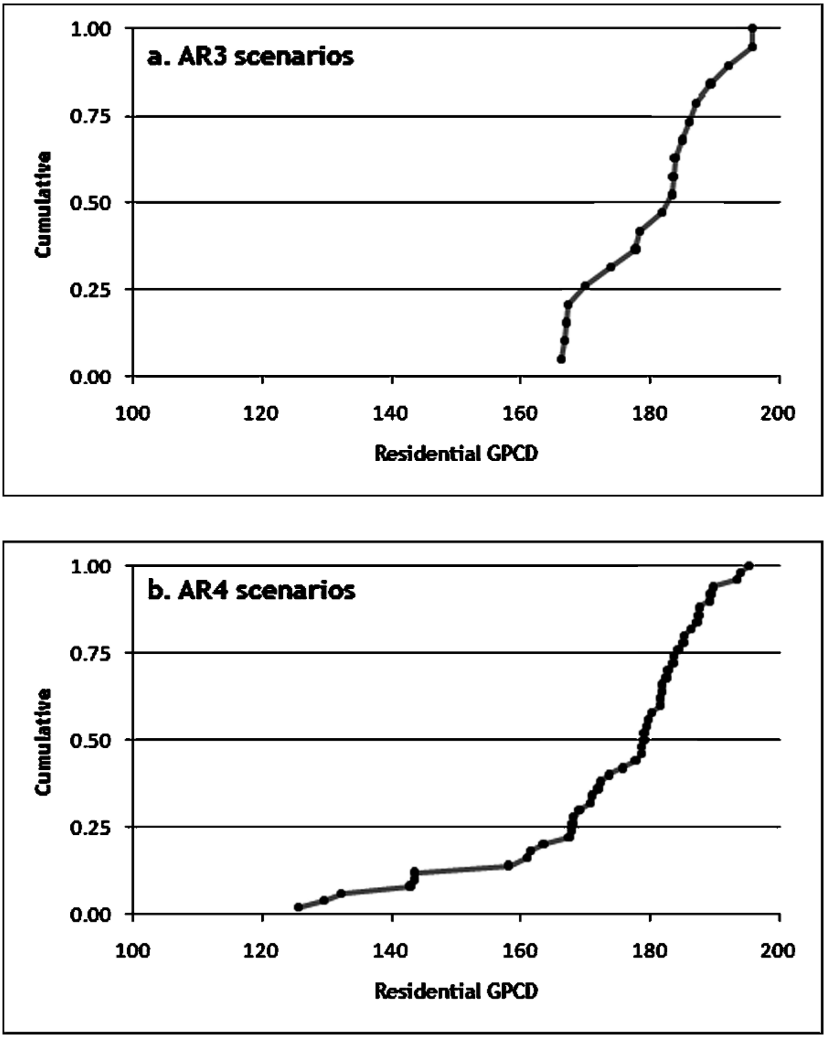

Figure 6. The results of IPCC climate model/scenario combinations from AR3 (2001) and AR4 (2007) for the Salt and Verde Watersheds were used as inputs to WaterSim. Results are shown as cumulative frequency distributions. The mean outcomes are quite similar, but the AR4 scenarios show greater uncertainty about the effects of climate change on the regional water supply and raise the prospects for the need to severely curtail water consumption – from today's ~230 GPCD to less than 140 at the end of the model run in 2030 (Figures courtesy of DCDC project)

The DCDC team has also experimented with new ways of translating WaterSim's results into useful information for water resource planning and analysis. The complexity of the water environment, in conjunction with the uncertainties associated with climate change, often leave decision makers over-loaded with data and unable to focus on the consequences of decisions made today for future water security and sustainability. They have developed new visualizations which show, for example, that the most recent IPCC (2007) scenarios from the Fourth Assessment Report (AR4) raise the possibility of some very dire climate and water resource futures that were not revealed in the Third Assessment Report (AR3; IPCC, 2001) scenario/model runs (Figure 6). It is of some comfort, however, that substantial but feasible reductions in gallons per capita per day (GPCD) would allow the region to weather the most pessimistic of the climate results but require a change in lifestyle and outlook from that of an oasis to a desert city.

4. Applying Lessons of Phoenix Water Management to the Middle East

Although today's water disagreements in Arizona are less likely to lead to armed conflict than those in the Middle East, they do have serious economic, social and environmental consequences. In both cases there is major concern about the magnitude of future supply and demand due to population growth, overexploitation by agriculture, and climate change, as well as uncertainty about how conflicts can best be resolved. The Arizona example thus has substantial relevance to the situation between Israel and its neighbors although its situation is more elastic because of the potential to retire water-wasting agriculture and activate more aggressive conservation efforts to reduce demand.

The hydrologic situation in and around Israel is complicated by trans-boundary issues. Israel's two largest groundwater sources – the Coastal and Mountain aquifers – extend into Palestinian territory in the West Bank and Gaza, and locally cross the borders with Jordan, Lebanon and Egypt (Figure 7). Headwaters for many of the rivers that contribute to Israel's water supply are in neighboring countries. Even the seemingly vast desalination potential of the Mediterranean and Red Seas involve changes in near-shore water quality that could affect neighboring countries' fisheries, beaches, ability to cool power plants, and industrial processes. Desalination also has significant greenhouse gas emission implications because of the large amount of power it requires.

The region's most contentious water issues occur in the West Bank and Gaza, where population and water demand are increasing rapidly (Lowi, 1993; EXACT, 1995; National Research Council, 1999). An interim agreement as part

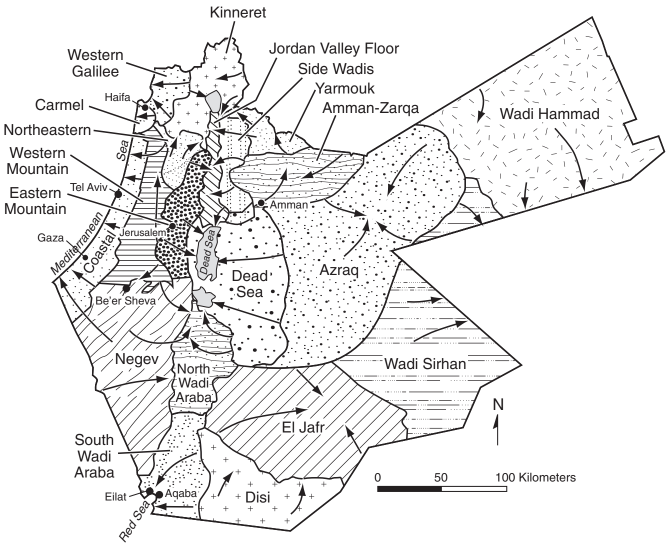

Figure 7. Sketch of map showing aquifers and surface water sources in Israel, Jordan, the West Bank and Gaza. Arrows represent directions of sub-surface water flow (Based on map in EXACT, 1998)

of the Oslo Peace Process in 1995 provided the Palestinians in the West Bank with guaranteed, fixed allotments of groundwater, but also prohibited them from drilling new wells. A portion of Gaza's fresh water today comes from existing desalination facilities along the Israeli coast, but Israel can (and has) shut off this flow in response to political circumstances. Much of the groundwater in Gaza flows in from the southern Negev, where it becomes highly saline due to both geological and agricultural processes (Vengosh et al., 2005). An elaborate plan to build a series of inland desalination facilities along Israel's western border with Gaza to clean this water before it enters the aquifer beneath Gaza has recently been proposed (Weinthal et al., 2005).

The "tragedy of the commons" referred to earlier is exacerbated in the West Bank, as the Palestinians do not feel motivated to conserve water that they fear will be used to expand Israeli settlements or allowed to flow westward into the main Israeli national water supply. Similarly, the Palestinian Authority and Hamas have accused Israel of restricting the availability of water (or of the diesel fuel needed to pump groundwater) as a tool to suppress economic opportunity and political independence in the West Bank and Gaza. In Phoenix, similar concerns are raised by long-time residents reluctant to conserve because they think that the water they save will be wastefully used by nearby private golf resorts and luxury developments.

Even in the absence of disputes involving the Palestinians, the Israeli Water Authority confronts many other complications in meeting regional fresh water needs. Virtually all of Israel's water has been fully allocated for the past 2 decades, even though the population continues to rise. Thus new supplies will be needed, coming either from desalination of seawater or brackish groundwater, re-use of grey water, or repurposing of agricultural water for municipal and industrial uses. The Coastal Aquifer is seriously contaminated by pesticide and fertilizer runoff from agriculture, under-treatment of municipal sewage, and pollution from defense-related industries. Lowering of the water table beneath Israel's coastal plain is leading to ever-increasing degrees of seawater intrusion. Although the needs of ecosystems are generally considered a lower priority than societal uses, environmentally-sensitive riparian and marsh areas are also gravely threatened by the redirection of fresh water flow to agriculture and cities (National Research Council, 1999). In addition, region-wide water stress can be greatly intensified by the droughts that occur with regularity. Finally, concerns about "virtual water" (water that is traded in the form of water-hungry agricultural products) have recently emerged, leading to questions about whether it makes economic and hydrologic sense for arid countries like Israel to export water-intensive crops like flowers and vegetables that then require expensive replenishment of domestic water supplies.

Based on these many challenges, it is unrealistic to assume that a tool like WaterSim, a program like DCDC, or a facility like the Decision Theater could operate in exactly the same ways in the Middle East as they do in the relative calm and affluence of central Arizona. However, in conjunction with other political negotiations about larger territorial and economic issues, these decision-making aids involving the creation and evaluation of alternative future water scenarios could prove useful. Here we consider two examples.

4.1. THE FUTURE OF THE DEAD SEA

The Dead Sea (Nieme et al., 1997) is the lowest and one of the saltiest bodies of water in the world. It is traversed by the border separating Jordan on the east from Israel and the West Bank on the west. It receives fresh water from the Jordan River to the north and from springs along its shores. Evaporative ponds in its southern portion are used to extract various industrial minerals. There are also tourist hotels on both the Jordanian and Israeli sides. Over the past few decades the level of the Sea has dropped steadily due to diversion of the Jordan River and its headwaters to fulfill the various water needs and wants of the riparian parties. The rate of this recession has accelerated recently to about 1 m/year, impacting the industrial and tourist facilities. Falling groundwater levels have caused fresh water to flow beneath the shoreline, leading to the formation of major sinkholes that are damaging roads and other infrastructure on the western coast.

Over the past century, more than a dozen schemes have been proposed to redirect water from wetter to drier parts of the Middle East. The latest would halt this retreat by building a canal running from the Red Sea near Aqaba north through the Arava Valley to the southern end of the Dead Sea. The 400 m elevation drop into the Dead Sea would provide hydroelectric power that could be used to desalinate some of the seawater for Jordanian use, with the saltier residue then being discharged into the Dead Sea, arresting its decline. Jordan would receive virtually all the fresh water, but in exchange would give up access to some water they currently receive from the Jordan River and from Israel.

There are significant environmental concerns about the hydrologic implications of this plan, especially the chemical and mineralogical reactions that would occur from the mixing of the dissimilar Red Sea and Dead Sea water, and the potential danger of a major leak of seawater from the canal into the aquifer of the agriculturally-rich Arava Valley. There are also political and financial considerations about route selection and overall practicality. The World Bank is currently conducting a feasibility study for the plan.

A Decision Theater project about the Dead Sea could be built with a GIS interface showing alternate routes and their implications, including sites for seawater intake, pumping stations, hydroelectric facilities, and distribution systems for the resulting freshwater and brine. Chemical and mineralogical models for the mixing of waters from the Red and Dead Seas could help water managers visualize the reactions and their products. Three-dimensional representations of the subsurface around the Dead Sea could show the interactions between fresh and salt water and the potential for more subsidence and collapse events. Possible real estate and agricultural patterns resulting from the influx of desalinated Red Sea water could be shown. Topographic and aquifer representations could illustrate the hazards of leaks in different locations along the Arava Valley. Adjustable depictions of economic variables could allow cost-benefit analyses of different routes and development schemes to be explored.

Designing a system for evaluating scenarios requires identification ahead of time of those points that are most likely to be of interest and others that are potentially contentious. In the case of the Dead Sea, these would include competition among Jordan, Israel and the Palestinian Authority for economic development opportunities, and access to desalinated fresh water and hydroelectric power. On the other hand, successfully resolving potential conflicts could have a positive spillover effect in generating momentum toward broader negotiations. Recent discussions have been encouraging, although the current global economic downturn puts short-term financing for the project in jeopardy.

4.2. SHARING THE MOUNTAIN AQUIFER

Most water conflicts associated with the Dead Sea involve two sovereign nations, Israel and Jordan, which have been officially at peace since 1994. However, in the case of the Mountain Aquifer, which underlies the highlands on the western side of the Dead Sea Rift Valley, the issues are clouded by territorial and political disputes between Israel and the Palestinian residents of the West Bank. This relatively unpolluted subsurface reservoir provides water for Jerusalem, as well as Ramallah, Bethlehem, Nazareth, Hebron, and many of the other cities, towns and villages administered by the Palestinian Authority. The aquifer also feeds into the National Water Carrier system, which supplies most of the agricultural and municipal water needs of the rest of Israel. Although the Palestinian Authority has influence over how certain infrastructure in the West Bank is used, decisions about water use continue to be controlled by Israel. Thus, any discussions about future allocations of the Mountain Aquifer's water are likely to be politically and emotionally charged. Simple questions like how borders are to be represented on maps, or who gets to participate in discussions could become major obstacles to progress. Palestinian culture in the West Bank has long been centered on villages and their local springs or wells; proposals that involve disrupting these traditional relationships with the land are likely to be controversial (Isaac, 2005).

The Decision Theater methodology contains features that can help avoid these potential flash points. Answers to posed questions can be tallied confidentially using secret balloting on networked laptop computers. "Rival" models based on different assumptions can be shown simultaneously on different screens, and potentially divisive underlying aspects can be explored in parallel. For instance, assumptions about population growth rates for Israeli settlements or Palestinian villages or cities are among the most sensitive "hot button" issues in the region, involving questions about Israel's Law of Return and Palestinians' desire for a Right of Return. These variables can be incorporated into adjustable slider bars that can be moved without implying any value judgment about the different trajectories. What then becomes critical is who gets to design the simulation tool. Given that the goal of the visualization apparatus is to allow as wide a range of options as possible to be shown, preparing it can become a non-confrontational experience for technical managers and facilitators. These politically nonaligned actors can work to achieve display configurations that would defuse conflicts rather than exacerbate them.

Designing and building a Decision Theater in the Middle East region, rather than relying on one located elsewhere, could also serve to spur more peaceful outcomes. If the primary funds could be raised by relatively neutral third parties (e.g., the EU, USAID or World Bank), with additional contributions from Israel and various Arab countries, the whole process could ideally be seen as non-partisan. The actions involved with planning such a facility could be as important as the conclusions that would eventually be reached within it. Staffing for the Theater could also reflect the mix of parties likely to use it, with technical background and regional diversity being equal determinants of participation. If such a facility, with a mandate to assist in achieving peaceful outcomes, could be built in a city like Ramallah, Bethlehem, or Jericho, it could serve at once as an economic development driver and as a hopeful symbol of peaceful coexistence. Engaging the emerging Palestinian information technology industry could be another excellent good will gesture. Connecting, via high speed video links, with other such facilities throughout the region and world could help the local players feel better engaged with larger global issues of water management and urbanization, and lead to a faster path to normalization of relations.

5. Conclusion

Successful conflict resolution requires finding ways for the competing parties to see the benefits of a common solution. Such processes typically necessitate trust between the antagonists and agreement about the starting and ending conditions. Visualization of alternative future scenarios can allow the two sides to explore, in a relatively non-confrontational way, the consequences of different paths forward, including the implications of relatively unconstrained factors, like the impacts of climate change on future water supplies. The process of model design can be as important to bridge-building as the actual plan decided upon through negotiation. In central Arizona, Arizona State University has facilitated a visioning process to help water managers look at allocation options in the face of persistent uncertainties due to climate change, drought, and population growth, factors that are also important in the Middle East. Successful engagement of the practitioners was based on getting buy-in through the construction of shared models, gaining access to the best available data, and convening meetings in a “safe space” that was perceived as neutral. Many of the same conditions could be achieved in helping Israel, the Palestinian Authority and Jordan explore strategies for future use of their limited transboundary water resources.

References

Christensen, N.S. and Lettenmaier, D.P., 2007. A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River basin, *Hydrology and Earth System Sciences*, 11: 1417–1434.

EXACT, 1998. *Overview of Middle East Water Resources: Water Resources of Palestinian, Jordanian and Israeli Interest*, Executive Action Team, Middle East Water Data Banks Project (EXACT) (ISBN 0-607-91785-7); http://exact-me.org/, 44 p.

EXACT, 2005. Executive Action Team (EXACT), Multilateral Working Group on Water Resources, Water Data Banks Project, http://exact-me.org/.

Fink, J.H., Steiner, F., Redman, C.L., and Grimm, N.B., 2003. Greater Phoenix 2100: Building a national urban environmental research agenda, in Earth Sciences in the Cities, G. Heiken, R. Fakundiny, and J. Sutter, eds., *American Geophysical Union Special Publication Series*, 56: 413–426.

Forrester, J., 1987. Lessons from system dynamics modeling, *System Dynamics Review*, 3(2): 136–149.

Gammage, G., Jr., 1999. *Phoenix in Perspective: Reflections on Developing the Desert*, Herberger Center for Design Excellence, Tempe, AZ, 180 pp.

Gober, P., 2006. *Metropolitan Phoenix: Place Making and Community Building in the Desert*, University of Pennsylvania Press, Philadelphia, PA.

Gober, P., Wentz, E.A., Lant, T., Tschudi, M.K., and Kirkbood, C., in review. WaterSim: a simulation model for urban water planning in Phoenix, Arizona, USA. *Environment and Planning B*.

Hardin, G., 1968. The tragedy of the commons, *Science*, 162: 1243–1248.

IPCC (Intergovernmental Panel on Climate Change), 2001. *Climate change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson, eds., Cambridge University Press, Cambridge/New York.

IPCC (Intergovernmental Panel on Climate Change), 2007. *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds., Cambridge University Press, Cambridge/New York.

Isaac, Jad, Director General of the Applied Research Institute of Jerusalem, personal communication, July 2005.

Jacobs, K.L. and Holway, J.M., 2004. Managing for sustainability in an arid climate: Lessons learned from 20 years of groundwater management in Arizona, USA, *Hydrology Journal*, 12: 52–65.

Lowi, M.R., 1993. Bridging the divide: transboundary resource disputes and the case of West Bank water, *International Security*, 18(1): 113–138.

Milly, P.C.D., Dunne, K.A., and Vecchia, A.V., 2005. Global pattern of trends in streamflow and water availability in a changing climate, *Nature*, 438: 347–350.

NRC, 1999. National Research Council (NRC), Commission on Life Sciences. *Water for the Future: the West Bank and Gaza Strip, Israel, and Jordan*, http://books.nap.edu/books/030906421X/html/53.html.

Nieme, T.M., Ben-Avraham, Z., and Gat, J., eds., 1997. *The Dead Sea: The Lake and Its Setting*, Oxford University Press, New York.

Seager, R., Ting, M., Held, I., Kushnir, Y., Lu, J., Vecchi, G., Huang, H., Harnik, N., Leetmaa, A., Lau, N., Li, C., Velez, J., and Naik, N., 2007. Model projections of an imminent transition to a more arid climate in southwestern North America, *Science*, 316: 1181–1184.

Stave, K.A., 2003. A system dynamics model to facilitate public understanding of water management options in Las Vegas, Nevada, *Journal of Environmental Management*, 67: 303–313.

U.S. Census Bureau, 2008. Population finder (December 23, 2008); http://www.census.gov.

Vengosh, A., Kloppmann, W., Marei, A., Livshitz, Y., Gutierrez, A., Banna, M., Guerrot, C., Pankratov, I., and Raanan, H., 2005. Sources of salinity and boron in the Gaza strip: Natural contaminant flow in the southern Mediterranean coastal aquifer, *Water Resource Research*, 41, W01013, doi:10.1029/2004WR003344.

Weinthal, E., Vengosh, A., Marei, A., Gutierrez, A., and Kloppmann, W., 2005. The water crisis in the Gaza strip: prospects for resolution, *Ground Water*, 43(5): 653–660.

AN ECONOMIC ASSESSMENT OF DEAD SEA PRESERVATION AND RESTORATION

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Abstract: The level of the Dead Sea has been dropping rapidly over the last decades as a result of diversion of waters from upstream tributaries and intensive mineral extraction along its shores. This has led to a wide range of environmental damage throughout the basin. This study provides partial estimates of the non-market economic value of conservation of the Dead Sea basin to the local population. Two methods were used to assess these values, one a revealed preference model – travel cost – and the other a stated preference model – contingent valuation. All three local populations, Israeli, Jordanian and Palestinian, demonstrated a substantial willingness to pay to preserve the environmental and cultural heritage of the region. Hopefully these estimates will be useful in assessments of the relative merits of various options for conservation and development of the Dead Sea region presently being undertaken by the governments of the region.

Keywords: Conservation; contingent valuation; Dead Sea; environmental economics; Middle East; non-market valuation; travel cost; water management

1. Introduction and Study Rationale

Upstream diversion of tributary waters, combined with intensive mineral extraction in both Israel and Jordan, has resulted in a precipitous decline in the level of the Dead Sea. As of 2008, the Sea has dropped 20 m since its level in the early 1900s, and is now dropping at a rate of over 1 m/year. This decline has brought with it a host of environmental changes. The surface area of the Sea has

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contracted by one third, springs around the sea are drying up, sinkholes – areas of severe land subsidence – are forming, and threatening historical sites and infrastructure, and the composition of the Sea itself is changing as the waters become increasingly more saline. Given the Dead Sea's importance as a center for both tourism and industry, these environmental changes, in turn, also have significant economic consequences.

The Israeli, Jordanian, and Palestinian governments are now considering options for addressing, and perhaps reversing, the decline of the Dead Sea. All three governments have indicated interest in a canal between the Red Sea and the Dead Sea (henceforth the Red–Dead Canal), and in 2008, the World Bank allocated over $15 million for a feasibility study for the project. The terms of reference for this study require consideration of all options for addressing the loss of the Dead Sea, and call for an economic assessment of the various options (World Bank, 2005). In 2007, a private Israeli academic think-tank, the Shmuel Neaman Institute, published an economic assessment of different options to address the Dead Sea issue, including a "do nothing" option, a Red–Dead canal, returning flows to the Jordan River, and various routes for a canal between the Mediterranean Sea and the Dead Sea (henceforth Med–Dead canal) (Shmuel Neaman Institute, 2007).

The study by the Neaman Institute was secondary research, integrating results of existing economic assessments. Given the massive data needs of the World Bank study, it is extremely likely that this too will simply attempt to assess existing data. Most of the economic studies on the Dead Sea alternatives have focused on the costs of construction of various projects. Relatively little systematic primary empirical research has been conducted into the value of conservation and development of the Dead Sea basin. This study is an attempt to fill in some of the current knowledge gaps regarding these economic values.

The economic valuation described in this chapter is based on survey research conducted in 2002 at the behest of the environmental organization Friends of the Earth – Middle East. Non-market values associated with preservation of the basin for Israeli, Jordanian and Palestinian populations were estimated using both contingent valuation (stated preference) and travel cost (revealed preference) studies. These non-market benefits are then compared with the market value of current uses of water resources, primarily agriculture and mineral extraction. The study finds that opportunity costs of "business as usual," including the loss of environmental quality, infrastructure, and productive land, are substantial.

This chapter continues with a brief outline of some of the primary benefits provided by the Dead Sea and identifies the threats facing these benefits in the future. It then presents an explanation of the study goals and methodologies, followed by discussion of the results of the non-market valuation surveys. A traditional market valuation of damages from use of Dead Sea resources is also presented. In order to place the results in a useful policy context, these damages are compared to assessments of the economic benefits from the two primary causes of the drop in the Dead Sea level: diversion of Jordan River water for use as an agricultural input and mineral extraction. The chapter concludes with a brief discussion of different policy implications for the countries of the region.

2. Economic Background

2.1. EXISTING MACRO-ECONOMIC CONDITIONS

The economies of the nations bordering the Dead Sea are drastically different from one another, reflecting different historical, political and cultural development paths. The issues of most relevance to this study are the differences in levels of income, the importance of tourism and mineral extraction as a source of employment and foreign currency and the chronic water shortages faced by all three parties. Service sectors dominate the economies of all three countries; however, the Israeli economy dwarfs that of its neighbors, both in absolute and per capita terms. The Jordanian and Palestinian economies are of the same order of magnitude and the populations share many of the same cultural and demographic characteristics. Selected demographic and economic indicators are included in Table 1.

TABLE 1. Economic and Demographic Data (World Bank, 2008)

	Israel	**Jordan**	**West Bank and Gaza**
Population 2007, total (millions)	7.17	5.72	3.87
GDP 2007 (current US$ [billions])	161.82	15.83	4.01
GDP 2007 (constant 2000 US$ [billions])	149.36	12.86	3.73
GDP per capita 2007 (constant 2000 US$)	20,825	2,248	965
Employment in agriculture 2003 (% of total employment)	1.9	3.6	n.a.
Employment in industry 2003 (% of total employment)	22.6	21.8	n.a.
Employment in services 2003 (% of total employment)	75.1	74.5	n.a.
Unemployment, total 2003 (% of total labor force)	10.7	15.4	n.a.
Arable land (% of land area)	14.7	2.1	17.8
Arable land (hectares per person)	0.05	0.03	0.03
Arable land (1,000 ha)	317	184	107

West Bank and Gaza population figure is higher than most other estimates.

2.2. BENEFITS PROVIDED BY THE DEAD SEA

Israel and Jordan are similar in terms of use of Dead Sea resources. Both divert upstream waters, have significant mineral extraction industries, and established tourism sectors along the Sea's shores. Palestinian diversions of waters are limited to a relatively small amount of water from the Eastern Aquifer, and the Palestinians have no mineral extraction industry along the Dead Sea. Palestinian tourism is also limited, given current restrictions on movement of Palestinian citizens and lack of sovereignty over any of the shoreline of the Dead Sea. Tourism in the basin is, however, planned by the Palestinian Authority in the event of transfer of sovereignty.

The primary direct market benefits from use of the waters that supply the Dead Sea include provision of drinking water and water for irrigation. The primary direct market benefits produced from the Dead Sea itself include mineral extraction and tourism, both local and international. Much of the economic benefits from tourism in the region, however, are non-market benefits; that is, benefits accrued without direct purchase of goods within the basin; for example, hiking, bird-watching, and photography. In contrast to upstream diversions and mineral extraction, these non-market benefits are primarily based on non-consumptive uses of the Dead Sea's resources.

Upstream diversions of the Jordan River system by Israel and of the Yarmouk River system by Jordan and Syria are responsible for between 60–75% of the loss of the Dead Sea (EcoPeace, 1996; Gavrieli, 2008). These diversions provide the majority of Jordan's current total freshwater supplies and about one third of Israel's.[1] In both cases, the majority of water is dedicated to agriculture, which represents only a small percentage of gross domestic product (GDP) and employment in both countries.[2] The other 25–40% of the loss of the Dead Sea waters has been attributed to evaporation ponds belonging to two mineral extraction factories, one in Israel and one in Jordan (EcoPeace, 1996; Gavrieli, 2008). Each factory is the largest factory in its respective country. Collectively the two directly employ nearly 4,000 people and earn combined revenue of over $1 billion annually (based on figures in APC 2008 and ICL 2008). For Jordan especially, mineral extraction is a major source of foreign currency.

Thousands of tourists, both local and international, visit the region each year. Primary attractions include the historical and cultural heritage of the basin, floating in the hyper-saline waters of the sea, the reputed therapeutic value of the sea's water, the natural features in the surrounding area including unique flora and fauna and a stark desert landscape, and the year-round warm climate.

[1] The amount of water from the Jordan River system consumed by Palestinians is relatively minor in terms of the overall water balance of the Dead Sea.

[2] Agriculture accounted for less than 2% and 3% of gross domestic product in Israel and Jordan respectively in 2007 (Central Bureau of Statistics (Israel), 2008; World Bank, 2008).

Currently over 5,500 hotel rooms exist in the area, with thousands more proposed (FoEME, 1998; CBS, 2008). Tourism in the basin provides roughly 11,000 jobs directly and more indirectly.

In terms of non-market ecological benefits, the Dead Sea basin serves as habitat to diverse desert wildlife, including over 400–450 species of plants and nearly 150 species of animals, many of which are rare and/or endemic (Raz, 1993; Raz and Frumkin, 2004). In addition, Dead Sea levels regulate water table levels and spring flow in the surrounding area as well as land subsidence in the basin.

3. Economic Valuation Methodology

The economic benefit derived from conservation of the Dead Sea is the primary focus of this study. Benefits gained from conservation of the Dead Sea were measured as consumer surplus.[3] This was estimated using two methods. A contingent valuation method (CVM) model using payment cards was used to identify non-use values of conservation, while a zonal travel cost method (TCM) was used to identify direct use value from tourism. The decline in tourism caused by the drop in the sea level was estimated in order to measure only the economic value associated with conservation. Given Palestinians limited access to the Dead Sea and the near absence of control over tourism facilities at the Dead Sea, a travel cost study was not attempted for the Palestinian community. Rather, a benefit transfer approached was used to estimate potential Palestinian use value, based on responses from the Jordanian samples.

A preliminary assessment of defensive expenditures undertaken by parties along the Dead Sea to mitigate and respond to environmental damage from the drop in sea level is also provided. The avoidance of such expenditures in the future, should a conservation plan be successful, would also be included as a benefit of preservation. Unfortunately, because of limited ability to project future damage, only very rough estimates of avoided defensive expenditures were possible.

While this study makes some comparisons between estimates of conservation benefits versus those of continued exploitation of the sea's resources, it does not provide a full benefit cost analysis (BCA) of various conservation plans, given limitations on the precision of estimates, the inability to measure several auxiliary benefits that might come from conservation of the Dead Sea (for example, increased in-stream flows in the lower Jordan) and gaps in scientific knowledge about future impacts on ecosystems, hydrology and geomorphology. Instead, this study compares the identified benefits and costs of both conservation and continued exploitation and draws general conclusions regarding their scale

[3] Willig (1976) established that in many cases consumer surplus can be a good approximation of other forms of welfare such as equivalent or compensating variation.

and regarding potential winners and losers from the alternative policies. The benefits and costs measured and methods used are summarized in Table 2 below.

TABLE 2. Analysis Summary

Benefits and costs estimated	**Method**	**Study populations***
Conservation benefits measured		
Willingness to pay (WTP) for Dead Sea preservation/restoration	Contingent valuation	I, J, P
WTP for Dead Sea recreation	Travel cost	I, J
	Benefits transfer	P
Damage prevention	Defensive expenditures	I, J
Opportunity costs of conservation		
Value of water in agriculture	Replacement costs	I
	Lost producer surplus	I
	Avg. return per unit of water	J, P
Value of water in mineral extraction	Lost profits	I, J

* Study populations: (I = Israeli, J = Jordanian, and P = Palestinian).

4. Valuation of Preservation or Restoration of the Dead Sea Basin

4.1. CONTINGENT VALUATION METHOD

The contingent valuation method (CVM) essentially surveys populations regarding their willingness to pay (WTP) for various benefits. Because CVM does not measure actual market behavior, rather, only stated preferences, some analysts have criticized its use as an estimator of true economic values (see for example Diamond and Hausman, 1994). However, given that few other options exist which can estimate non-use values, use of CVM in public policy and adjudication is widely accepted and, in fact, increasingly popular (e.g., Federal Register, 1993; Freeman, 2003). Empirical evidence has tended to corroborate figures coming from CVM studies. Several studies conducted over the past 2 decades, for instance, have found a close correspondence between results found by CVM and other non-market valuation methods in measuring use values in CVM (e.g., Carson et al., 1996; Freeman, 2003).

Separate contingent valuation studies were conducted in Israeli, Jordanian, and Palestinian communities. Random samples of people from different households were surveyed about socio-demographic characteristics and willingness to contribute annually to a fund to preserve the Dead Sea.[4] Prior to actual field research, the surveys were given to focus groups to ensure that respondents understood what in fact was being asked of them. Actual field surveying was undertaken face-to-face. Before being asked regarding their willingness to pay, respondents were:

- Informed of the importance of the Dead Sea as natural habitat, as a center of cultural heritage and as a recreational spot.
- Told of competing uses for resources of the Dead Sea, including competition for scarce water between domestic use, agriculture, mineral extraction and ecological purposes.
- Informed of the threats facing the future of the Dead Sea and shown a schematic map of the Dead Sea illustrating the loss of surface area at various historical stages.
- Reminded of their budget constraints and of other potentially important and worthy uses of their money.

Finally they were asked to estimate their willingness to contribute to a fund, collected yearly, which would maintain the natural integrity of the Dead Sea.

Accepted practice in the United States, as recommended by a panel of experts studying the use of CVM in public policy recommended a "referendum format" for CVM studies.[5] Such a format poses WTP questions in a format similar to a public referendum taxation or millage question. One of the rationales for such a format was that it best replicates actual decisions that citizens might actually be asked to make. Such a format was not implemented in this study, however, as referenda on public policy issues are rare or non-existent in the study region and therefore, this approach would not have replicated a familiar real-life choice setting. Instead, interviewees were given a payment card with a range of responses and asked to choose their WTP to the proposed Dead Sea conservation fund. The range of the WTP of the payment card was established based on two focus groups. The response given was taken as representing a household level response.

The responses of WTP for annual contribution to a Dead Sea fund were regressed on the socio-demographic variables using ordinary least squares: age, gender, lifestyle (urban/suburban/rural), environmental attitudes (defined as whether or not people surveyed held membership in an environmental

[4] Sample sizes were: 627 Palestinians, 545 Jordanians and 450 Israelis. The Palestinian surveys were conducted in the West Bank only and thus, may be upwardly biased if there exist significant differences in WTP between West Bank and Gaza residents. At least three factors may differentiate Gaza and West Bank WTP: differences in average income, proximity to the Dead Sea, and ability to access another sea/beach. Even if the Palestinian figure is upwardly biased, however, this should not make a substantial difference to the overall WTP for the region.

[5] This panel was chaired by Nobel Prize winning economist Ken Arrow, under the auspices of the National Oceanographic and Atmospheric Administration (NOAA) (Federal Register, 1993).

organization [yes/no]), highest level of education completed (elementary/high school/professional/academic), country or region of origin (Israel/Jordan/Palestine/other Middle East/Europe/North America/Other) and income (in shekels for Israelis and Palestinians and Jordanian dinars for Jordanians). Qualitative data was entered using quasi-interval scaling. Reduced form equations were used to rerun the regressions using only variables statistically significant at the 5% level. The results of both the full and reduced forms are presented in Table 3.

The results of the global *F*-test for joint significance of the independent variables were significant at the 1% level in all cases. The *R*-squared, however, was relatively low for all, indicating that several factors other than those modeled are the primary determining factors for visitation. The regression coefficients were used to adjust the sample responses to the socio-demographics of the countries as a whole to provide an estimated average WTP per household for each country. As it was assumed that contributions would be made on a household basis and not an individual one, the average WTP was multiplied by the number of households in each country to give a total annual WTP for a Dead Sea conservation fund.[6] These figures are provided in Table 4.

Jordan had an especially high number of zero WTP responses (52.2%). Most zero responses were, in fact, identified as protest zeros, i.e., respondents indicated through answers to other questions that they did, in fact, value the Dead Sea, but were unwilling to pay for it. Several possible explanations exist for zero responses in CVM surveys (Kolstad and Guzman, 1999; Freeman, 2003).[7] Because Jordan had such a high percentage of zero responses, multiple estimates of WTP were made. A low-end estimate included the zero responses, while a high-end value was estimated by dropping the zero responses from the sample. A mid-range value was calculated by taking the average of the low and high-end samples.

[6] The relatively high individual WTP by the Palestinian and Jordanian respondents relative to their income is lessened if calculated at a per capita rate rather than by household, due to their larger number of persons per household (5.9 and 5.6, respectively, as compared, for instance, to 3.5 for Israeli households in 2002).

[7] Certainly some respondents may place zero value on the preservation of the Dead Sea, however, many who value the Dead Sea may simply not have believe that the money pledged to a fund would actually contribute to the preservation of the sea. It is also possible that some respondents value the Dead Sea but refuse to state a willingness to pay because they feel it is not their responsibility to fund it, but rather that of the governments, industry, or other parties responsible for the drop in the sea's level. Such "protest zeros" are a common phenomenon (Freeman, 2003) and might be especially expected in situations in which respondents are not used to paying for public goods, do not have faith in the proposed remedy (in this case the effectiveness of the proposed conservation fund), or can identify other agents they feel are responsible for the degradation. Why this occurred especially among Jordanian respondents rather than among Palestinians, who, at a national level, are least culpable for the current situation, is an interesting focus for further research.

In theory, CVM studies should capture both use and non-use values, however, contribution funds formats are unlikely to capture this total value.[8] The CVM study results, therefore, were used primarily to calculate non-use values. An analysis of the Israeli questionnaires estimated that roughly 55% of the stated value of the WTP could be attributed to non-use values. If this ratio is applied to the region as a whole, the mid-range estimate of the total annual WTP for non-use values only would amount to $37,494,000.[9,10]

TABLE 3. Coefficients from CVM – OLS Regression of Willingness to Pay

	Israeli		**Jordanian**		**Palestinian**	
Dependent variable	**Full regression**	**Reduced form**	**Full regression**	**Reduced form**	**Full regression**	**Reduced form**
Age	0.06212 (0.157)		−0.0849 (−1.36)		0.404 (3.017)	
Gender	0.0498 (0.053)		1.602 (−1.128)		1.876 (0.632)	0.393 (3.039)
Lifestyle	−11.578 (−1.352)		3.864 (2.61)	1.429 (3.419)	4.846 (1.894)	
Environmental attitudes	−17.136 (−1.448)		−0.671 (−0.507)		−22.649 (−4.714)	−21.684 (−4.754)
Education	1.893 (0.368)		−1.2 (−1.738)	−2.227 (−1.739)	1.211 (1.256)	
Origin	1.46 (0.241)				−2.718 (−4.714)	
Income	26.84 (4.713)	24.934 (5.321)	3.606 (5.631)	6.131 (10.117)	1.136 (1.129)	
Global F-test	4.418	28.368	6.833	14.777	5.228	14.979
R-squared	0.138	0.111	0.183	0.188	0.063	0.05

The first number in each cell represents the regression coefficient, while the number below in parentheses represents the t-score for each coefficient. Figures for Israeli and Palestinian responses reflect WTP in Israeli shekels ($1 = 4.35 shekels), while Jordanian responses reflect WTP in Jordanian Dinar (JD) ($1 = 0.71 JD). The exchange rates reflect those in effect at the time of the survey. Because of little variation in the variable *Origin* among the Jordanian sample, this variable was dropped for the Jordanian regression.

[8] As we shall see in the following section, the results from the travel cost studies which, in theory, should reflect only use values were in fact, larger than those from the CVM, indicating that the CVM most likely did not capture the full range of benefits accrued.

[9] All dollar figures in this study are in 2007 dollars unless otherwise stated. The dollar figures for survey data were calculated using the exchange rates current at the time of the study and adjusted for inflation according to the U.S. Consumer Price Index (CPI).

[10] Economic theory predicts that people will under-provide public goods (i.e. state a WTP below their true valuation), owing to their ability to “free-ride” or gain benefits from the provision of public goods from others’ contributions. Given that many of the benefits of the conservation of the Dead Sea are public goods, contributions to the proposed conservation fund may, in fact, be a lower-bound estimate of their true economic value (Champ et al., 1997).

TABLE 4. Average Adjusted Annual WTP for Dead Sea Fund

Country	**Avg. adjusted WTP (per household) (2007 US$)**	**Estimated number of households (2002)**	**Estimated national WTP (total in millions of 2007 US$)**
Israel	$26.58	1,819,700*	48.37
Jordan (low)	$9.67		8.64
(midrange)	$15.12	893,500**	13.51
(high)	$20.57		18.38
Palestine	$10.93	575,736***	6.29
TOTAL (low)			63.30
(midrange)			68.17
(high)			73.04

* Central Bureau of Statistics (CBS) – Israel (2003).
** Jordanian Department of Statistics (2003) – http://www.dos.gov.jo/jorfig/2001/jor_f_e.htm.
*** Palestinian Central Bureau of Statistics (2003).

4.2. TRAVEL COST METHOD

The travel cost method calculates WTP for a recreational destination based on the expenditures people make in order to access the site. For the Dead Sea region, travel cost studies were conducted by surveying samples of 154 Israeli and 200 Jordanian visitors at tourist centers within the basin, regarding travel expenditures, opportunity costs and socio-economic characteristics.[11] For each country, five independent variables were used to explain visitation: age, education, income, number of adults accompanying the respondent, and travel cost. As travel cost is a function of distance from the site, visitors were categorized according to the geographic origin of their trip. Israel was divided into seven zones differing in distance to the Dead Sea, and Jordan divided into six. Cost of arrival at the Dead Sea was assumed to be identical within each zone. For both countries, the distance of trip origin to the Dead Sea was strongly negatively correlated with the number of visits per capita ($p < 0.05$).

Total travel costs of the trip were calculated according to the following equation:

$$\text{Eq. (1): } C_i = \left(W/4 * T_{iz} \right) + \left(KM_{iz} * P * 2 \right)$$

[11] As mentioned, a Palestinian travel cost study was not undertaken because Palestinians do not have control over tourist facilities along the Dead Sea shores and because the movement of Palestinians was restricted at the time of the study. International tourists, who make up the majority of visitors to the region, were also not surveyed because political violence during this period largely affected the scale and type of tourists present.

Travel cost, C, included both actual expenditures and opportunity costs associated with travel to the Dead Sea. Following accepted practice, opportunity costs were estimated by taking one-quarter of forgone wages, W.[12] Since visitors were not surveyed about their income, average salary national salaries were taken and prorated on an hourly rate, based on a work week of 180 h.[13] This was then multiplied by the average trip duration from each home region, T, measured in hours. Actual out of pocket expenses for travel were calculated by multiplying the twice the distance of the relevant zone of origin from the Dead Sea, KM, measured in kilometers, by the average cost of petrol per kilometer, P, measured in shekels/km for Israel and JD/km for Jordan.[14] The subscripts i and z represent the individual visitor and zone of origin, respectively.[15]

4.2.1. The Israeli travel cost study

Of the five variables evaluated only travel cost differed at the 95% significance level manner between regions. Results of regressions of visitation rates on travel cost and on the log of travel cost for Israelis are presented in Eqs. (2) and (3), respectively:

$$\text{Eq. (2): } V_{\mathrm{i}} = 1.55 - 0.00085(TC_{\mathrm{i}}) \ (R^2 = 0.895)$$
$$(7.329) \ (-6.531)$$

$$\text{Eq. (3): } V_{\mathrm{i}} = 4.622 - 1.413 \ln(TC_{\mathrm{i}}) \ (R^2 = 0.991)$$
$$(24.967) \ (-23.703)$$

where V = the number of visits annually, TC = average travel cost and i represents the individual surveyed. The numbers given in parentheses below the coefficient parameter estimates represent the estimate t-values.

The negative coefficient on travel cost indicates that the frequency of visits per capita decreases as the trip cost increases, and the high R-squared values imply that travel cost explains much of the variance in visitation rates. Taking

[12] In a survey of Travel Cost methodology, Freeman (2003) notes that researchers commonly use a fraction of wages ranging from one-third to one-quarter; thus, our choice of one-quarter represents a lower end estimate.

[13] Average Israeli salary at the time of the survey was estimated as US$1582 per month (CBS, 2003), while that of Jordan was US$174.

[14] Average cost per kilometer of travel was obtained from local accounting firms. The average cost per km for travel in Israel at the time of survey was 1.92 shekels, while the average cost in Jordan was 0.18 JD. The number of kilometers traveled to the Dead Sea was multiplied by two to reflect a round trip visit.

[15] Because on average Israeli visitors spent 33 h at the Dead Sea per visit, the average price of one night of lodging for the average family size was included in the calculation of the Israeli travel cost. For Jordanians, the average stay at the Dead Sea was 17.8 h for each visitor. Because the average stay was under 24 h, the cost of a night's stay in a hotel was not included in the travel cost. Since, many tourists do, in fact, spend the night, this implies that the travel cost estimate may be biased downward.

visitation rates as a function of travel cost, consumer surplus for Israelis at the Dead Sea was estimated at $178 million.[16]

4.2.2. The Jordanian travel cost study

Similar methods were used for the Jordanian travel cost study. In contrast to the Israeli study, several variables in addition to travel cost were found significantly to influence the number of visits per capita. Because of this, all variables found to differ significantly among regions were utilized to calculate a Jordanian demand curve for visitation. The results of this regression are presented in Eq. (4):

$$\text{Eq. (4): } V_{\mathrm{i}} = 2.032 - 0.002(TC) - 0.179(Ed) - 0.218(Inc) - 0.166(\text{Adults}) \quad (R^2 = 0.99)$$

$$(18.709)\ (-11.866)\ \ (-7.373)\ \ (-8.465)\ \ (-20.842)$$

Again, V = number of visits annually, TC = travel cost, Ed = education, Inc = average regional income and $Adults$ = number of adults accompanying the person surveyed on this trip. The WTP for visits by those surveyed was adjusted to represent the socio-demographics of the population at large. This enabled construction of a reduced form demand curve for Jordanian recreation, presented in Eq. (5):

$$\text{Eq. (5) } V_{\mathrm{i}} = 224{,}456.1 - 1042.502(TC_{\mathrm{i}}) \ (R^2 = 0.92)$$

$$(34.953)\ (-0.24.018)$$

Using this demand curve, total annual consumer surplus for Jordanians visiting the Dead Sea was estimated at $27.9 million.[17]

4.2.3. The Palestinian travel cost estimate

Because the Palestinian Authority (PA) does not control any areas in the West Bank that abut the Dead Sea and because of travel restrictions on the Palestinians at the time of the study, travel cost estimation was not undertaken for the Palestinian population. Leaving the Palestinians out of the travel cost study, however, would wrongly imply a zero value for potential benefits of travel to the Dead Sea. To address this issue, a benefits transfer approach was used to estimate Palestinian WTP, using estimates from the Jordanian travel cost study. Such an approach is supported by similarities in cultural and demographic characteristics between Jordanian and Palestinian populations. The ratios of 2002 GDP to national WTP in the CVM study for the Palestinian and the mid-range Jordanian estimates were similar. Assuming that the ratio of GDP to WTP for travel to the Dead Sea is also similar between Palestinians and Jordanians, the Palestinian travel benefits would amount to $21.3 million

[16] Using an exchange rate of US$1 = 4.347 Israeli shekels.
[17] Using an exchange rate of US$1 = 0.71 Jordanian dinars.

annually. Alternatively, assuming that the Palestinians have a ratio of TCM to CVM results identical to that of the Jordanians gives an estimate of Palestinian travel benefits of $12.9 million annually. Thus, a range of $12.9–21.3 million per year is an approximate estimate of what a Palestinian travel cost study might have produced if the Palestinian population had access to the Dead Sea for recreational purposes.

4.2.4. International travelers and travel cost studies

A large share of the tourism in the Dead Sea region consists of international tourists. The study did not attempt to assess a travel cost value for international tourists even though they constitute a large share of the tourism in the area, due to uncertainties regarding the future of tourism in the region and the questions regarding how representative any sampling might be at the time of the surveys. Because of their numbers and expenditures, however, annual WTP for international tourists is likely to be significant.

4.2.5. Total welfare benefits from travel cost studies

The consumer surplus from locally-based tourism, the sum of the Israeli, Jordanian and Palestinian[18] estimates, amounts to nearly $223 million per year (see Table 5). Clearly, the entire consumer surplus from tourism cannot be considered as a benefit of conservation of the Dead Sea region, as many tourists will continue to come even as the sea recedes and springs dry up. Estimates based on survey data from the travel cost and contingent valuation studies, indicated that a drop in visitation rates by local tourists of 0.67% per year can

TABLE 5. Average Adjusted Annual WTP from Travel Cost Surveys

Country	**Estimated annual national WTP (Total in millions of 2007 US$)**
Israel	178.0
Jordan	27.9
Palestine (low)	12.9
(midrange)	17.1
(high)	21.3
TOTAL (low)	218.8
(midrange)	223.0
(high)	227.2

[18] Using the average of the two Palestinian travel cost estimates, US$17.12 million per year.

be attributed to the drop in the sea level and the associated damage caused by this drop. If consumer surplus is assumed to drop at the same rate for 60 years then the loss in consumer surplus for domestic travelers caused only by the drop in sea level would be $821 million, using a discount rate of 3%.[19] This amounts to an average of slightly over $13.7 million per year in present value terms as the economic loss to visitors of the Dead Sea only from the further degradation of the Dead Sea from its current status and does not include the losses already incurred, nor does it include the loss in consumer surplus of international visitors.

4.3. MARKET VALUATION OF ENVIRONMENTAL DAMAGE FROM USE OF DEAD SEA RESOURCES

An additional benefit resulting from conservation of the Dead Sea may be avoided damages and defensive expenditures. Sinkholes, forming as a result of falling water levels, have already resulted in damage to roads, infrastructure and private property on both shores. Over 1,700 sinkholes have been recorded on western shore alone and the rate of sinkhole formation is increasing with the continued drop of water levels (Rinat, 2007). A complete assessment of future damages would be highly speculative as we are only now beginning to witness the types and scale of damages. A description of some of the damages already experienced is, however, provided below.

Forgone revenues from agricultural lots, primarily date palm plantations, impacted by the sinkholes are already a reality in both Israel (e.g., Ein Gedi) and Jordan (e.g., Ghor Haditha). In Jordan, the average area impacted exceeded 50 dunums. Attempts by the Jordanian government to fill the sinkholes have been largely unsuccessful and most damaged lots have simply been abandoned. In Israel, over 6 km^2 have already been impacted. Lost income as a result of both the inability to work plantations already damaged and the cost of planting new crops already reaches several million, if not tens of millions, of US dollars in present value terms.

In Jordan, many hotels have already spent tens of thousands of dollars each to halt beach erosion and stabilize newly-exposed shores. In Israel, the tourism industry is largely concentrated along large evaporation ponds with water levels regulated by the Dead Sea Works and, therefore, are less directly affected by the deterioration of the Dead Sea. Israeli plans to develop up to 5,000 new hotel rooms along the northern shore were frozen, however, in part due to fear of sinkhole formation. This would have doubled the existing number of hotel rooms and provided roughly 10,000 jobs (FoEME, 1998). In addition, plans for

[19] The mid-range estimate of consumer surplus, US$222 million, was used for this calculation. A discount rate of 3% was used, rather than actual market interest rates, in order to reflect a social discount rate as is common in economic analysis of public goods.

residential development in the area remain on a tentative basis only, again, in part due to the receding of the sea and to sinkhole formation.

Transportation infrastructure including both roads and bridges are at risk both from sinkhole formation and from changes in the flow regime of the seasonal streams and the widening of their beds. Stretches of the main highway on the Israeli side are in danger of collapsing and the road will need to be repaved at a higher topographical level. The cost of repaving is over $1 million per kilometer. Already one bridge has collapsed. The cost of its redesign and reconstruction was estimated at roughly $3.5 million.

In sum, only crude estimates of the non-market economic benefits from avoided environmental damage are possible. It is clear that the potential scale of these benefits is large, potentially tens or even hundreds of millions of dollars of damages and forgone benefits annually. What is unclear, however, is what effect conservation and restoration of the Dead Sea level will have on the rate of formation of sinkholes. According to geologists familiar with the phenomenon, stabilization of the sea levels is unlikely to eliminate sinkholes, but may slow the rate of their formation (Gavrieli, 2008).

5. Opportunity Costs of Conservation: Benefits of Maintaining the Status Quo

In order to provide context for the economic value found for conservation of the Dead Sea, one can compare it to sectors that could be adversely affected by certain conservation measures. The primary factor affecting the sustainability of the Dead Sea basin is lack of traditional water supply. This study therefore now turns to a valuation of the two sectors with the largest impact on the water balance of the Dead Sea: agriculture and mineral extraction.

5.1. ASSESSMENT OF THE ECONOMIC VALUE OF WATER IN AGRICULTURE

The primary cause of depletion of the Dead Sea is the abstraction of water from the Jordan River system. The Jordan River and its tributaries serve as the main surface water system in the region, providing Jordan with the majority of its overall water supply and Israel with roughly one third of its total freshwater supply (NAS, 1999). While the Jordan system is not currently a primary source of water for the Palestinian community, the Eastern Aquifer, which drains into the lower Jordan, nevertheless represents an important source for those living in the Jordan Valley. Furthermore, according to international agreements such as the Oslo Peace Accord, this aquifer is to be the primary natural water source for the Palestinian community in the future, given its location almost entirely within the West Bank.

Agriculture is the largest consumer of water in the region. Several methods exist to estimate the value of water for agriculture.[20] Since the focus of this study is ultimately to see the potential for restoring most or all of the natural flow of the Jordan River to the Dead Sea, one method would be to estimate the cost of replacement of water taken from farming with water from an alternative source. Israel has the option to desalinate water in amounts equal to that supplied by the Jordan River system. The cost of production of desalinated water of sufficient quality for agriculture has been estimated at $0.50/m^3 to $0.60/m^3 (Dreizin, 2006). Historically the Jordan River system supplies Israel with roughly 500 million cubic meters (MCM) annually on average. Replacement of this entire amount with desalinated water would come to a cost of $250–300 million. This figure most likely grossly overestimates the actual value of water as an input in agriculture. It is useful, however, as an upper bound estimate.

The fact that, as a sector, agriculture has not fully exploited its allocation of freshwater over the past decade (Blitz et al., 2002), even at subsidized prices, can be seen as evidence that water is in effect a price-rationed, not a quantity-rationed good (Kislev, 2001). If this is in fact the case, then the production cost price of roughly $0.20 can be seen as reflecting the marginal value of water in agriculture. Assuming a close-to-constant marginal benefit curve at this price would entail zero surplus from water. Thus, the range of values for Jordan River water in agriculture is between zero and $300 million annually. An intermediate figure of $150 million per year is likely to be a reasonable estimate, given reasonable assumptions about the elasticity of demand.

Most of Jordan's irrigated agriculture is located in the Jordan Valley. The amount of freshwater allocated annually for irrigation in the Jordan Valley is roughly 200 MCM, of which nearly 150 MCM is from surface waters (i.e. the Jordan River system, primarily from its main tributary the Yarmouk) and the rest from groundwater. No attempt to calculate the replacement costs of water to agriculture were made as they are almost certainly prohibitively high and thus, would not reflect the actual value of water in agriculture there.

Historically, water has been sold to farmers at highly-subsidized rates (FAO, 2003) that do not reflect the true value of the scarcity value of water and which have led to wasteful irrigation practices and low efficiency in terms of production per unit of water. One estimate placed average return on irrigation water at $0.0714/m^3, based on typical returns of net revenue per unit of water for various fruits and vegetables (Al Weshah, 2000). Using this figure, the return on water in agriculture in the Jordan Valley would be roughly $18 million annually.[21] Such values however, likely underestimate the value of agriculture as a whole, which would suffer if it ceased to have access to the

[20] See Young (2005) for a survey of methods.

[21] This figure values treated sewage as the same as freshwater. Excluding treated sewage, the return on water is estimated at US$14 million.

water. Furthermore, Magableh (2003), citing Jordanian Department of Statistics data, offers significantly higher values for the economic return on water in agriculture. Thus, such figures can be seen as a lower bound estimate.

An alternative method for valuing the use of water in agriculture would be to include the total producer surplus produced by irrigated agriculture in the Jordan Valley, since allowing the water to flow to the Dead Sea would be likely to mean the desiccation of much of the valley's agricultural fields. To this one could add also depreciation in the land if irrigation is not possible. Data for such calculations was unavailable; however, according to World Bank figures, the value added of all agriculture in the country as of 2007 was $410 million (World Bank, 2008). Such a figure relates to all agriculture, including rain-fed agriculture throughout the entire country. Therefore, it does not represent the value of irrigated agriculture from Dead Sea tributaries only; but it can, serve as an upper bound estimate of the value of water in agriculture in Jordan. Taking an average of the upper bound and lower bound estimates gives a figure of $214 million per year.

Palestinian water use in agriculture, while important to local economies and livelihoods, has a relatively minor impact on the overall water balance of the Dead Sea. Only one-quarter of Palestinian agriculture in the Jordan Valley is irrigated, accounting for approximately 56 MCM of water.[22] Irrigated crops, however, represent the overwhelming share of the value added by the region's agriculture (PCBS, 2002; Palestinian Ministry of Agriculture, unpublished data). Using available data from the 1999/2000 agricultural years (the last available reliable data), and adjusting for inflation, the total value added from irrigated crops for Palestinian areas in the Jordan Valley amounted to $60 million. This figure, then, represents a rough estimate of the annual value of Palestinian irrigation water affecting the Dead Sea.

Summing the values of all three countries, a mid-range estimate of the overall annual return on agricultural water from the Jordan River system is $424 million (Table 6).

5.2. ASSESSMENT OF THE ECONOMIC VALUE OF THE DEAD SEA MINERAL EXTRACTION INDUSTRY

By intentionally accelerating the natural evaporation of the Dead Sea's waters through construction of shallow evaporation ponds, the companies are able to collect, process and refine the sea's minerals. Primary mineral products include potash and potash fertilizers, bromides and magnesium. As noted above, the

[22] It should be noted that the extent of Palestinian agriculture is constrained by restricted access to water imposed by the Israeli government; thus, the estimates of the value of water in agriculture represent current uses, rather than use resulting from free-market processes.

Dead Sea Works and the Arab Potash Company collectively employ nearly 4,000 people and earn combined annual revenue of over $1 billion.

In the case of the Dead Sea mineral industries, isolating the value of water as an industrial input is not practical, if indeed, it is at all possible. Therefore, to assess the value of water for the mineral extraction, we estimated the producer surplus of the industry as a whole. In 2007, the Arab Potash Company (APC) took in revenues of $253 million and its annual pre-tax profits were $137 million (APC, 2008). Current data on the Dead Sea Works (DSW) was unavailable as the company is now a fully owned subsidiary of Israel Chemicals Ltd. (ICL) which does not publish separate financial data for its Dead Sea holdings. DSW's annual revenues in 2002 were $450 million (Dead Sea Works, 2003). If one assumes that DSW revenues grew at a rate similar to that of APC's, i.e., 79% between 2002 and 2007 (APC, 2008), DSW's 2007 revenues would be $804. Assuming that DSW's gross profit margin is similar to that of ICL as a whole, 37%, DSW's 2007 profits would be $298. Thus, total producer surplus from the Dead Sea mineral extraction industry, estimated as the gross profits of APC plus those of DSW, would be $435 million annually (Table 6).

TABLE 6. Annual Return on Dead Sea Waters in Agriculture and Mineral Extraction

Country	**Estimated annual return on water in agriculture (million 2007 $)**	**Estimated annual profits from Dead Sea mineral extraction (million 2007 $)**
Israel (low)	0	
(mid-range)	150	137
(high)	300	
Jordan (low)	18	
(mid-range)	214	298
(high)	410	
Palestine (low)		
(mid-range)	60	
(high)		
TOTAL (low)	**78**	
(mid-range)	**424**	**435**
(high)	**760**	

6. Policy Implications of Economic Assessment

The environmental damage affecting the Dead Sea has attracted significant attention by political leaders, media, the international financial community, and the public at large. To date, however, the economic value of the preservation of the Dead Sea and its environs has largely been overlooked in regional development planning. This study provides a preliminary assessment of public perceptions of the value of preservation. All three local populations expressed a significant willingness to pay for conservation of the Dead Sea basin, despite great variation in economic means. Perceived benefits of such conservation efforts include preservation of aesthetic, ecological and historical values and avoidance of damage to infrastructure and private property in the basin. The figures provided in this study do not include the value placed on conservation by the international community, and thus, should not be seen as an estimate of the total value of preservation, but rather, a lower bound. Given the unique natural and cultural heritage of the area and the large number of international visitors that have traditionally come to the region, actual WTP for conservation of the basin is likely to be significantly higher.

The opportunity costs of preserving and/or restoring the Dead Sea level would be likely to involve limiting the upstream abstraction of water from the Jordan River system and altering the mineral extraction activities of industry in the basin. Together these sectors bring in hundreds of millions of dollars annually. This study does not attempt to assess all of the benefits of restoration of the Dead Sea, and provides only very broad estimates of benefits and costs calculated.[23] It should not be seen, therefore, as a thorough Benefit–Cost Analysis. In addition, environmental awareness in the region is only just beginning to develop. Administering a survey at any one point in time gives only a snapshot of social preferences, but does not provide any indication of trends or changes in these preferences. Sensitivity to rapidly changing parameters, such as environmental awareness and preferences, should be taken into consideration when considering policies with long term implications.

From the estimates made herein, it is possible to make a few tentative conclusions, however. First, preservation of the Dead Sea is a public good with substantial benefits shared by all three peoples of the region, as well as by international tourists. Secondly, the benefits of sectors that consume the Dead Sea’s waters are also substantial, and perhaps even larger than those of preservation. Thus, if the preservation of the Dead Sea is adopted as a policy goal for political, moral, or ecological reasons, it should be done in a manner that does not completely threaten agriculture and mineral extraction.

Two points should be taken into account, however. The first one is that international visitors were not taken into account. This is true both in terms of use and non-use value. It is estimated that including them may double the benefits or more. The second point is that estimates are presented on an annual basis. However, the time span of the mineral extraction is finite, while those

[23] For instance, the study does not include the costs of developing and implementing an actual restoration plan, the WTP of the international community, the benefits of restoration of the Jordan River itself, if restoration flows were restored, and both positive and negative externalities from irrigated agriculture (for example, the preservation of open space and pollution to groundwater and wildlife caused by pesticides), to name but a few.

associated with preservation not only will continue for a much longer time frame but would likely also increase over time. These two points might well turn the net benefit sign from negative to positive, but a more definitive determination on this matter would entail future study.

The authors feel that under the present conditions, efforts should be concentrated on finding solutions that would allow a coexistence of policy goals, to the extent possible. In terms of water conservation, such an effort may concentrate, for instance, on developing methods for mineral extraction that do not depend on accelerated evaporation, accelerating the use of drip irrigation and reclaimed wastewater throughout the region, domestic water conservation projects, and leakage repairs on aging infrastructure. In terms of the Dead Sea, it would be prudent to begin identification of critical or highly valued areas for conservation within the Dead Sea basin that can be attained at much lower opportunity costs than would complete restoration.

Another insight gained from this study is that, while all three countries have potential gains and losses from conservation as well as continued exploitation, these gains and losses are not distributed equally across countries. Palestinians, for instance, presently contribute relatively little to the current degradation of the Dead Sea, but highly value its conservation. They will also be likely to incur fewer costs if the region is preserved. In relative terms, Jordanians have the most at stake if resources were denied to agriculture and mineral extraction in favor of conservation. Israelis, who predictably, based on their larger average income, have the highest WTP for conservation, also have many other options for both productive agriculture and industry. Also, international tourists have a minimal effect in terms of their contribution to the drop of the Dead Sea level, but likely have a substantial interest in its preservation. These disparities in costs and benefits should inform policies regarding relative cost sharing for whatever preservation policies are ultimately pursued.

References

Al Weshah, R., 2000. Optimal use of irrigation water in the Jordan Valley: a case study, *Water Resources Management*, 14(5): 327–338.

Arab Potash Company, 2008. *Annual Reports*, 1999–2007; http://www.arabpotash.com.

Becker, N., 2001. *Strategy of Water*. unpublished manuscript (in Hebrew).

Bein, A., 2003. Personal communication.

Blitz, N., Shoratz, D., and Nuessbaum, S., eds., 2001. *Water in Israel: Consumption and Production 2001*, Water Commission (Israel), Ministry of Infrastructure. December.

Carson, R., Flores, N., Martin, K., and Wright, J., 1996. Contingent valuation and revealed preference methodologies: comparing the estimates for quasi-public goods, *Land Economics*, 72(1): 80–99.

Central Bureau of Statistics (CBS) (Israel), 2003. *Statistical Yearbook of Israel, 2002*, Jerusalem.

Central Bureau of Statistics (Israel), 2008. http://www.cbs.gov.il/.

Champ, P., Bishop, R., Brown, T., and McCollum, D., 1997. Using donation mechanisms to value nonuse benefits from public goods, *Journal of Environmental Economics and Management*, 33(2): 151–162.

Dead Sea Works, 2003. http://www.dsw.co.il.

Diamond, P. and Hausman, J., 1994. Contingent valuation: Is some number better than no number? *Journal of Economic Perspectives*, 8(4): 455–464.

Dreizin, Y., 2006. Ashkelon seawater desalination project – off-taker's self costs, supplied water costs, total costs and benefits, *Desalination*, 190: 104–116.

EcoPeace, 1996. *Dead Sea Challenges*, Jerusalem.

Food and Agriculture Organization (FAO) of the United Nations, 2003. *Aquastat – FAO's Information System on Water and Agriculture*; http://www.fao.org/ag/agl/aglw/aquastat/countries/jordan/index.stm.

Federal Register, 1993. Vol. 58, 4016–4614, Office of the Federal Register, National Archives and Records Administration (NARA), Washington, DC.

Freeman, A.M., 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*, 2nd edition, Resources for the Future Press, Washington, DC.

Friends of the Earth-Middle East (FoEME), 1998. *One basin, one strategy, Final Report of the Symposium on Promoting an Integrated Sustainable Regional Development Plan for the Dead Sea Basin*. Jerusalem.

Gavrieli, I., 2008. Presentation given at the Knesset (Israeli Parliament). 17 November.

Israel Chemicals Limited (ICL), 2008. *Harnessing Nature Creating Value: 2007 Annual Report*, ICL Group.

Jordanian Department of Statistics, 2003. http://www.dos.gov.jo/dos_home_e/main/index.htm and http://www.nra.gov.jo/mining/mining_sector_in_jordan.htm.

Kislev, Y., 2001. The water economy of Israel. Paper prepared for the Conference: *Water in the Jordan Valley: Technical Solutions & Regional Cooperation*, University of Oklahoma, International Programs Center, Center for Peace Studies, Norman, Oklahoma, 13–14 November 2001.

Kolstad, C. and Guzman, R., 1999. Information and the divergence between willingness to accept and willingness to pay, *Journal of Environmental Economics and Management*, 38(1): 66–80.

Magableh, S., 2003. unpublished report and personal communication.

National Academy of Sciences (NAS) (1999). *Water for the Future: The West Bank and Gaza Strip, Israel and Jordan*, National Academy Press, Washington, DC.

Palestine Economic Pulse, 1996. *Palestinian Economic Forum*. November.

Palestinian Central Bureau of Statistics (PCBS), 2002. http://www.pcbs.gov.ps/.

Palestinian Central Bureau of Statistics (PCBS), 2003. *Impact of the Israeli Measures on the Economic Conditions of Palestinian Households*, 5th Round, April–May.

Raz, E., 1993. *The Dead Sea Book*, Israel Nature Reserve Authority & Tamar Regional Council, Jerusalem (in Hebrew).

Raz, E. and Frumkin, R., 2004. *Ecology and Natural and Human Environment*, draft background paper on the Dead Sea for the Jerusalem Institute.

Rinat, T., 2007. Dead Sea Level Drops, Hundreds of Sinkholes Threaten Shore, *Haaretz*, 5 June. (in Hebrew).

Shmuel Neaman Institute, 2007. *Decline of the Dead Sea Level: Alternatives in Action*, Shmuel Neaman Institute, Haifa (in Hebrew).

Willig, R., 1976. Consumer's surplus without apology, *American Economic Review*, 66(4), 589–597.

World Bank, 2002. *World Development Indicators 2003*, Washington, DC.

World Bank, 2003. *World Development Indicators 2004*, Washington, DC.

World Bank, 2005. *Red Sea–Dead Sea Water Conveyance Project – Feasibility Study – Environmental, Technical and Economic and Environmental and Social Assessment – Terms of Reference*, http://siteresources.worldbank.org/MENAEXT/Resources/RDS-TOR-18_July2007.pdf?resourceurlname=RDS-TOR-18_July2007.pdf.

World Bank, 2008. *World Development Indicators*, http://web.worldbank.org/WBSITE/ EXTERNAL/DATASTATISTICS/0,,contentMDK:20398986~menuPK:64133163~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html.

Young, R.A., 2005. *Determining the economic value of water: concepts and methods*, Resources for the Future, Washington, DC.

CONSTRUCTING AN ADAPTIVE REGIONAL VISION OF WATER DEVELOPMENT IN THE JORDAN RIVER BASIN

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Abstract: In response to the Middle Eastern regional water crisis and a World Bank Study underway to evaluate the feasibility of building a Red Sea–Dead Sea water conveyance, the AVOW (Adaptive Visions of Water in the Middle East) initiative has outlined components of an adaptive regional vision of water development for the Jordan Basin. The authors, leading members of AVOW, reflect on the vision with respect to its scalarity, flexibility and multi-lateral character and coordination. They argue that water development should be guided by cross- and trans-boundary considerations, apply diverse technologies, draw upon regional and international expertise, be partially shaped by political efforts to foster regional cooperation and by international development agencies, build upon existing structures of regional cooperation, engage civil society groups and involve local communities. They articulate a vision rooted in diverse sources of knowledge, noting lessons learned and areas requiring additional research.

Keywords: Adaptive development; Integrated Water Resource Management (IWRM); sustainable development; alternative development; Water Demand Management; Red Sea–Dead Sea Canal; Jordan River; Middle East Region; Israel; Palestinian Authority; Jordan; regional cooperation; transboundary; civil society; stakeholder participation; community engagement; knowledge; multi-scalarity; education

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1. Introduction

As the 21st century unfolds, it is clear that water management will become increasingly critical and challenging for Jordan, the Palestinian Authority (PA) and Israel. Population in the region is growing – faster than the rate of growth of world population. Agriculture, which accounts for most water use in the region, remains vital to its economic and community development. Large and small industries require water of various qualities to operate. Water use is already severely restricted in Jordan and the Palestinian Authority, and is contentious in Israel.

Mounting pressures on the demand side are compounded by a host of problems on the supply side. Already, water withdrawn from coastal and mountain aquifers exceeds what rainfall replenishes, and aquifers of 'ancient' fossil water only offer partial and temporary relief. The Jordan River carries a fraction of the water it did 40 years ago, and the Dead Sea is shrinking. Furthermore, climate change projections forecast drought and insecurity. To make matters worse, existing water supplies are vulnerable to contamination by sewage, other waste and salt water infiltration.

These conditions pose a challenge, not simply to any one party and its particular water management agency, but to the region as a whole. When European colonialism left behind new Middle Eastern states, each one undertook unilateral development of the water sources it was able to control. Water, however, flows without regard for sovereign boundaries. It flows underground as well as above ground, further complicating management efforts. Nevertheless, it is often to used to delineate borders, and all the adjacent countries share an interest in the Jordan River, the Dead Sea, the Red Sea and the Mediterranean. Under these conditions, as in similar cases elsewhere, separate interests in managing this essential resource are at once a source of tension, creative friction (Tsing, 2005) and an opportunity for cooperation (Assaf, 2006: 237; Wolf, 1996).

There is a history of regional water negotiations as far back as the Johnston Plan of the 1950s (Allan, 2001: 78; Lowi, 1993). It set the tone with informal arrangements between Jordan and Israel, which were eventually formalized with the Jordanian–Israeli Peace negotiations. Water has also emerged as a major focus of Palestinian–Israeli negotiations.

Given the regional character of the water crisis, with international and globalized dimensions, it flows that an appropriate response will be multi-scalar, while predominantly regional, building on past diplomatic efforts, bi-lateral successes and transboundary civil society activities. At the very least, this would entail Israelis, Palestinians and Jordanians working together with some others from the region and internationally in an effort to formulate an integrated, regional, concerted, flexible and thus *adaptive* vision of water management in the Jordan River basin. This article will draw on our ongoing experience with AVOW (Adaptive Visions of Water in the Middle East), a group of regional and international practitioners and academics who have worked towards the development of such a vision.

2. Organizing an Integrated Regional Response

The AVOW project was organized in 2006, following a NATO-sponsored conference on "Integrated Water Resources Management and Security in the Middle East" held at the Arava Institute for Environmental Studies. AVOW aimed to promote an integrated regional perspective in response to the national and regional water challenges.[1] The immediate context was concern over the proposed multi-billion dollar, decades-long, World Bank-financed construction project to build a water conduit from the Red Sea to the Dead Sea. In theory, the pipeline would provide water to replenish the Dead Sea, and for desalination using hydropower generated from the drop in elevation (Al-Alem, 2002; Arkin, 2000; Asmar, 2002, 2003; Benveniste, 2004; Bromberg, 2004; Gavrieli and Bein, 2004; Gavrieli et al., 2005; Gertman, 2002; Lipchin, 2004; Moshen, 1998, 2007; Wolf and Murakami, 1995; Murakami, 1995; Nissenbaum, 1993; Oren, 2004; Yechieli, 1998; Zilberman, 1984). This is the most recent of many proposals stemming back to the mid-1800s to build a canal from either the Red Sea or the Mediterranean to the Dead Sea (Gavrieli et al., 2005: 8; Asmar, 2003: 331–333).

As of 2006, the World Bank has been making plans for a "feasibility study" for the project, at the request of the Beneficiary Parties – Israel, Jordan and the Palestinian Authority. What was known of the plans for the "feasibility study" neither integrated the proposed "water conveyance" into a larger water strategy for the region, nor recommended that other responses reflecting a regional concern about water receive equivalent attention.[2] Building on the interest in investigating alternatives to the Red–Dead Canal expressed by many at the aforementioned conference, two researchers at York University (Canada), with the support of the Centre for International and Security Studies and the Institute for Research and Innovation in Sustainability, approached regional partners.

The AVOW initiative was formed as a result of these discussions, with participants from Israel, Palestine, Jordan and abroad. The steering and advisory committees were composed of university-based researchers, civil society researchers and independent experts. The institutional partners were the Arab Scientific Institute for Research and Transfer of Technology (ASIR), the Arava Institute for Environmental Studies (AIES), the Israel–Palestine Center for Research and Information (IPCRI), Peacemedia-paixmedia, the Water and

[1] www.yorku.ca/avow/.

[2] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT/0,contentMDK:20664264~pagePK:146736~piPK:146830~theSitePK:256299,00.html.

Environment Development Organization (WEDO) as well as York University's Centre for International and Security Studies (YCISS) and Institute Research and Innovation in Sustainability (IRIS).

Within the group, discussion soon moved from initial concern over the development of alternatives to the Red–Dead conduit to a focus on the broad range of possible responses to the challenge of sustainable water management in the region. At the same time, other regional water initiatives were taking place. Friends of the Earth Middle East (FOEME), which has various regional environmental initiatives, has been actively promoting restoration of the Jordan River as an alternative to the Red–Dead conveyance.[3]

Regional civil society organizations have expressed skepticism about the water conveyance proposal, including notably, at public consultations on the project hosted by the World Bank in the region in 2007.[4] A subsequent 2007 conference on the Dead Sea[5] provided a forum for Israeli, Jordanian, Palestinian and international experts to share information and examine multiple proposals.[6]

After working on AVOW for over a year, we have reached a number of conclusions. While various technical solutions figure in what follows, the emphasis here is on the benefits and quality of stakeholders' involvement and the process of articulating and implementing responses (Adger, et al., 2006; Pahl-Wostl et al., 2007; Rogers, 2006; Turton, 1999). The themes that run through the following sketch of an integrated, adaptive, regional response to concern over water are: the importance of openness to a wide range of solutions, strategic integration of possible responses, and promoting social mobilization and cross-scale trust among political institutions, experts, civil society organizations and local communities.

3. Elements of an Integrated Regional Response

We see an adaptive, regional response to the regional water challenge as having a number of elements, each described in detail in this section.

It will:

- Be cross- and trans-boundary.
- Involve the application of diverse technologies.

[3] www.foeme.org.

[4] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT/0,contentMDK:21575756~pagePK:146736~piPK:146830~theSitePK:256299,00.html.

[5] Hosted by the Arava Institute for Environment Studies and the Dead Sea Institute for Research and Development, a NATO Advanced Research Workshop on "Transboundary Natural Resources Governance in Regions of Extreme Conditions", November 19–21, 2007, Ein Gedi, Dead Sea, Israel.

[6] For a discussion of communities of practice, learning communities and 'communities of the like-minded', see Adler (2005: 5–6, 15–16).

- Draw upon both regional and international expertise.
- Be partially shaped by political efforts to foster regional cooperation and by international development agencies.
- Be partially shaped by existing structures that foster regional cooperation.
- Engage, and develop in active consultation with civil society groups.
- Involve significant local community engagement through community-based organisations, grassroots civil society groups, municipal bodies, subnational political associations and others.

3.1. CROSS-BOUNDARY AND TRANS-BOUNDARY

A cross-boundary response will recognize and respond to challenges arising from the Westphalian significance of state-centric political boundaries, institutions and inter-state (including PA) dynamics. In the conflictual Middle East, political boundaries matter. It is simply impossible to ignore them or to ignore the significant political struggles in the region. Therefore, the regional response will have to account for national agendas and priorities, national institutions, the significance of national security perspectives on development planning related to water, and currents of mutual suspicion constitutive of the Middle East conflict (Fischhendler, 2004).

While cross-boundary activities are essential to Middle Eastern problem-solving, a nascent form of regionalism which transcends the states is emerging in the 'framing' of challenges, in practice and in international law (Tal, 2007). Kally (1986: 34–35) argues that the Jordan River, beyond a hydrological border, should be appreciated as a component of a wider, regional hydrological system which includes the Yarmuk River, the Dead Sea, Wadi Arava, the Aqaba-Eilat Gulf of the Red Sea, and arguably also the Mediterranean Sea, given the region's growing reliance on seawater desalination.

The proposed trans-boundary character of the response will reflect the efforts of Transboundary Communitarian Bodies (TCBs), including professional networks, social movements and civil society organizations, which, in increasingly coordinated fashion, have been defining regional political priorities and identities (Dallmayr, 1999). TCBs tend to prioritize regional agendas, particularly the environment (from water to birds), alongside (and occasionally over) national ones, suggesting the need to reconsider both the motivation and the shape of interventions in water policy formulation (Etzioni, 2004).

By working together in this way, Israelis, Palestinians, Jordanians and international actors create a trans-boundary frame of reference on the ecological crisis, promoting the idea that state-boundaries are also constraints and may be set aside, even temporarily, to allow the political and moral imagination to breathe with creativity and innovation (Murphy, 1999; Lederach, 2005). In this sense, we can begin speaking, although perhaps hesitantly, of a "community-region", comprised of people, organizations and institutions from across the Jordan River basin who are engaged in a collective process of negotiating and articulating the values, anticipated norms, and practices of water development for the region (Adler, 2005: 188).

Work on water in the region thus far suggests that an adaptive response will be comprised of interventions at multiple scales, from individual and local, to national, regional, and even global. New political groupings, institutions, dynamics and value systems may emerge as an ongoing, transforming effect of a trans-boundary deliberative approach. Nevertheless, implementation of the vision in the context of the Jordan River basin will likely rely on state, state-based and/or state-like institutions (Etzioni, 2004).

These are significant challenges at a time of immense tension and some promise of rekindled peace-building. Thus, a regional response will be rooted in cross-boundary, trans-boundary and even cross-scale relationship-building and trust-building (Adger et al., 2006; Brooks, 2007: 57) as much as it will be defined by ensuring the human need to water is adequately and sustainably met (Talozi, 2007: 95; Falkenmark et al., 1989). Given that Jordan, the PA and Israel are dependent on the same water systems, national planning without coordination will likely fail (Gray and Hilal, 2007).[7]

3.2. DIVERSE TECHNOLOGIES

No single "technological fix" can overhaul water management challenges. Rather, an adaptive response will bring together a wide range of both "low tech" and "high tech" approaches to form a flexible strategy. Within the policy realm, these technologies fall into the two broad categories of increasing supply and reducing demand, outlined below. (Arlosoroff, 2006; Brooks and Wolfe, 2006; Magiera et al., 2006; Scott, 2003; Turton, 1999). Both approaches can be combined in an integrated strategy, drawing on the range of water options outlined below (Abitbol, 2006; Achiron-Frumkin and Frumkin, 2006; Al-Jamal, 2001; Allan, 2001: 87–108, 111–158, 201–208; Assaf, 2004; Beyth, 2007; Brooks and Wolfe, 2006; Brooks, 2007: 47–49, 55; De Châtel, 2007: 155–158; Dreizin, 2004; Gray and Hilal, 2007: 102, 106; Kally, 1986: 21–29, 39–43; Kroneneberg, 2004; Lattemann and Höpner, 2008; Lipchin, 2006: 12; Mohsen, 2007: 31; Nassar, 2006; Salameh, 1990: 76, 77; Schoenfeld et al., 2007; Scott, 2003; Shuval, 2004; Soloway, 2003; Wolf, 1996: 9f; World Bank, 2007: 51–51, 61–69).

[7] Noteworthy, the concept of "good neighbourliness" is contained in the 1997 UN Convention on the Non-Navigational Use of International Watercourses, "calling on countries to take all appropriate measures to prevent the causing of significant harm to other states by any misuse of transboundary water resources" (Tal, 2007: 219). The Ballagio Draft Treaty (1989) further emphasizes "consensual allocation" (Tal, 2007: 220).

Reducing demand by:

- Changing consumption practices, including water use education.
- Decreasing losses in urban and industrial water delivery and in agriculture.
- Using crop shifting and other agricultural efficiency mechanisms.
- Instituting pricing mechanisms.
- Including water for nature in the planning and allocation of water resources.

Increasing supply through:

- Wastewater treatment and re-use, as well as shifting quality use in industry and agriculture.
- Rainwater harvesting.
- Seawater desalination.
- Water imports from Turkey and elsewhere.
- "Virtual water" imports.
- Desalinated water carried to the Jordan River or the Dead Sea as part of a conveyance system.

There is an overall need to investigate the possible ways in which the needs and integrity of human and ecological systems can be respected and integrated.[8]

3.3. REGIONAL AND INTERNATIONAL WATER EXPERTISE

Israel, Jordan and the Palestinian Authority each have ministries concerned with water governance. Water experts in the region also work out of universities, the private sector and a range of nongovernmental organizations. These local experts have sometimes been trained abroad, and participate in the global network of water experts. Water is an emerging global challenge affecting all regions of the planet and all countries. While it may be uniquely difficult in the Middle East, it is not unique. There is solid ground for the development of experience-sharing opportunities and expert consultation, to develop the Middle Eastern response capacity.

The global network of water experts developing research, policy and technical tools are critical resources for the region. Furthermore, scholars from abroad are major contributors to the expert knowledge of water in the Middle East. This international interest is closely related to political efforts to foster regional cooperation and to the presence of international development agencies. Also,

[8] In Israel, 'nature' has a right to water. Interview with Richard Laster, Environmental Lawyer, Jerusalem, Israel, 22 December 2003.

the comparative study of transboundary water governance mechanisms established elsewhere can provide models for technical and legal arrangements that could be adapted to the Middle East. Notable organizations in the global network of water experts include the Stockholm International Water Institute, the International Water Resources Association, the World Water Council, and the United National International Network on Water, Environment and Health. Each of these is a multi-sector framework, incorporating university researchers, government representatives, the private sector and civil society.

3.4. POLITICAL EFFORTS TO FOSTER COOPERATION AND INTERNATIONAL DEVELOPMENT AGENCIES

Shortly after the ratification of the 1993 Oslo Accords, the international community showed its support for the peace process by pledging over $2 billion to finance various development projects in the West Bank and Gaza. This donation effort would eventually become, in per capita terms, one of the largest in history (Brynen, 1996: 46; Selby, 2006: 322). Water was a priority sector, receiving over 10% of all aid money (Rouyer, 2000: 229; Selby, 2006: 323). Promoting regional cooperation on water was consistent with the emerging international interest in environmental security and human security (Brauch, 2007; Oswald-Spring, 2007).

In addition to direct aid driven by the peace process, aid agencies with a broader scope and continuing presence have contributed to the development of regional water policy. Among several international agencies active in the region is the World Bank (World Bank, 2007) with the Red Sea–Dead Sea Canal (RSDSC) process. The United States Agency for International Development (USAID) develops various water-related programs in both Jordan[9] and the Palestinian Authority,[10] as does the German Agency for Technical Cooperation (GTZ).[11] The Canadian International Development Research Centre (IDRC) also manages a strong "Water Demand Initiative" (WaDiMENA) in these areas and across the Middle East–North Africa (MENA) region.

In addition to these initiatives, various governments have made important contributions to the water development sector in the region, including the United Kingdom, Norway, Japan, Sweden and others. The European Union, through the Euro-Mediterranean Partnership, often supports meetings and programs in partner countries in the Middle East: Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestine, Syria, Tunisia and Turkey (Assaf, 2006: 239–240).[12] Further, international private foundations including the Ford foundation

[9] Budgeted for 2007: $45 million; 2006: 58 million. http://www.usaid.gov/policy/budget/cbj2007/ane/pdf/jo_278-008.pdf.

[10] http://www.usaid.gov/locations/asia_near_east/countries/wbgaza/westbank-gaza.html.

[11] http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/3791.htm.

[12] http://www.emwis.net/overview.

and the MacArthur Foundation have played a role in supporting investigations and programming in the field of water development in the region.

The high level of international interest is both an asset and a challenge. International interest brings expertise, financial resources and a diversity of approaches into the region. On the other hand, it is now common knowledge in the development community that donors come with their own backgrounds, ideas, priorities, preferred partners and approaches. That said, maintaining local control of the agenda rather than shaping projects around donor priorities is a widely acknowledged challenge. If there is a clear local message about how to proceed with regional water planning, this challenge is more likely to be met.

3.5. EXISTING STRUCTURES INTENDED TO FOSTER REGIONAL COOPERATION

While water development has predominantly been prioritized and implemented through a national lens since the creation of Israel and Jordan, recent efforts have been made to promote regional water cooperation and development on many levels (Schoenfeld et al., 2007: 9–17). Early informal contacts were supplemented by regional multilateral and bilateral working groups established as part of the peace process; these contacts eventually led to formal structures.

Following the Madrid peace conference, in 1992 various multilateral working groups were formed, including one on water resources. The Multilateral Working Group on Water Resources established EXACT (Executive Action Team, Water Data Banks Project), bringing together water-management experts from Israeli, Jordanian, and Palestinian agencies,[13] with a mandate to produce a common source of regional water data.

Under Clause II of Article 40 of the Oslo II agreement, Israel and the Palestinian Authority agreed to establish a Joint Water Committee (JWC). This unprecedented bilateral institution came into being in 1995. At an institutional level, it reflects recognition of Palestinian stakeholder status with regards to regional water resources. The Oslo II agreement also established JSETs (Joint Supervision and Enforcement Teams) with the "authority to rectify a host of environmental infractions" (Tal, 2007: 225).

In practice, the experience of the Israeli–Palestinian JWC highlights both constraints and opportunities. Cross-border bodies and institutions reflect and reaffirm the political relationships, hierarchies and tensions of the wider conflict in which they are situated. One expert concluded that the JWC formalized Palestinian cooperation with Israeli control of supply, led to overexploitation of Palestinian water resources and was complicit in the development of bad water governance practices in the Palestinian Authority (Selby, 2006). On the other hand, a senior official in the Palestinian Water Authority, while writing about

[13] http://www.exact-me.org/index.htm.

the failures and frustrations of the JWC, argued that the only way forward is enhanced cooperation (Jarrar, 2006). Similarly, another expert stressed the local consensus on hydrological interdependence, the continuing commitment of members of the JWC to work together, and its practical activity to protect water supply during the Second Intifada through joint declaration on the protection of water infrastructure (Jagerskog, 2007). Thus, the JWC may provide a nascent institutional base for further regional water institution building.

The Jordanian–Israeli peace treaty of 1994 contains Annex II on water. It established a bilateral Jordan–Israel Joint Water Committee (JWC) to implement the agreements on water, including those related to allocations and quality. As noted elsewhere, the joint committee has maintained a flexible, creative and forward-looking practice, with an agenda that upholds both national and regional considerations. (Tal, 2007: 221–222; Brooks, 2007: 60). After decades of armed conflict, Israel and Jordan were able to transform their hostile inter-state relations and practice cooperative institution-building. The JWC, one such institution, will likely provide the framework for broader, regional, cooperative institution building.

These regional structures are established institutional frameworks that provide a valuable forum for advancing shared regional water knowledge and shared initiatives. To improve upon existing regional institutions, Israeli environmental law expert Alon Tal suggests looking to the independent character of the institutional structure of the Canada–US International Joint Commission (IJC), one of the key reasons for its success (2007: 227–228). Brooks (2007) notes it is also likely that new, innovative institutions will emerge to adapt to multilateral, cross-scale water governance challenges as they arise.

Within and alongside these formal structures, regional experts have had opportunities to meet, become familiar with each other's research, work together and develop professional and personal relationships. The series of publications by Haddad and Feitelson (1995, 1997) and Feitelson and Haddad (1994, 1998) shows that it is possible for university-based experts to produce joint analyses. These studies are indicative of the kind of work that could be done in generating a joint knowledge base within the region. Beyond the contacts that are formalized by bilateral agreements or multilateral working groups, regional civil society groups have cultivated a multidisciplinary network of regional water experts, with a growing shared understanding of water issues. Based on surveys and focus group meetings throughout the Dead Sea region, Lipchin (2006: 25–26) concluded that the vast majority of Israelis (95%), Palestinians (79.8%) and Jordanians (72%) favored cooperating with their neighbors to address one major regional water issue – the continuing decline of the Dead Sea.

3.6. REGIONAL CIVIL SOCIETY GROUPS

Civil society formation has followed different paths in Israel, the PA and Jordan. Non-governmental organizations multiplied in Israel in the 1990s to address a wide range of social issues, including the environment. Israeli civil society organizations have consistently challenged what they consider to be unwise government policies and proposed alternatives. They have cultivated networks of experts, often drawing on university researchers and lawyers, and have had significant impact on several issues. Palestinian non-governmental organizations developed before the Oslo Accords, providing direct services to the population and expertise to the Palestinian national movement. They continue to contribute both direct services and expertise, with significant involvement in the water and peace-building sectors (World Bank, 2006). The Jordanian government has promoted and supported non-governmental organizations (see e.g., Talal, 2004), with recent initiatives focusing on "community-based organizations" and on the study and promotion of civil society.[14]

Throughout the region, the non-governmental sector is recognized as an increasingly important sector of society. In each society there are many NGOs with environmental interests. Civil society interest in water issues implies that political planning on water will necessarily involve engagement with civil society, and that cultivating a regional perspective in national environmental organizations will make regional cooperation more likely. While the domain of water issues planning has historically been dominated by scientists, technical experts, and state-based institutions, civil society groups in the region continue to expand their capacity and legitimacy to inform and support the regional water issues agenda.[15]

Three regional civil society organizations deal specifically with environmental issues, including water. The environmental program within the Israel/ Palestine Center for Research and Information (IPCRI) has developed a network of contacts with water experts, civil society and government agencies in the region.[16] IPCRI organizes well-attended conferences on regional water issues and publishes papers based on conference presentations, making significant contributions to the knowledge base with a regional perspective (Shuval and Dweik, 2006). The Arava Institute for Environmental Studies (AIES) has particularly strong connections to environmental civil society groups in Israel and fosters a regional perspective.[17] AIES has a particularly interesting regional and international alumni network. Friends of the Earth-Middle East (FOEME) has three coordinators – Israeli, Palestinian and

[14] See http://www.jordanriver.jo/ and the discussion there of the Qudorat initiative.
[15] The expanding civil society practice of intervening in environmental framing, advocacy and governance is discussed in Lipschutz, 2000: 17.
[16] http://www.ipcri.org.
[17] http://www.arava.org.

Jordanian. It fosters common water perspectives and actions, and advocates specific regional water policy initiatives (e.g., Friends of the Earth Middle East, 2005 and the proposal for the Dead Sea to receive World Heritage Site and Man and Biosphere designation). All three organizations have an active interest in research and policy on regional water issues. They have made a highly significant joint cumulative contribution to the literature on water in the region and the debates about policy.

3.7. LOCAL COMMUNITY ENGAGEMENT

In Jordan, water planning is centralized and guided by expert opinion. In Israel, water planning is conducted in the water commissioner's office, but is done in consultation with the main sectors invested in prioritizing water allocation. The Palestinian Water Authority struggles with various internal pressures for a share of relatively meager resources. Throughout the region, there is little broad-based community-level engagement in water management and water development processes.

Although local communities generally possess valuable local knowledge, they are often marginalized actors in knowledge production and in decision-making. This is particularly true in the realm of water management. Nevertheless, the magnitude of social, economic and cultural implications of water development for local communities cannot be underestimated. For example, crop shifting would have significant implications for the rural communities of the Jordan Valley. Recognizing such implications, the Jordanian Ministry of Water and Irrigation (MWI) has developed a strategy to guide the nation's water development until 2020. It "calls for the introduction and enhancement of the participation of stakeholders, and calls for the legislation for their involvement wherever necessary" (Talozi, 2007: 95).

What is planned from above by scientists, policy-makers, international development experts, or even unrepresentative civil society organizations, cannot be assumed to match local community desires or capabilities. Local communities need to be involved in a process that acknowledges their cultures, respects their identities and brings to light their values, beliefs, assumptions and priorities (Lipchin, 2006: 2–3). Despite the time requirement, an elaborate process of engagement must be designed and implemented which elicits their insights, informs the process of development, and improves the likelihood of its successful implementation (WMIA, 2002–2003). Otherwise, energies invested in drafting extensive plans may be for naught.

4. Towards an Effective Regional Response

Based on the elements of a regional response outlined above, it is possible to identify next steps in responding to the regional water challenge. The first step is to recognize the importance of what has already been done, as outlined above. The next step towards effective, integrated regional water policy involves an agenda of knowledge consolidation, additional knowledge production (including both water and policy research), professional and public education, and popular engagement.

4.1. KNOWLEDGE CONSOLIDATION

The literature on water issues is considerable though scattered. A series of "literature review" projects would be helpful, which it may be advantageous to combine with new research.

One regularly updated web portal with a virtual library and links to relevant sites would make it possible for the now substantial and growing number of interested people and organizations to become familiar with the issues and with each other's work.

4.2. ADDITIONAL KNOWLEDGE PRODUCTION: WATER AND POLICY STUDIES

Water Knowledge: Section 3 above lists the diverse range of options that could be used to respond to the regional water challenge. Further research on most of them will be needed to inform the effective development of integrated regional policy.

- It will be necessary to investigate the social, cultural, economic, political and ecological implications of the different options, thereby creating new configurations of situated knowledge (Lipschutz, 2000: 18).
- Regional policy studies: In addition to research on options, policy studies will help with strategies of implementation. Different strategies will reflect the priorities of specific constellations of networked power, or in Foucauldian terms, "discursive regimes".

4.3. PROFESSIONAL AND PUBLIC EDUCATION

- Professional education and contacts: The variety of engaged experts, practitioners, authorities and specialized civil society members focusing on Middle Eastern water issues suggests a number of initiatives: (1) continued contacts between experts from across the region; (2) within each national group, broadening the circle of water professionals who understand and seek to develop water issues from a regional perspective; (3) cultivating human capital: training and involving the next generation of water professionals.

- Sites of experience-sharing and knowledge construction: Continuing regional conferences, an academic journal, university research partnerships and continuing engagement with development agencies could each promote regional professional expertise.
- Public Education: Here, partnerships of experts, governments, civil society and communities are important. In some ways, the water community in the Middle East is in the same position as the climatologists of the IPCC (Intergovernmental Panel on Climate Change) who advocated for recognition of the enormous significance of climate change.[18] The experts understand (and continue to develop their knowledge about) the magnitude of the problem and the magnitude and direction of required societal responses. In order for the response to be adequate, the experts have to play a role in shaping public education and making a contribution to envisioning water sustainability (Lipchin, 2006: 27–28). Civil society groups often have the experience to shape contextual, relevant and effective public education materials and campaigns. Finally, governments have the capacity to enable, support and participate in the process; by creating a favorable political environment, incorporating materials into school curricula, providing financial resources for implementation, for example. Experts, governments and civil society can each help to educate the public and involve it in the transition to water sustainability.

4.4. POPULAR ENGAGEMENT

The engagement of local communities is a challenging and painstaking, yet necessary priority. Experts in popular engagement emphasize the importance of elicitive strategies that are informed by local cultural values and political conditions (Lederach, 1995). Similarly they stress the development of priorities and practices which are not divorced from realities on the ground. Thus, a complex, multi-faceted process of engagement might include: public education as defined above, popular spaces of dialogue across the region,[19] a consultation on priorities, and a feedback process for sharing drafts of a vision document at various stages of development.[20]

[18] Interestingly, the IPCC became the co-recipients of the Nobel Peace Prize in 2007, for their research and advocacy work on climate change. This suggests that ‘epistemic communities’ like the IPCC make a significant contribution to shaping the public agenda.

[19] The University of the Streets Café Program (http://www.univcafe.org) and the Public Conversation Project (http://www.publicconversations.org/pcp/index.php) are particularly relevant here.

[20] The work and resources of the Canadian Policy Research Networks is particularly helpful for the design of complex, multisectoral engagement processes. In particular, see Sheedy, Amanda (2008). Handbook on

5. Conclusion

This piece brought together various lessons from the experience of working with AVOW, perhaps most notably, a deeper understanding of water as a regional issue. We have come to see how AVOW develops earlier efforts to promote regional water policies by advocating coordination of a broad range of possible actions in a collaborative, inclusive project, cognizant of regional and international power dynamics and hierarchies.

In the present context, promoting a regional water policy involves weaving together and putting into perspective state policies, international treaty obligations, growing international and regional water expertise, civil society activism and community engagement, international aid agencies and a diverse range of possible actions. Deciding on policies in a timely manner involves consolidating what has been learned from earlier policy research, producing the additional research needed and recognizing the value of proceeding on this critical issue through public education and engagement.

The experience with AVOW has also deepened our respect for the wide network of people – political leaders, civil servants, experts, civil society actors and community members – who have put so much thought and care into the challenge of water in the region. Our reflections in this piece are offered as a contribution to their efforts.

References

Abitbol, E., 2006. Giving the Dead Sea a New Life: Have All Options Been Responsibly Considered? *Journal of Peacebuilding and Development*, 3(1).

Achiron-Frumkin, T. and Frumkin, R., 2006. Water Allocation for Nature and the ‘End of Conflict’ Era, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East*, *Antalya, Turkey, October 10–14, 2004*. H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 205–219.

Adger, N.W., Brown, K., and Tompkins, E.L., 2006. The Political Economy of Cross-Scale Networks in Resource Co-management, *Ecology and Society*, 10(2): 9, http://ecologyandsociety.org/vol10/iss2/art9/.

Adler, E., 2005. *Communitarian international relations: The epistemic foundations of International Relations*, Routledge, London/New York.

Allan, J.A. (Tony), 2001. *The Middle East water question: Hydropolitics and the Global economy*. I.B. Tauris, London.

Al-Alem, Z., 2002. Red–Dead Canal project – protecting the Dead Sea, in: *The Dead Sea: Between Life and Death: Proceedings of Two Parallel Conferences*, Y. Abu Taleb, G. Bromberg, S. Hörmann, S. Porat, eds., Friends of the Earth, Ein Bokek, Israel and Amman, Jordan, pp. 27–34.

Citizen Engagement: Beyond Consultation Canadian Policy Research Networks. It can be downloaded from: http://www.cprn.org/doc.cfm?doc=1857&1=en.

Al-Jamal, K., 2001. Prospects for Desalination in Gaza, *Watermark: The Newsletter of the Middle East Desalination Research Center*, http://www.ewatermark.org/watermark14/article1.htm.

Arkin, Y., 2000. Dead Sea sinkholes – an ever-developing hazard, *Environmental Geology*, 39(7): 711.

Arlosoroff, S., 2006. Water Demand Management – a strategy to deal with water scarcity in Israel: case study, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East*, *Antalya, Turkey, October 10–14, 2004*. Hillel Shuval and Hasan Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 463–473.

Asmar, B.N., 2002. Environmental Effects of the Dead Sea–Red Sea Canal, *The International Journal of Environmental Studies*, 59(6): 647.

Asmar, B., 2003. The Science and Politics of the Dead Sea: Red Sea Canal or Pipeline, *The Journal of Environment & Development*, 12(3): 325–339.

Assaf, K., 2006. Joint projects and programs promoting Middle East cooperation and knowledge in the water sector, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East*, *Antalya, Turkey, October 10–14, 2004*. H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 236–249.

Assaf, S.A., 2004. The need for implementation of a water for peace strategy for the Jordan River Basin countries through a shift in cropping patterns, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East.* H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, pp. 851–864.

Benveniste, R., 2004. Addressing the Dead Sea Water Issues. IPCRI's Water Conference Power point presentations, *Second Israeli–Palestinian International Conference on Water for Life in the Middle East, Israel/Palestine Center for Research and Information, Antalya, Turkey, October 10–14, 2004*, http://www.ipcri.org.

Beyth, M., 2007. The Red Sea and the Mediterranean–Dead Sea canal project, *Desalination*, 214(1–3): 365.

Biswas, A.K., 1997. *Core and periphery: a comprehensive approach to Middle Eastern water*. Oxford University Press, Delhi/Oxford.

Brauch, H.G., 2007. Environmental security in the Middle East: conceptualizing Environmental, Human, Water, Food, Health and Gender Security, in: *Integrated Water Resources Management and Security in the Middle East*, C. Lipchin et al., eds., Springer, Dordrecht, The Netherlands, pp.121–162.

Bromberg, G., 2004. The Dead Sea – A Living Treasure Though Still Wild and Breathtakingly Beautiful Will It Survive? in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Antalya, Turkey; http://www.ipcri.org/watconf/papers/gidon.pdf.

Brooks, D., 2007. Fresh Water in the Middle East and North Africa: Source of Conflict/Base for Cooperation, in: *Integrated Water Resources Management and Security in the Middle East*, C. Lipchin et al., eds., Springer, Dordrecht, The Netherlands, pp. 33–64.

Brooks, D. and Wolfe, S., 2006. Water Demand Management as Governance: lessons from the Middle East and South Africa, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East*, *Antalya, Turkey, October 10–14, 2004*. H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 474–501.

Brynen, R., 1996. International Aid to the West Bank and Gaza: a primer, *Journal of Palestine Studies*, 25(2): 46–53.

Dallmayr, F.R., 1999. Globalization from below, *International Politics*. 36 September.

De Châtel, F., 2007. *Water Sheiks and Dam Builders: Stories of People and Water in the Middle East*, Transaction, New Brunswick, NJ.

Dreizin, Y., 2004. The Impact of Desalination: Israel and the Palestinian Authority, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East Antalya, Turkey, October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/ Palestine Center for Research and Information, http://www.ipcri.org/watconf/dreizin1. pdf.

Etzioni, A., 2004. The capabilities and limits of global civil society, *Millennium Journal of International Studies*, 33(2).

Falkenmark, M., Lundviqst, J., and Widstrand, C., 1989. Macro-scale water scarcity requires micro-scale approaches: Aspects of vulnerability, *Natural Resources Forum*, 13(4): 258–267.

Feitelson, E. and Haddad, M., eds., 1994. *Joint Management of Shared Aquifers: The First Workshop*, The Harry S Truman Institute for the Advancement of Peace and the Palestine Consultancy Group, Jerusalem.

Feitelson, E. and Haddad, M., eds., 1998. *Joint Management of Shared Aquifers: The Fourth Workshop*, The Harry S Truman Institute for the Advancement of Peace and the Palestine Consultancy Group, Jerusalem.

Fischhendler, I., 2004. Legal and Institutional Adaptation to Climate Uncertainty: a Study of International Rivers, *Water Policy*, 6: 281–302.

Friends of the Earth Middle East, 2002. *The Dead Sea: Between Life and Death: Proceedings of Two Parallel Conferences*, Amman and Ein Bokek: Friends of the Earth. Y. Abu Taleb, G. Bromberg, S. Hörmann, S. Porat, eds.

Friends of the Earth Middle East, 2005. *Crossing the Jordan: Concept Document to Rehabilitate, Promote Prosperity and Help Bring Peace to the Lower Jordan Valley*. Amman, Bethlehem and Tel Aviv.

Gavrieli, I. and Bein, A., 2004. Formulating a regional policy for the future of the Dead Sea – the 'Peace Conduit' alternative, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East*, *Antalya, Turkey, October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, pp. 965–980.

Gavrieli, I., Bein, A., and Oren, A., 2005. The expected impact of the peace conduit project (the Red Sea–Dead Sea pipeline) on the Dead Sea, *Mitigation and adaptation strategies for global change*, 10(1): 3.

Gertman, I., 2002. The Dead Sea hydrography from 1992 to 2000, *Journal of marine systems*, 35(3/4): 169.

Gray, A. and Hilal, J., 2007. Water and Security for Palestine, in: *Integrated Water Resources Management and Security in the Middle East*, C. Lipchin et al., eds., Springer, Dordrecht, The Netherlands, pp. 99–117.

Haddad, M., 2004, Politics and Water Management: a Palestinian Perspective, in *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, http://www.ipcri.org/watconf/papers/marwan.pdf.

Haddad, M. and Feitelson, E., eds., 1995. *Joint Management of Shared Aquifers: The Second Workshop*, The Harry S Truman Institute for the Advancement of Peace and the Palestine Consultancy Group, Jerusalem.

Haddad, M. and Feitelson, E., eds., 1997. *Joint Management of Shared Aquifers: The Third Workshop*, The Harry S Truman Institute for the Advancement of Peace and the Palestine Consultancy Group, Jerusalem.

Jägerskog, A., 2007. Why States Co-Operate over Shared Water: The Water Negotiations in the Jordan River Basin, in H. Shuval and H. Dweik, eds., Water Resources in the Middle East: Israel-Palestinian Water Issues – From Conflict to Cooperation, Springer, Berlin, pp. 194–202.

Jarrar, M.A., 2006. The Palestinian–Israeli Joint Cooperation in the Water Sector: A need to Enhance Cooperation, A communication submitted to the International Conference on the Implementation of the European Water Framework Directive, sponsored by the International Network of Basin Organizations, http://www.inbo-news.org/euro-riob/megeve2006_a.htm.

Kally, E. 1986. *A Middle East Water Plan Under Peace*, The Armand Hammer Fund for Economic Cooperation in the Middle East, Tel Aviv University, March.

Kroneneberg, G., 2004. The Largest SWRO plant in the World: Ashkelon 100 million m^3/y BOT project, *Desalination*, 166: 457–463.

Lattemann, S. and Höpner, T., 2008. Environmental impact and impact assessment of seawater desalination, *Desalination*, 220: 1–15.

Lederach, J.P., 1995. *Preparing for Peace: Conflict Transformation Across Cultures*, Syracuse University Press, Syracuse.

Lederach, J.P., 2005. *The Moral Imagination: The Art and Soul of Building Peace*, Oxford University Press, Oxford.

Lipchin, C., 2004. A Future for the Dead Sea Basin: Options for a more sustainable water management, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, pp. 904–919.

Lipchin, C., 2006. *A Future for the Dead Sea Basin: Water Culture Among Israelis, Palestinians and Jordanians* Working Paper 115. 2006 published by the Fondazione Eni Enrico Mattei, September.

Lipchin, C., Pallant, E., Saranga, D., and Amster, A., eds., 2006. *Integrated Water Management and Security in the Middle East*, Springer, Dordrecht, The Netherlands.

Lipschutz, R.D., 2000. Crossing borders: Global civil society and the reconfiguration of transnational political space, *GeoJournal*, 52: 17–23.

Lowi, M.R., 1993. *Water and Power: the Politics of a Scarce Resource in the Jordan River Basin*, Cambridge University Press, Cambridge.

Magiera, P., Taha, S., and Nolte, L., 2006. Water demand management in the Middle East and North Africa, *Management of environmental quality*, 17(3): 289.

Mohsen, M., 1998. Potentials for development of hydro-powered water desalination in Jordan, *Renewable energy*, 13(4): 537.

Mohsen, M., 2007. Water strategies and potential of desalination in Jordan, *Desalination*, 203(1–3): 27–46.

Murakami, M., 1995. Eco-political Decision Making and Techno-political Alternative Strategies in the Inter-state Development of the Jordan Valley and Dead Sea Beyond the Peace, *Water resources Development*, II(4): 391–410.

Murphy, B.K., 1999. *Transforming Ourselves, Transforming the World: An Open Conspiracy for Social Change*, Zed Books, London.

Nassar, Y., 2006. Virtual Water Trade as a Policy for Achieving Water Security in Palestine, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East Antalya, Turkey, October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 46–57.

Nissenbaum, A., 1993. The Dead Sea – an economic resource for 10,000 years, *Hydrobiologia*, 267(1–3): 127.

Oren, A., 2004. Biological effects of dilution of Dead Sea brine with seawater: Implications for the planning of the Red Sea–Dead Sea “Peace conduit”, *Journal of Marine Systems*, 46(1–4): 121.

Oswald-Spring, U., 2007. Hydro-Diplomacy: Opportunities for Learning from an Interregional Process, in: *Integrated Water Resources Management and Security in the Middle East*, Lipchin, C. et al., eds., Springer, Dordrecht, The Netherlands, pp. 163–200.

Pahl-Wostl, C. et al., 2007. Social Learning and Water Resources Management, *Ecology and Society*, 12(2): 5; http://www.ecologyandsociety.org/vol12/iss2/art5/.

Rogers, K.H., 2006. The real river management challenge: integrating scientists, stakeholders and service agencies, *River Research and Applications*, 22(2): 269–280.

Rouyer, A., 2000. *Turning Water into Politics: the water issue in the Palestinian–Israeli Conflict*, Macmillan, London.

Salameh, E., 1990. Jordan's Water Resources: Development and Future Prospects, *American–Arab Affairs*, 3: 69–77.

Scheumann, W. and Schiffler, M., 1998. *Water in the Middle East: potential for conflicts and prospects for cooperation*, Springer, Berlin.

Schoenfeld, S., Abitbol, E., and de Châtel, F., 2007. Retelling the Story of Water in the Middle East, in: *Integrated Water Resources Management and Security in the Middle East*, C. Lipchin et al., eds., Springer, Dordrecht, The Netherlands, pp. 1–29.

Scott, C., 2003. Facing water scarcity in Jordan: reuse, demand reduction, energy, and transboundary approaches to assure future water supplies, *Water International*, 28(2): 209.

Selby, J., 2006. Joint Mismanagement: reappraising the Oslo water regime, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, October 10–14, 2004*. H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 322–340.

Sheedy, A. et al. Forthcoming. *Handbook on Citizen Engagement: Beyond Consultation*, Canadian Policy Research Networks.

Shuval, H., 2004. The Role of "Virtual Water" in the Water Resources Management of The Arid Middle East, in: *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, October 10–14, 2004*, H. Shuval and H. Dweik, eds., Israel/Palestine Center for Research and Information, Jerusalem, pp. 99–111.

Shuval, H. and Dweik, H., eds., 2006. *Proceedings of the Second Israeli–Palestinian International Conference on Water for Life in the Middle East*, *Antalya, Turkey, October 10–14, 2004*. Israel/Palestine Center for Research and Information, Jerusalem.

Shuval, H. and Dweik, H., eds., 2007. *Water Resources in the Middle East: Israel–Palestinian Water Issues – From Conflict to Cooperation*. Springer, Berlin.

Solowey, E., 2003. *Small Steps Towards Abundance: Crops for a More Sustainable Agriculture*, Biblio Books.

Tal, A. 2007. International Water Law and Implications for Cooperative Israeli–Palestinian Transboundary Water Management, in: *Integrated Water Resources Management and Security in the Middle East*, C. Lipchin et al., eds., Springer, Dordrecht, The Netherlands, pp. 213–236.

Talozi, S., 2007. Jordan: An Oasis of Security & Thirst, in: *Integrated Water Resources Management and Security in the Middle East*, C. Lipchin. et al., eds., Springer, Dordrecht, The Netherlands, pp. 73–98.

Tsing, A., 2005. *Friction: An Ethnography of Global Connections*, Princeton University Press, Princeton, NJ.

Turton, A.R., 1999. Water Scarcity and Social Adaptive Capacity: Towards and Understanding of the Social Dynamics of Water Demand Management in Developing Countries, in: MEWREW Occasional Paper No. 9, ed. Water Issues Study Group. London: School of Oriental and African Studies (SOAS).

Talal, B.B., 2004. *Rethinking an NGO: Development, Donors and Civil Society in Jordan*. I.B. Tauris, London.

USAID, n.d. *Water Resource Development: Activities*. USAID West Bank and Gaza; http://www.usaid.gov/wbg/program_water_activity_1.htm.

USAID, 2005. *Water Resource Development: Improved Water Supply, Water Quality and Water Management*. USAID West Bank and Gaza. http://www.usaid.gov/wbg/program_water.htm.

WMIA, 2003. Final Progress Report (June 2002–November 2003), *Water Resources Management for Irrigated Agriculture*. Second and Final Progress Report of Phase I. Amman, Jordan: Jordan Valley Authority and GTZ.

Wolf, A.T., 1995. *Hydropolitics Along the Jordan River: Scarce Water and Its Impact on the Arab–Israeli Conflict*. United Nations University Press, New York.

Wolf, A.T., 1996. *Middle East Water Conflicts and Directions for Conflict Resolution*. International Food Policy Research Institute, Washington, DC.

Wolf, A.T., 2000. Hydrostrategic territory in the Jordan Basin: water, war and Arab–Israeli peace negotiations, in: *Water in the Middle East: a geography of peace*, A.A. Amery and A.T. Wolf, eds., University of Texas Press, Austin, TX.

Wolf, A.T. and Murakami, M. 1995. Techno-political Decision Making for Water Resources Development: the Jordan River Watershed, *Water Resources Development*, II(2): 147–162.

World Bank, 2006. *The Role and Performance of Palestinian NGOs in Health, Education and Agriculture*. Bisan Center for Research and Development.

World Bank, 2007. *Making the Most of Scarcity: Accountability for Better Water Management Results in the Middle East and North Africa*, The International Bank for Reconstruction and Development/The World Bank, Washington, DC.

Yechieli, Y., 1998. Will the Dead Sea die? *Geology*, 26(8): 755.

Zilberman, D., 1984. Solar energy and hydroelectric power generation in the Dead Sea: a dynamic analysis. *Water resources research*, 20(11): 1469.

Zalul Sea Report, 2007. (December 19, 2007); http://www.zalul.org/en/default.asp.