Natural Resource Management and Policy
Ariel Dinar and David Zilberman, Series Editors

Management of Shared Groundwater Resources: The Israeli-Palestinian Case with an International Perspective

edited by

Eran Feitelson
Marwan Haddad

International Development Research Centre (IDRC)
and
Kluwer Academic Publishers

MANAGEMENT OF SHARED GROUNDWATER RESOURCES:
The Israeli-Palestinian Case with an International Perspective

MANAGEMENT OF SHARED GROUNDWATER RESOURCES:
The Israeli-Palestinian Case with an International Perspective

Edited by

Eran Feitelson

and

Marwan Haddad

The Truman Institute for the Advancement of Peace,
The Hebrew University of Jerusalem
and
The Palestine Consultancy Group

KLUWER ACADEMIC PUBLISHERS
Boston/Dordrecht/London

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE
Ottawa - Cairo - Dakar - Johannesburg - Montevideo - Nairobi - New Delhi - Singapore

Library of Congress Cataloging-in-Publication Data

A C.I.P. Catalogue record for this book is available from the Library of Congress.

Canadian Cataloguing in Publication Data

Main entry under title:

Management of shared groundwater resources : the Israeli-Palestinian case with an international perspective

Co-published by Kluwer Academic Publishers.
Includes bibliographical references.
ISBN 0-88936-912-7

1. Water resources development — Israel.
2. Water resources development — Palestine.
3. Groundwater — Management — Israel.
4. Groundwater — Management — Palestine.
5. Water resources development — Case Studies.
6. Groundwater — Management — Case Studies.

I. Feitelson, Eran, 1956- .
II. Haddad, Marwan, 1950- .
III. International Development Research Centre (Canada)

HD1698.I75 2000 331.91'0415'095694 C00-980416-1

Published in hardcover by
Kluwer Academic Publishers
101 Philip Drive, Assinippi Park, Norwell, MA 02061, USA
http://www.wkap.nl

Printed on acid-free paper in the United States of America

Contents

Preface

Most of the world's freshwater resources in liquid state (i.e. not in glaciers and polar caps) are underground. As the population grows and demand for water rises the reliance on groundwater increases. Many parts of the world already rely on groundwater. In many cases the groundwater underlies boundaries, or is part of a hydraulic system that crosses boundaries. In such cases there is always the danger that the "prisoner's dilemma" will run its course and all parties will compete over who will pump the most water, ultimately destroying the storage potential to the detriment of future generations of all parties based on the groundwater. This book explores the options and means for averting this all too realistic scenario by managing these shared groundwater resources.

Nowhere is the likelihood of excessive use of groundwater greater than in the water scarce Middle East, and especially in the Israeli-Palestinian case. Here both sides are heavily reliant on a shared aquifer, the Mountain aquifer, and are embroiled in long standing highly complex feud. Many see this conflict over the Mountain Aquifer as a major obstacle for peace between Israelis and Palestinians.

This book is the outcome of a seven year effort to find ways to manage the Mountain aquifer, perhaps the most important resource shared by Israelis and Palestinians. As part of this cooperative study four workshops were held, in which a selected number of Palestinian, Israeli and foreign experts were invited. Most of the chapters in this book were originally presented in one of these workshops. To these papers introductory and concluding chapters were added. Essentially, these additional chapters set the scene of the study and advance the main points raised in the final report of phase two of the study.

The study was conducted under the auspices of the Truman Institute for Advancement of Peace at the Hebrew University of Jerusalem and the Palestine Consultancy Group. Sari Nusseibeh, Dan Bitan, Moshe Maoz,

Amnon Cohen and Edi Kaufman gave the continuing leadership as directors and deputy directors of these bodies. Issa khater and Idit Avidan facilitated all the meetings and administrative matters.

This study began before anybody could guess the twists and turns the peace process will take. We have experienced them all. Continuing this project through many difficult periods, as well as short time periods of elation, has made us and our colleagues, Shaul Arlosoroff and Taher Nassereddin from mere co-researchers to partners in what turned out to be a long, difficult voyage into uncharted water. It soon became obvious to us that the experience with shared groundwater is so meager that we'll have to come up with new and innovative options. In this book we present the highlights of our journey. We present the context, the most important views we heard along the way and the conclusions we reached. These pertain first and foremost to ourselves, Israelis and Palestinians. However, as we realized some time ago they could be of great use to people in other places who will sooner or later face the same predicaments we face today. It is our hope that this book may help them shorten their journeys.

The study was funded by the International Development Research Centre (IDRC) of Canada and the Charles R Bronfman Foundation. We are most grateful to David Brooks of the IDRC not only for his support, but also for his active interest and participation in this study throughout. Supplementary funds were provided by the Dialogue Fund of the Government of Canada and the Jewish Community Foundation of Los Angeles. We are grateful to all. Needless to say none but the authors bear any responsibility for the ideas and views expressed in this book.

In bringing this book for print we were greatly assisted by Lisa Perlman, who helped make the often convoluted prose into a readable text and Anat Segev who prepared the camera ready manuscript for publication.

While the main highlights of the journey are presented herein, the ideas expressed in the chapters, and particularly our concluding recommendations, benefited greatly from the discussions with all participants in the four workshops. We would like to thank, therefore, all the participants in the workshops and along the way.

Finally, we would like to dedicate this book to our wives, Rachel and Hana, who always supported our work in innumerable ways.

Eran Feitelson and Marwan Haddad
March 2000

Introduction

Eran Feitelson & Marwan Haddad
College of Engineering, An-Najah National University, Nablus, Palestinian Territory and the Palestine Consultancy Group (PCG), East Jerusalem
Department of Geography, The Hebrew University of Jerusalem and the Harry S Truman Research Institute for the Advancement of Peace, Mount Scopus, Jerusalem

Groundwater accounts for more than 22% of the total worldwide freshwater resources and over 97% of the water in liquid state - that is, freshwater not locked up in glaciers, polar caps and permanent snow.[1] Most of the groundwater is found in aquifers. Many of these aquifers are shared by two or more countries.

Groundwater can be defined as shared if it forms part of an international hydrological system. Barberis (1991) identifies four such cases:

1. Confined aquifers, not linked hydrologically to any other water body, divided by an international boundary.
2. Aquifers found entirely in the territory of one state but connected to an international river. Such a river might be an influent river, recharging the aquifer on balance, or an effluent river, being fed on balance from the aquifer.

[1] There are no clear figures on the total amount of groundwater. The differences are an outcome of the uncertainty regarding the total amount underground, and differences in definitions of what constitutes groundwater. These definitions differ in terms of the depth to which groundwater should be estimated and whether soil water should be included in the groundwater estimates. The numbers mentioned here are the lowest of the estimates we came across in the comparisons presented in Gleick (1993a, Table A.1, p. 120) and Cohen (1995, Table 14.1, p. 300). Some researchers suggest the percentage of groundwater is higher. For example, Shiklomanov (1993), in his well-known review of world water resources, suggests groundwater accounts for some 30% of the total freshwater resources and over 99% of those in liquid state.

3. Aquifers located entirely in the territory of one state but linked hydrologically with an aquifer underlying the territory of another country.
4. Aquifers that lie entirely within the territory of one state, but whose recharge area lies at least partially within another state.

Groundwater is crucial for the water supply of many countries and regions the world over. This is particularly true in arid and semi-arid countries where the potential evaporation (the total amount of water that would evaporate if available) is equal to or greater than the total precipitation and the variance of precipitation in percentage terms is high. In such circumstances the amount of water that is recharged into aquifers is often the basis for survival during dry periods - dry months and drought years.

As aquifers are not visible, the need to manage them is less obvious than surface water. It is not surprising, therefore, that groundwater management has lagged behind surface water. This is true also for transboundary groundwater. While much attention has been given to transboundary rivers, which have been the focus of international treaties for centuries, only recently have international lawyers and other experts turned their attention to shared groundwater.

The discussion of shared groundwater in the international arena has mostly been in the context of international law. This discussion has focused primarily on the application of allocation principles developed for surface water to groundwater (Benvenisti, 1996). However, groundwater differs from surface water in several important respects. Groundwater is not readily controlled, and hence cannot be diverted by dams and channels. It is more difficult and costly to clean up groundwater than surface water, if it is at all possible, and hence pollution or salinization may have more detrimental effects in the case of groundwater. Groundwater is less visible and less well understood. As a result, its management is arguably more complex than surface water management. This is true also when an aquifer is a pure "state-owned" aquifer. It is not surprising, therefore, that there is only scant experience in managing shared groundwater.

The management of groundwater is a complex task. It requires that many decisions be made over time. Moreover, it requires the use of data-intensive models. This data is not easy to come by. Even seemingly simple questions, such as what is the spatial extent of an aquifer - i.e. where do its boundaries lie - has to be assessed and cannot be determined easily (in contrast to surface water). The management of groundwater has to continually adjust, therefore, to new data and insights, as well as to the natural fluctuations in levels of water tables and to changes in water quality. As groundwater management requires continuous actions and decisions institutional structures have to be established for this task. The formulation of such structures is made ever more difficult when the aquifers are shared by two or more parties. The first goal of this book is to identify possible options for institutions and approaches to managing such shared groundwater.

The Israeli-Palestinian case is especially poignant in this respect. Both sides are heavily dependent on a set of shared aquifers, collectively known as the Mountain Aquifer. Israel-Palestine is part of the most water-stressed region of the Middle East. It has often been suggested that this part of the Middle East is the most prone to natural resource-based conflicts over water (Gleick, 1993b; Homer-Dixon, 1994).

From a Middle Eastern perspective the Israeli-Palestinian conflict is the most complex element in the Israeli-Arab conflict. Water is seen as one of the core areas of this conflict. Water is one of the principal issues addressed in the Israeli-Jordanian peace treaty and in the Oslo B accords signed by Israel and the Palestinian Authority in September 1995. Water is also at the center of the negotiations between Israel and Syria (ongoing at the time of writing) and is the theme of one of the groups in the multilateral track of the peace process. Water is one of the outstanding issues to be negotiated in the permanent status negotiations between Israel and the Palestinians. The Mountain Aquifer is thus important also for the future of the Middle East peace process.

The purpose of this book is twofold: to identify and advance options for the management of shared aquifers, and to scrutinize the special case of the Palestinian-Israeli Mountain Aquifer within this international perspective and identify the options that may be most suitable for this case. Therefore, the themes raised in the chapters that follow move back and forth between general issues that would have to be addressed in any place where shared groundwater exists and the specific Israeli-Palestinian case.

THE BOOK

The book begins with an overview of the management principles of groundwater. This is intended for the uninitiated reader, so that subsequent chapters and their purpose are clearer for those not specializing in groundwater management. These principles are based on the conventional professional wisdom as it is presented in the academic and professional literature. It is followed by a chapter that also derives management principles, but from a very different source - the Quran.

The second part of the book presents the Israeli-Palestinian case. First the basic features of the Mountain Aquifer are introduced to readers not familiar with it. Then the Israeli water economy and the Palestinian water situation are presented, followed by several chapters providing Israeli and Palestinian perspectives regarding the need to manage the shared aquifers cooperatively. While many of the points raised in these chapters are agreed upon by Israelis and Palestinians, it should not be surprising that the views expressed in these chapters do not conform. Indeed, the reader will find several seeming inconsistencies between chapters. While this may seem a deficiency in many books, in one concerned with the management of a transboundary resource shared by parties that have a history of mutual hostilities and that brings forth the voices of those involved from both parties such inconsistencies are integral to the discourse. They have been left, therefore, as they have been presented by the different authors.

In the third part of the book the international experience with managing transboundary groundwater is presented. The principle issue that has to be addressed if an aquifer is to be managed is the allocation of its water. Aaron Wolf reviews the allocation principles of water in the extensive set of international water treaties he compiled. The most important lesson that he gleans from this review is that allocations are most often determined by the local situation rather than the abstract principles so widely discussed in the academic literature. Carel De Villeneuve then discusses the Dutch experience with groundwater management, with particular reference to the relations with Belgium and Germany. Greg Thomas addresses the question at which level groundwater should be administered - local, regional or nation/state - and whether groundwater management should be centralized or decentralized. While the discussion focuses on the US experience the questions, and hence the lessons, are of consequence generally. Joseph Dellapenna and Miguel Solanes bring the experience of the law. Dellapenna reviews the evolution of international law with regard to transboundary groundwater. Solanes discusses the legal principles for water management in different countries, focusing on property rights, principles of management, economic aspects and institutional aspects. The most difficult strains on any water management regime is during periods of drought. Ariel Dinar reviews, therefore, the way droughts are handled in different countries.

As noted earlier, the management of groundwater requires much data and knowledge. These are based on monitoring, modeling and research. These aspects are discussed in part four of the book. First Jac van der Gun discusses the relations between monitoring and modeling to decision making. He forewarns that data collection can become an end to itself, thus creating "data graveyards." Hence, monitoring and data collection should be governed by the needs of decision making, rather than be seen as an issue unto itself. Yoav Harpaz discusses the role of hydrological factors and of models in groundwater management. Jaad Isaac and Maher Owewi then present the potential of Geographic Information Systems (GIS) for handling the data needed for groundwater management, focusing already on the Israeli-Palestinian Mountain Aquifer.

As the experience with groundwater management, in general, and the management of transboundary groundwater, in particular, is scant there are many options that have not yet been tried, or have hardly been tried, anywhere. In part five of the book some of these options are discussed. The first three focus on measures that enhance water use efficiency. Stephan Lonergan begins with a discussion of the possibilities to use economic instruments within joint management frameworks for groundwater, with particular reference to the Israeli-Palestinian case. Then, William Easter and Robert Hearne discuss the potential of water markets based on the experience elsewhere. Finally, David Brooks widens the discussion arguing for the implementation of demand management in the water field, including non-market measures.

The remaining chapters in part five pertain to different aspects that should be considered in the management of shared groundwater, but may be of special relevance in the Palestinian-Israeli case. Eran Feitelson discusses how water rights should be defined and allocated. Specifically, he argues that water allocations, and rights, should be defined by vectors including time, return flows and quality levels, rather than by single numbers. When viewed from a water cycle perspective such definitions allow for multiple use, providing decision makers with a wider variety of options. Then he draws implications from these notions to the Israeli-Palestinian case. Eyal Benvenisti then discusses the legal aspects of establishing joint management mechanisms, an issue generally overlooked in international law, and the features such mechanisms should include. Ismail Najjar advances options for managing droughts, focusing on the institutional aspects. Finally, Numan Mizyed discusses the need for incorporating land use aspects in aquifer management, focusing on the Palestinian-Israeli setting.

In the last part of the book the different strands discussed in previous parts are brought together. First a sequential flexible approach for structuring a management regime for shared aquifers is presented. This approach allows for the incorporation of the different ideas raised earlier according to the particularities of the specific setting. Moreover, it allows decision makers to change the focus of the management efforts over time. Then the agenda that has to be addressed in order to implement this approach to the Israeli-Palestinian case is advanced.

REFERENCES

Barberis J., 1991, "The Development of the International Law of Transboundary Groundwater", *Natural Resources Journal* 31, pp. 167-186.

Benvenisti E., 1996, "Collective Action in the Utilization of Shared Freshwater: The Challenges of International Water Resources Law", *The American Journal of International Law* 90, pp. 384-415.

Cohen J., 1995, *How Many People Can the Earth Support?* W.W. Norton & Co., N.Y.

Gleick P. (ed.), 1993a, *Water in Crisis: A Guide to the Worlds Freshwater Resources*, Oxford University Press, Oxford and N.Y.

Gleick P., 1993b, "Water and Conflict: Freshwater Resources and International Security", *International Security* 18, pp. 79-112.

Homer-Dixon T.F., 1994, "Environmental Scarcities and Violent Conflicts: Evidence from Cases, *International Security* 19, pp. 5-40.

Shiklomanov I., 1993, "World Freshwater Resources", in: P. Gleick (ed.) *Water in Crisis: A Guide to the Worlds Freshwater Resources*, Oxford University Press, Oxford and N.Y.

I

THE PROBLEMS AND APPROACHES TO GROUNDWATER MANAGEMENT

Chapter 1

The Management of Shared Aquifers

Principles and Challenges

Marwan Haddad, Eran Feitelson & Shaul Arlosoroff

Department of Geography, The Hebrew University of Jerusalem and the Harry S Truman Research Institute for the Advancement of Peace, Mount Scopus, Jerusalem

College of Engineering, An-Najah National University, Nablus, Palestinian Territory

The Harry S Truman Institute for the Advancement of Peace, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem

The basic principle for management of an aquifer is seemingly simple: extraction rates should not exceed recharge (that is, a sustainable yield should be maintained), thereby assuring that the aquifer is not depleted, and that water quality be maintained. This principle resembles that governing the management of all renewable resources, as propagated by conservationists more than ninety years ago. In practice, however, groundwater management is perhaps the most complex challenge facing the water policy community. This complexity is compounded when aquifers underlie boundaries.

The purpose of this chapter is to outline the main issues that make the management of shared aquifers such a difficult challenge. The chapter begins by outlining the problems that make the simple principle of management so complex in practice. Then the basic principles for aquifer management are outlined, charting the actions that aquifer management entails. The additional difficulty presented when boundaries overlay an aquifer is introduced in Section Three. Finally, the scope of options for management of shared aquifers is presented.

This chapter serves primarily as background for the remainder of the volume. Therefore, it does not delve into details or comprehensively review any of the issues presented herein, many of which are elaborated upon in subsequent chapters. Rather, the issues are presented in a simplified form in order to establish a common reference for all readers, regardless of their disciplinary background.

1. THE PROBLEMS

Groundwater problems can be grouped into two main categories: (1) quantitative—those caused by over-exploitation, and (2) qualitative—those caused by contamination. Oftern the majority of these problems are as yet unidentified, as they are hidden from view. Because, in general, groundwater flows tend to be slow, the ramifications of current actions may not be apparent for decades, thus delaying response times (UNESCO, 1992).

When establishing an extraction regime from an aquifer it is important to note that prior to extraction a steady state existed, whereby recharge equaled the natural outflow plus changes in the water table. Thus, any pumpage regime, including such that adhere to the sustainable yield principle noted above, reduces the natural outflow and affects the water table (Cohen, 1994). Moreover, the artificial extraction of water from the aquifer is not related to the rate of recharge directly, and hence the temporal discrepancy between recharge and extraction is likely to increase. Also, the establishment of a sustainable yield requires that the aquifer's recharge rate and properties be understood. Yet this is not always the case, as underground geology or geohydrology is often complex and the funds available for studying the subject limited.

On the basis of these preliminary observations, it is possible to identify four basic problem areas precluding a straightforward application of the sustainable yield principle. These are the temporal (and, to a lesser extent, spatial) discrepancy between demand for the groundwater and its recharge rate; uncertainty regarding the aquifer; the effect of water extraction on the quality of the groundwater; and the interaction between land use and groundwater.

1.1 Temporal and Spatial Discrepancies

The first problem is that temporal and spatial demand patterns are not directly related to recharge rates. This is especially evident in arid and semi-arid regions where recharge rates vary widely as a function of the high seasonal and inter-annual variability of precipitation. The variability in recharge rates is further increased by the variability in precipitation patterns, as different types of precipitation in terms of intensity, duration, frequency and weather between episodes imply different recharge rates (USEPA, 1990).

Generally, the importance of groundwater (as reflected in its true opportunity cost) increases as the availability of alternative water sources decreases. Opportunity costs usually rise in dry periods (whether seasonal or drought years), when demand is high and recharge rates low. This problem can be partially overcome by artificially recharging the aquifer during wet periods for use in dry periods. However, the ability to use an aquifer to store water is constrained by the structure, natural replenishment and capacity of the aquifer, by water quality considerations and by properties of the water system as a whole (Schwartz, 1989).

As a result of the discrepancy between recharge and withdrawal rates, water tables fluctuate. It is difficult to forecast these fluctuations on an annual basis, as climate cycles introduce a stochastic element. This raises the question of whether aquifers should be managed according to multi-year average recharge rates or whether some safety factor should be introduced (Amiran, 1995). If the multi-year average recharge is allowed to be extracted annually, an aquifer may be severely depleted after a series of drought years. Such depletion may have significant implications for water quality in the aquifer, discussed below, and subsequently reduce the aquifer's capacity. It is, thus, not trivial to define what "over-exploitation" of an aquifer is. This issue is further complicated by the possibility of climate change, which could effect long-term precipitation patterns and hence both the average recharge rates and the variance of such rates.

Demand is not distributed evenly over space. It is usually concentrated in several major areas or nodes. To minimize energy use, and water costs, it is necessary to optimize well location as a function of drilling, pumpage and water transport costs. The result may be, however, that most wells are drilled in one part of the aquifer. In such a situation an aquifer can be severely depleted locally even if overall extraction rates do not exceed the recharge. Therefore, pumping and management regimes have to be defined for sub-aquifers. This requires that local features of the aquifer's formation be known, requiring very detailed studies—a complex and costly endeavor.

1.2 Uncertainty Regarding the Aquifer

Groundwater is subsurface water that fills voids in soils and permeable geological formations. Water stored in an aquifer is usually in motion, flowing slowly toward lower outlets under the influence of gravity, until it discharges into a spring, stream, lake, wetland or the sea, is taken up by plants and/or extracted by wells. The rates of flow, their nature and the ability to extract water are a function of the attributes of the geological formations that compose the aquifer. Thus, an estimation of how much water is available in an aquifer, and when and where, requires a sound understanding of the geological formations, their porosity, permeability and specific yield, and data regarding water inflow and outflow (USEPA, 1990; UNESCO, 1992). This data can be incorporated into models. However, as a model is only a simplification of reality, any model of an aquifer using available data can only approximate the real aquifer. The calibration of such models necessitates multi-year observations and measurements of the main parameters. In practice, then, many decisions are made on the basis of models that are not fully calibrated.

The inter-relations between groundwater and surface water, and between different groundwater basins, are of great importance in analyses of water inflow and outflow from an aquifer, and hence from a groundwater management perspective. However, often these inter-relations are not fully understood or known. Moreover, the relations may change over time or fluctuate, as a drop of a water table may change a gaining stream (a stream whose flow increases downstream due to groundwater runoff) to a losing stream. Similarly, a rise in the water table can change a losing stream to a gaining one.[1]

Analyses of the inter-relations between water bodies requires that flow patterns in the streams be analyzed in detail and with great care (USEPA, 1990). In many cases, however, both the geological and hydrological data are incomplete. Moreover, the models necessary to analyze the effects of different actions on the aquifer may be inaccurate or not fully calibrated. Management decisions then have to be made in a situation of substantial uncertainty regarding the basic attributes of the aquifer being managed, and the implications of such decisions. While the level of uncertainty is generally greater in developing countries, some level of uncertainty characterizes aquifer management in developed countries as well.

1.3 Effects on Water Quality

The possibilities for using the water extracted from an aquifer and its opportunity costs are functions of the water's quality. Artificial extraction reduces the natural outflow and changes the hydrostatic pressures within the aquifer. This may affect the quality of the groundwater in two ways: (1) the reduction in natural outflow may lead to the salinization of the aquifer as a result of the accumulation of minerals that were previously flushed out by the natural outflow; and (2) the change in hydrostatic pressures may allow saline water to encroach into the aquifer. This problem is typical in coastal aquifers, but is also well known in land aquifers (such as the Mountain aquifers in Israel-Palestine).

The determination of a "sustainable" extraction rate has to take into account these possible processes. The implication of such awareness is that

[1] These inter-relations are also affected by the type of aquifer. Thus, streams over karstic aquifers are more likely to be losing water.

maintenance of water quality should become a second guiding criterion for the sustainable yield of aquifers and, especially, shared aquifers. That is, extraction should be controlled to levels that would not lead to a significant deterioration of an aquifer's water quality—which may preclude its continuous future use.

Water quality in the aquifer, however, is not affected solely by the extraction rates. It is also affected by the quality of both natural and artificial recharge and by the activities taking place over the aquifer's recharge area. Hence, land use intensity and patterns may have important implications for water quality in the aquifers.

1.4 Groundwater-Land Use Interactions

Changes in natural outflow affect the ecosystems based on these outflows. Changes in the ecosystems, in turn, affect transpiration rates and runoff and recharge rates. In other words, determination of extraction rates affects recharge rates. It also affects biodiversity and other ecosystem services. Such effects are also part of the issues that should be considered within a sustainable development framework, but are not reflected in the simplistic sustainable yield principle. Todd's (1959) redefinition of sustainable yield—"the safe yield of a ground water basin is the amount of ground water which can be withdrawn from it annually without producing an undesirable result"—provides a partial answer to this lacuna. The policy discussion henceforth focuses on the meaning of "undesirable results".

Land use patterns can have a direct effect on both recharge rates and the quality of water being recharged. Increase of impervious areas, particularly in urban regions, can increase runoff and reduce local recharge rates (Foster, 1988). Land use patterns also effect the likelihood that contaminants would reach the aquifer. Contaminants leach to the aquifer with the water percolating to the groundwater from land fills, sewage flows, industrial estates or agricultural areas. The extent to which contaminants reach the groundwater is a function of both the soil and the aquifer's structure and the way the different activities are conducted (Custodio, 1989). The effects can be mitigated by measures enacted by land users.

The remediation of a polluted aquifer is notoriously time consuming and expensive. The implication of contaminants reaching the groundwater may thus well be a reduction in the aquifer's usable capacity. It is usually cheaper and more effective to prevent pollution by enacting appropriate measures by land users than to clean up the aquifer (Custodio, 1989). But, as percolation to the saturated zone may take many years, the effects are often felt long after the measures are taken. In such situations it may be too late to prevent pollution. Regrettably, as a result, it is likely that in many places future generations will feel the full implications of the lack of appropriate land use policies and subsequent pollution effects.

One of the main threats to aquifers is untreated wastewater flowing over their recharge areas. Wastewater may also be more saline than the aquifer. It can, therefore, not only pollute an aquifer but also contribute to its salinization. This issue is particularly grave when domestic and industrial wastewater are not separated, or when industrial wastewater is not treated adequately. The quantity, location and content of wastewater is a function of land use patterns and practices, of the level to which wastewater is treated, and of the extent and location of its re-use. In addressing land use aspects, therefore, aquifer management strategies have to give special attention to wastewater collection, treatment and re-use policies.

2. PRINCIPLES FOR MANAGING AN AQUIFER

Sustainable development, as defined by the Brundtland Commission, suggests that the needs of the present should be met, but not at the expense of future generations (WCED, 1987, p.43). There have been many interpretations of this dictum (e.g., Pearce et al., 1989; Pezzoli, 1997). From an aquifer management perspective, however, all interpretations imply that aquifers should be managed with future generations in mind. While the specific stipulations within the management regime, such as determination of extraction rates and "red lines" or the importance of ecosystem protection considerations, would be a function of the interpretation adopted, the types of actions needed to manage an aquifer are not a function of the interpretation of sustainability. In this section the principles that should be adhered to if an aquifer is to be managed in a sustainable manner are outlined, regardless of the exact interpretation of sustainability.

2.1 Comprehensibility

With the possible exception of some fossil aquifers, all aquifers are part of the water cycle (Figure 1). It is impossible to manage an aquifer without due regard to all the other variables of the water cycle shown in Figure 1. Many of the key variables in Figure 1 are affected, however, by human actions. Urbanization and subsequent increase in impervious areas affect direct runoff patterns, the amount of water used for domestic and industrial use, and hence wastewater generations. It may also affect the amount and type of vegetation, and hence transpiration. Agriculture affects transpiration, the demand for water for irrigation, vegetative cover, and also direct runoff. Industrialization, urbanization and agriculture cause pollution, which in turn affects water quality, somenot seen in Figure 1. The management of an aquifer cannot be limited, therefore, to the determination of points of extraction and amounts extracted from the aquifer. It has to take into account a much wider array of issues, including artificial recharge, the environment of the aquifer, the water supply system, water use patterns and their social and economic ramifications, as well as the administrative and legislative milieu (Schwartz, 1989).

2.2 Continuous Improvement of Data and Models

The starting point for the management of any aquifer has to be an assessment of water quantities and quality in all the factors shown in Figure 1. It is necessary to know long-term precipitation patterns, to understand the geological structures, surface flows and groundwater outflow to external basins. For the groundwater component baseline information is needed on: the location, water quality and potential yield of all parts of the aquifer, subterranean flow patterns, potential sources of pollution, the aquifer's natural degree of protection and current location and extraction rates of wells (UNESCO, 1992). As Van der Gun argues later in this volume, this data has to be collected in conjunction with the development or application of models that would be used to analyze the aquifer and water system. Such models are essential for understanding the implications of different actions, and for determining the "red lines" for withdrawals. Therefore, there is a need for continuous evaluation of the aquifer, supported by appropriate research and development programs.

The development of a database that includes all these variables is likely to be a slow, costly and lengthy process. A wide variety of sources and methods have to be used. Once collected the data have to be input, and the database must be continually updated and enlarged. To this end a monitoring network is needed—including, where possible, direct subsurface measurements. This can be accomplished by a network of monitoring wells and by the monitoring of pumping wells. Conditions between wells are then usually extrapolated or measured using indirect methods.

Monitoring and modeling are requisites for the management of an aquifer (Harpaz, this volume), but unless they are incorporated in a decision support framework their outcome may go unheeded (Van der Gun, this volume). It is thus necessary to integrate these activities with other management actions.

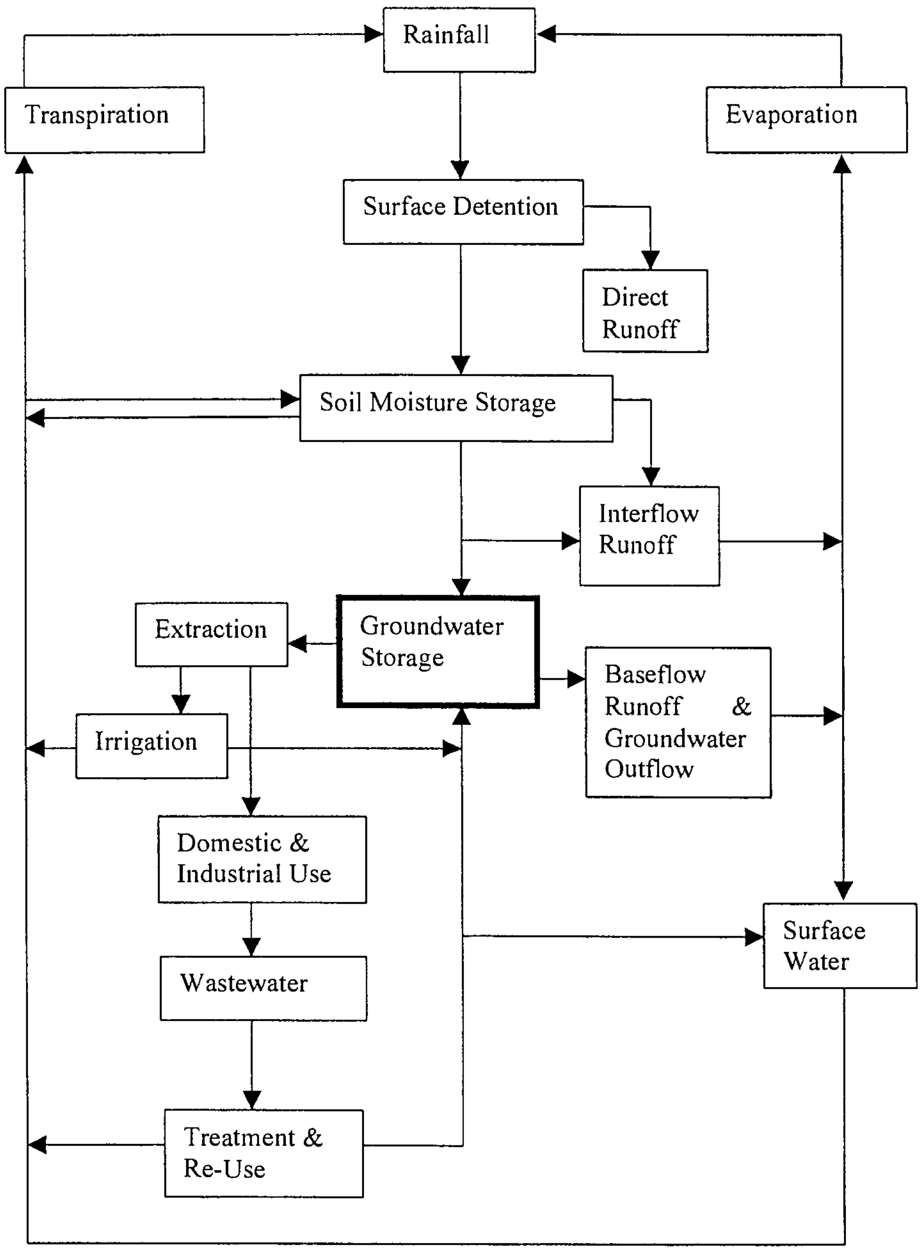


Figure 1. Groundwater Within the Water Cycle

2.3 Control of Extraction

On the basis of available data and knowledge, extraction has to be controlled to levels that would assure that no unacceptable damage is done to the aquifer (in terms of water quality and capacity) or to ecosystems dependent on the aquifer's outflow. To this end, "red lines" for total extraction have to be established. In societies where groundwater is not seen as a public good in public ownership this may require that the ownership be separated from the right to use the groundwater. Extraction has to be related to recharge. Thus, in drought years extraction has to be reduced. This requires that criteria for declaring a drought are agreed upon, as are ways for determining to what extent extraction should be reduced and how to implement such measures. As users differ in terms of their ability to accommodate a reduction in water allocation priorities have to be established for such an occurrence.

Fossil aquifers may be a special case in this respect, as recharge rates are too low for allowing a meaningful sustainable yield. Thus, when utilization of a fossil aquifer is considered, a different definition of sustainable development may have to be used, whereby the yield is set to a level where the current option price is sufficient to compensate future generations for the additional water production costs they will have to bear. In other words, the use of a fossil aquifer has to be justified by the high-value product of the water extracted from it. It may also be desirable to establish a fund whose revenues would come from current water fees and that would be earmarked for development of future water resources, once the fossil aquifer has been depleted.

It is also possible to allow for the over-exploitation of a non-fossil aquifer, if it is seen as a temporary measure until new resources are developed. However, such a strategy is risky, as there is a need to assure that sufficient funds are reserved for the benefit of future generations, and that no unacceptable environmental or ecological damage is inflicted. This latter constraint is particularly difficult, conceptually, as from a sustainable development perspective it is necessary to ensure that any environmental and ecological damage inflicted would be acceptable not only to the current generation but also to generations to come.

2.4 Managing Artificial Recharge

If there is excess water available in the system as a whole it is possible to enhance the aquifer's recharge artificially (Schwartz, 1989). There are several potential sources for excess water. These include underutilized surface flows that are captured and stored in the aquifer for use during dry periods, thus assuring minimal loss to evaporation and ephemeral surface flows. Another source is recycled wastewater, often as part of an infiltration-percolation system (Brissaud et al., 1989). The quantities and distribution of artificial recharge sites must be determined according to their impact on quantity, quality and flow patterns in the aquifer. The possibility for recovering the infiltrated water via wells also has to be assured.

In addition to determining the source for recharge and location of recharge, a management strategy has to address the impacts of artificial recharge on water quality. Hence, the hydrological chemistry of the aquifer must be understood prior to such activities. It is necessary to avoid adverse impacts on the aquifer and clogging. This is especially pertinent in cases where there is recharge of reclaimed wastewater. However, it is also possible to use artificial recharge to improve the quality of water extracted, if water with low salinity is introduced to an aquifer with higher salinity levels, for example.

2.5 Prevent Pollution

In order to reduce the danger of pollution a protection plan should be prepared. This would include land use controls, at least in sensitive recharge areas and near well heads. Sensitive areas have to be delineated and principles for protecting them promulgated. In addition, well heads have to be protected, to prevent pollution from nearby activities.

Additional measures for protecting groundwater can include regulation of hazardous materials storage and transport and waste disposal location and methods. Use of pesticides, herbicides and fertilizers can also affect groundwater; thus, measures to control such usage should also be included in a protection plan. Wastewater treatment standards and re-use guidelines, relating such re-use to treatment level and sensitivity of the underlying aquifer, may also be part of the protection plan. In addition, contingency plans for dealing with pollution incidents should be prepared and adequate teams for dealing with such contingencies trained.

2.6 Manage Demand

Water extractions from an aquifer are driven by demand. However, in many places water is not used efficiently. It is often preferable to increase the efficiency of water use rather than increase pumpage. Demand management, and subsequently water conservation measures, can thus be seen as an integral part of aquifer management, an issue pursued in David Brooks' chapter in this volume.

Recent years have seen growing recognition of the importance of attributing to water its true economic value. If water prices would reflect the commodity's scarcity and quality, water extraction would become a function of the aquifer's condition. Water pricing can be an important element in managing water demand, in addition to signaling the need to increase or decrease pumpage.

Trading in water allocations can help determine the value of water, and hence is increasingly considered an integral part of water policy, in general, and aquifer management, in particular. However, pricing and trading should be conducted with care, taking into account their social and environmental ramifications. The options for use of such economic instruments are discussed by Lonergan and by Easter and Hearne in this volume.

2.7 Institutional Structure and Authority

All the elements of a management strategy mentioned thus far are important for managing an aquifer. However, they are insufficient. To ensure the success of a management strategy it is necessary to actually make the right decisions in time and to implement them. To make such timely decisions an appropriate institutional structure is needed.

It is tempting to propose that a single agency be given full authority to manage an aquifer, and indeed many propositions to this effect have been made. In reality, however, it is rare that a single agency has the authority to manage all facets affecting the aquifer. It is likely, then, that a more complex institutional structure would have to be formulated.

In establishing an institutional structure it is important that the necessary authority be vested in the agencies responsible for the different facets of aquifer management, that all facets be included in the institutional structure, and that appropriate mechanisms be established to facilitate inter-agency coordination and cooperation. The institutional structure has to operate within an appropriate legal structure that would determine the authority and actions allowed for each agency or unit. The legal structure chosen is a function of local political, social and legal conditions. Thus, in several countries (such as Israel, Poland, the UK and USA) provisions within special water legislation have been passed to this end, while in others (the Netherlands and France) a wide range of regulations dealing with specific aspects of groundwater management have been enacted, thus embedding the management within an existing legal structure. Regardless of the specific legal basis of authority, it is important that an effective enforcement mechanism be established. Unless the regulations and standards promulgated can be enforced the management strategy is likely to be ineffectual.

2.8 Choice of Measures

The institutions entrusted with managing the aquifer have to deal with a large number of issues. To do so they can use a wide variety of means. The question that should be addressed in structuring a management strategy is, what measures would make the strategy both effective and feasible?

In Table 1 some of the possible actions, and the purpose they may serve, are enumerated. The measures are grouped for convenience into four. However, to effectively address the issues outlined above a portfolio of measures would have to be used drawing on all these groups. For example, regulative measures, such as pumpage licensing, are required to control water extraction and preclude over-pumping. To establish and implement such a system a monitoring and research program is needed. However, when demand grows rapidly the pressures to increase water extraction rises. Hence, it may be infeasible to maintain a strict quota system if a complementary water demand program is not implemented. Such a program may well make use of economic instruments, such as real-cost fresh water pricing. Hence, a policy package whose purpose is ultimately to prevent over-pumping may include, in addition to the regulatory tools needed to control extraction, monitoring, research and pricing elements.

An additional consideration that may effect the choice of instruments is political feasibility. One of the main impediments to the use of different measures is their equity implications. If, for example, extraction by certain right holders has to be curtailed it is likely that they would object. However, if a trading mechanism is introduced in conjunction with the reduction in extraction the value of water rights increases, and right holders can be partially compensated via the market for the loss of water. Thus, a portfolio of measures can make a management strategy more politically palatable. Similarly, other combinations of measures should be considered when structuring a management strategy that is effective, technically feasible and politically acceptable in the local conditions.

Table 1. Actions for Groundwater Protection

POSSIBLE ACTION	PURPOSE
Regulations	
Groundwater Extractions	Control location and rate of extractions; set standards for well construction
Sewage Treatment and Wastewater Re-use	Set standards for location of treatment plants, level of treatment, re-use or disposal; construction of septic systems
Landfills/Solid Waste disposal	Set standards for siting and constructing of new landfills; remedial measures for existing landfills
Toxic and Hazardous Materials	Control the transport, storage, use and disposal of toxic and hazardous materials
Land use Controls	Control the siting of potentially harmful activities in sensitive areas; Maintain portions of recharge areas undeveloped or with natural vegetation to protect recharge and water quality
Wellhead protection	Prepare plans for protecting water quality in wells
Planning	
Groundwater Protection Areas	Identify sensitive areas and prepare guidelines for their protection
Drought	Designate criteria for declaring a drought; Prepare actions to be taken once a drought is declared
Contingency	Identify possible contingencies; Prepare actions to be taken in case of contingency
Incentives/Disincentives	
Pricing	Price water to reflect its scarcity value
Subsidies	Provide subsidies for conservation and protection measures
Taxes	Tax potentially harmful activities
Water Trading	Establish water markets to facilitate efficient water use
Other Actions	
Land Acquisition	Permanently protect groundwater from land-based pollution
Education	Inform and involve the public
Monitoring	Verify extraction rates; establish quality trends; augment database
Research	Improve understanding of the physical properties of the aquifer, of the implications of different actions, and of options for protecting the aquifer
Training	Improve the institutional capacity to manage the aquifer

2.9 Public Involvement

The management of an aquifer is not something that should be the exclusive concern of experts. Ultimately it is the concern of the public, whose welfare is affected by the management strategy chosen. However, public involvement is not limited to informing the public. It has two goals: (1) to improve the management decisions by introducing detailed local knowledge, in some cases accumulated over centuries; and (2) oversight of the public bodies, to assure that particular interests do not appropriate the aquifer for their exclusive benefits.

Public involvement can be achieved in several ways. Information can be disseminated and grassroots responses elicited at public hearings. More effective public involvement may be achieved by opening meetings to the public, or to representatives of public bodies or citizen groups. In this latter case the citizen groups of non-government organizations (NGOs) can hire their own experts to provide better oversight of the decisions made by the institutions involved. Finally, citizens can be given authority over specific actions, or part of the system (such as monitoring or allocation of water at the village level).

To facilitate public participation and boost its efficacy educational programs may be introduced or groundwater issues may be incorporated into existing programs. These may be part of a more comprehensive capacity building effort, as suggested by Alaerts (1999).

3. THE PROBLEM OF SHARED AQUIFERS

The discussion so far has implicitly assumed that aquifers lie within a single jurisdiction, or country. However, aquifers do not conform to administrative or national boundaries. Many aquifers underlie such boundaries. This fact alone substantially complicates their management. To accommodate this complication the following aspects need to be addressed.

3.1 Water Allocations

The first issue this situation raises is that of water rights or allocations. In most societies groundwater use is governed by some system of rules and norms. These do not exist in a cross-boundary situation. While international law provides some guidelines regarding allocation of cross-boundary water, they leave wide room for interpretation (see Dellapenna's chapter below). In practice, therefore, transboundary water treaties exhibit a wide variety of allocation principles (see Wolf's chapter below). Most of these treaties, however, pertain exclusively to surface water. To illustrate the complexity in a groundwater context a hypothetical example is presented in Figure 2.

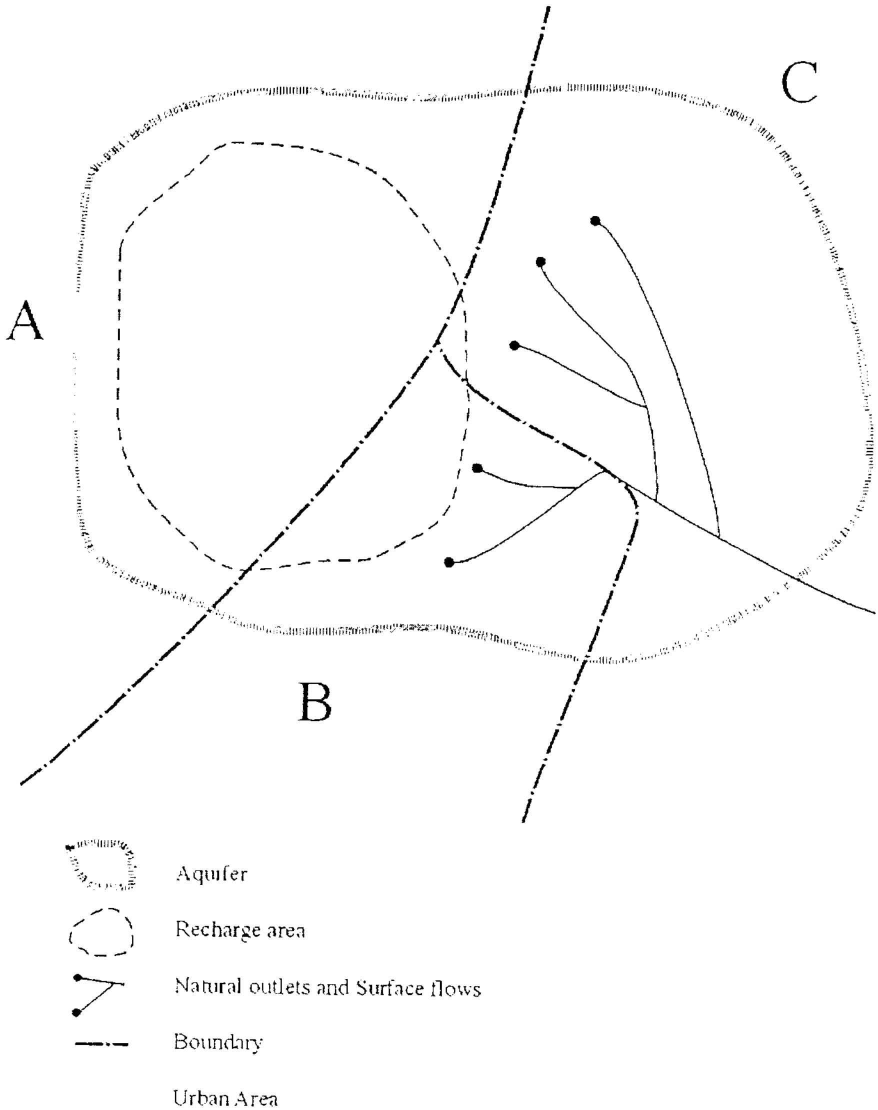


Figure 2. A Hypothetical Shared Aquifer

A hypothetical aquifer underlies three entities (countries). Most of the recharge area is within country A. All of the natural outlets are in countries B and C. The natural flow is from country A, through B to C. Extraction costs are lowest near the natural outlets. Country C was the first to utilize the aquifer's water, mainly for irrigation. However, the population in countries B and A has increased, with most residents of country B living in urban centers. Country B also has the highest GDP per capita. Table 2 summarizes several different options for allocation rationales and their implications. According to the historical use rationale, country C in the hypothetical example would receive most of the water. In contrast, according to the human rights or efficiency rationale, it is likely that country B would receive most of the water. Country A contributes most of the recharge, and hence would stand to gain most from the third rationale. Country A also occupies the largest share of the aquifer's area, followed by country C. An allocation by this principle would thus provide additional water to country A, take some from country C, and leave a relatively small amount to the highly populated and urbanized country B. This example shows thus that each country would favor a different allocation rationale. As the rationales are not complementary, conflict is likely to ensue, unless an agreement between them is reached.

Table 2. Examples of Allocation Principles

PRINCIPLE	IMPLICATION
Historic Use	Existing use cannot be reduced, thus the country that exploited the aquifer first (often where natural outflow occurs) has a priority.
Efficiency (willingness-to-pay)	Water is to be used where it provides the highest marginal value product. Can be allocated by auction. Countries with higher marginal product value of water or higher ability to pay may purchase most of the rights.
Contribution to the Aquifer	Water allocations are a function of the share percentage of recharge coming from each country
Share of the Aquifer	Water allocations are a function of the share of the aquifer's area.
Human Rights	Water is allocated on a per-capita basis. The most populous countries will receive most of the water. Allocations would have to be modified as a function of population growth.

3.2 Institutional Structures

Regardless of the allocation principle decided upon, it is necessary to agree on the quantity that can be utilized. This is part of a wider concern regarding the welfare of future generations, as well as present ones. Essentially, a shared aquifer situation raises the questions, how is total extraction going to be determined (i.e., who determines total extraction from the aquifer) and how will the measures needed to protect the resource (aquifer) be decided upon and enforced, especially in cases where there are still unresolved water disputes?

The second issue a cross-boundary situation raises, therefore, is that of decision making, and hence institutional structure. In all societies where water use has to be governed (where an open-access regime cannot function) some sort of institutional structure exists to govern the property rights, enforce them and adjudicate in case of disagreements. In many societies such institutions also assure that use is kept within some kind of a sustainable yield constraint. There are no such institutions at the international level, and international law has not yet created sufficient incentives for establishing them for groundwater resources (Benvenisti, 1996). Moreover, in many cases there is a lack of such institutions also when an aquifer underlies an administrative boundary within a country.

4. MANAGEMENT OF SHARED AQUIFERS

There are four basic options to manage a shared aquifer: separately, in a coordinated manner, jointly, or by delegating responsibility to an outside body. Clearly, different options fit different cases. In specific circumstances it may be possible also to combine two or more options. Thus, when searching for a way to overcome the problems noted above all four options should be considered.

4.1 Separate Management

If each party manages its part of the aquifer separately, each sets its own developmental perspective and policies, drills its own wells, designates the extraction rates in those wells, sets its own standards, collects data, runs models and determines the water rights and use within its area by itself. If the amounts extracted by the parties are smaller than the recharge rates, and there is no substantial hydrogeological interdependence between the parts of the aquifers controlled by each party, this option may be the most efficient, as it involves none of the transaction costs necessary to establish the institutional structures required for any of the other options. However, if these conditions do not hold true, this option does not allow for any mechanism that would preclude unsustainable use of the aquifer. In this case, it is likely that the aquifer would be eventually depleted, or parts of it would be polluted and rendered unusable.

Under this regime it is likely that the specifics and level of management would differ between the parties. That is, the different parties would set different goals, set different standards and have a different level of commitment to the management of the aquifer. In this situation, however, even if one party shows true concern it may be unable to affect the trends if other parties control critical areas.

As separate management does not interfere with any party's sovereignty, and requires no special action and hence minimal transaction costs, it is the default option. That is, if no concrete effort is made to address the fact that the aquifer is shared by more than one party we can expect to find separate management. As the problems associated with the mismanagement of an aquifer are usually not readily apparent, it is not surprising that most shared aquifers are managed separately.

4.2 Coordinated Management

The second option for managing a shared aquifer is for each party to manage the aquifer in its territory, but that there would be some mechanism to allow the parties to coordinate their management activities. They could coordinate, for example, the extraction rates in wells between which there is a clear geohydrological interdependence, while at the same time each party separately sets the extraction rates in other parts of the aquifer. Similarly, they can coordinate data collection efforts and modeling, while retaining the right to determine extraction separately. In essence, the parties can agree to coordinate any of the elements of aquifer management seen as useful by them, while retaining their right to continue and conduct separately all other activities, including developmental policies.

Coordinated management retains full authority in the hands of each party. It thus does not impinge on sovereignty. At the same time it allows for economics of scope and better management in situations where the conditions mentioned above for successful separate management do not hold. In cases where there is substantial interdependence between the parties in terms of their shared aquifer, or when the demand is substantially larger than recharge rates, such coordination will likely not be sufficient.

4.3 Joint Management

A third option is to manage a shared aquifer jointly. In this case, a single institutional structure is established by the different parties which is empowered either to manage the aquifer or to carry out certain tasks viewed as the most crucial for adequate management of the aquifer and its sustainability.

In the Bellagio Draft Treaty (BDT) one such institutional structure is proposed (Hayton & Utton, 1989). In essence, the BDT proposes that a joint commission be established and empowered to manage the aquifer. It would carry out all or most of the tasks outlined above as necessary for a comprehensive management of an aquifer. This commission would be provided with appropriate power to carry out the tasks and implement the measures noted in Table 1. Such a structure would require that the parties forgo at least some of their sovereignty. This requirement, and the substantial transaction cost necessary to enact this draft agreement, may explain the fact that no such structure has been established since, despite the obvious benefits from an aquifer management perspective.

The BDT, however, is not the only option for joint management of a shared aquifer. As shown in the last two chapters of this volume, the range of options is wide. Thus, it is possible to establish a less onerous joint management structure than proposed in the BDT.

4.4 Delegation of Responsibility

A fourth possibility is to delegate responsibility for the aquifer, or for some management tasks, to an external body. This could be a regional or international body or a privately-owned corporation. In other words, it is possible that the parties would agree to privatize some aspects of aquifer management (such as monitoring, extraction and selling of water, or wastewater management), leaving them in the role of regulators.

As this option implies a loss of control by the parties over a resource it is not surprising that it has not been considered seriously yet, except for very limited facets such as wastewater treatment. However, in discussing the management of shared groundwater basins in the future this option should not be overlooked.

5. CONCLUSIONS

Sustainable management of an aquifer is a complex task in the best of circumstances. However, as subterranean water flows are very slow, mismanagement of aquifers is not readily apparent. Consequently, many, and perhaps most, aquifers are not managed in a sustainable manner.

The management problems of aquifers are magnified when the aquifers underlie borders, thereby making them shared aquifers. In such cases the many decisions that need to be made for their sustainable management have to be taken by more than one pa, in a situation where there is often no force binding the parties to agree on the measures that should be taken.

The problem of shared aquifers has not received much attention. As a result, the options for managing such aquifers have not been explored sufficiently. This volume examines and discusses the different issues that have to be addressed within the context of shared aquifers. A comprehensive approach for identifying the relevant structures for joint management is presented in the final two chapters.

REFERENCES

Alaerts G.J., 1999, Capacity Building as Knowledge Management: Purpose, Definition and Instruments, in: G.J. Alaerts, FJ.A. Hartveld and F-M. Patorni (eds.) *Water Sector Capacity Building: Concepts and Instruments*, A.A. Balkema, Rotterdam.

Amiran D., 1995, *Rainfall and Water Policy in Israel*, The Jerusalem Institute for Israel Studies, Jerusalem.

Benvenisti E., 1996, Collective Action in the Utilization of Shared Freshwater: The Challenges of International Water Resources Law, *The American Journal of International Law* 90, pp. 384-415.

Brissaud F., Lefevre F., Joseph C., Alamy Z. and Landreau A., 1989, Waste water Infiltration-Percolation for Aquifer recharge or Water re-use, in: A. Sahuquillo, J. Andreu and T. O'Donnell (eds.) *Groundwater Management: Quantity and Quality*, Proceedings of the symposium held at Benidrom, Spain, International Association of Hydrological Sciences.

Cohen P., 1994, Some Comments about Managing Groundwater, in: E. Feitelson and M. Haddad (eds.) *Joint Management of Shared Aquifers: The First Workshop*, The Harry S Truman Research Institute for the Advancement of Peace and The Palestine Consultancy Group, Jerusalem.

Custodio E., 1989, The Role of Groundwater Quality in the Decision Making Process for Water, in: A. Sahuquillo, J. Andreu and T. O'Donnell (eds.) *Groundwater Management: Quantity and Quality*, Proceedings of the symposium held at Benidrom, Spain, International Association of Hydrological Sciences.

Foster S.S.D., 1988, Impacts of Urbanisation on Groundwater, Proceedings of the international symposium "Urban Water 88", Duisberg, Germany, UNESCO-IHP.

Hayton R. and Utton A., 1989, Transboundary Ground Water: The Bellagio Draft Treaty, *Natural Resource Journal* 29, pp. 663-722.

Pearce D., Markandya A. and Barbier E.B., 1989, *Blueprint for a Green Economy*, Earthscan, London.

Pezzoli K., 1997, Sustainable Development: A Transdisciplinary Overview of the Literature, *Journal of Environmental Planning and Management* 40, pp. 549-601.

Schwartz J., 1989, Aquifers as Components of the Water Resources System, in: A. Sahuquillo, J. Andreu and T. O'Donnell (eds.) *Groundwater Management: Quantity and Quality*, Proceedings of the symposium held at Benidrom, Spain, International Association of Hydrological Sciences.

Todd D.K., 1959, *Ground Water Hydrology*, Wiley, New York.

United Nations Educational scientific and Cultural Organization (UNESCO), 1992, *Ground Water; Managing the Invisible Resource*, Environmental Development Briefs No. 2, London.

United States Environmental Protection Agency (USEPA), 1990, *Ground Water Handbook: Volume 1: Ground Water and Contamination*, Office of Research and Development, EPA 625-6-90/016a. Washington D.C.

World Commission on Environment and Development (WCED), 1987, *Our Common Future*, Oxford University Press, Oxford.

Chapter 2

The Islamic Approach to the Environment and Sustainable Groundwater Management

Marwan Haddad
College of Engineering, An-Najah National University, Nablus, Palestinian Territory and the Palestine Consultancy Group (PCG), East Jerusalem.

1. INTRODUCTION

There has been concern for the environment throughout human history. However, the environmental sciences and grassroots activism focusing on pollution, depletion of natural resources and waste production and disposal have only significantly developed since the late-1960s. Today there is widespread concern that the state of the earth's environment is worsening: natural resources are being depleted, per capita food production is decreasing, waste generation is increasing—and is increasingly difficult to manage and dispose—and public health problems are on the rise.

The fact that natural resources, such as water, and food production capacities are limited makes environmental management and pollution control vital in the quest for sustainable development.

Islam, since its very inception, through the Quran and the teachings of the Prophet Mohammed, has advocated balance and appropriate conduct in all aspects of life that can contribute to a good and sustained environment. This approach, however, was not extracted, organized and documented, or developed to cope with current societal needs (e.g., Islamic environmental laws, act, regulations, or code of conduct).

The driving force behind the Moslem code of conduct, which is characterized by self-control, is the fact that Allah[1] knows and continuously

[1] Allah is the Arabic word for God.

observes all creatures and their deeds. Therefore, Moslems feel that although no other human is observing their actions and conduct Allah is, and they will be accountable for these after death. This extends even to behavior relating to issues such as natural resources protection, conservation, and environmental control and pollution prevention.

Moslems represent about one-fifth of the global population. Most of them live in developing countries. Applying the Islamic approach to the environment and its sustainable management (IATESM) may have thus widespread implications, thereby leading to greater fulfillment of Allah's laws on earth and to a better world. In addition, informing and educating the Islamic public on this approach and encouraging a positive attitude toward the environment would enhance public cooperation, contribution, and participation in environmental protection and conservation activities and programs.

This chapter represents an effort to present and discuss a general framework for the Islamic approach to the environment and its sustainable management. The approach is adapted to water and the implications of the approach for groundwater management are discussed. It is hoped that this will constitute a step towards more detailed studies that would further develop the proposed approach.

2. BACKGROUND

The IATESM, encompassing environmental protection, conservation, and pollution control, has not previously been comprehensively addressed, presented and/or documented. This can be attributed to several reasons:

- The weakness and fall of the Islamic *khilafeh* (state) around the late-nineteenth and early-twentieth centuries resulted in a freeze on many aspects of Islamic thinking toward development, including industrial and technological developments, scientific research, agricultural development and food security, urbanization and population growth and distribution, and environmental management and pollution control.
- The environment and its management in developing countries, including those in the Islamic world, were not considered a priority by the governments of those countries. Consequently, few if any programs related to the environment were devised in these countries. Experts were rarely recruited to assist in this field, little information was gathered on the state of the local environment, and public awareness and education programs were all but insignificant.
- Most experts in the fields of environmental engineering, environmental health, environmental protection and preservation, and pollution control

in developing countries were educated in Western and non-Islamic countries. Consequently they brought and applied Western approaches to their work. Because the political, social, cultural, and economic conditions differ greatly between the West and the Islamic world, this application did not have clear influence on the process of local environmental protection and preservation.

The Islamic approach toward the environment and its management has received some attention in the literature. However, as the following brief review shows, none of the previously published papers provides a viable framework, systematic breakdown or planning context that may help formulate a management strategy for the environment and sustainable management.

Ba Kader et al. (1983) examined Islamic principles for the conservation of the natural environment. This systematic approach acknowledges that Islam is a comprehensive life status encompassing an overall view of the universe, life, man and the interrelationships between them, and also combining conviction, beliefs, legislation and enforcement of this legislation. The authors found that conservation, in Islam, needs to be embodied in an environmental planning and management concept and that legislation is the prime element in conserving the natural environment.

Al-Helou (1995) wrote a book on the law of environmental protection based on Islamic legality. The book reviews issues related to environmental protection and the tools needed for its achievement, citing international legal experience and quoting the Islamic position, according to the Quran and the teachings of the Prophet. The book is a general text and does not present an Islamic legal or administrative framework for environmental management.

Izzi Deen (1987) indicated that Islamic environmental ethics are based on clear-cut legal foundations which Moslems believe were formulated by Allah and, therefore, differ from those set by other cultures which base their laws on humanistic philosophies. He also noted that Islamic law (Shariah) contains both legal rules and ethical principles without the necessity to separate the two. He discussed the practice of Islamic environmental ethics, sustainable care of nature, human-environment relationships, and ethics based on the five known Islamic legal categories of actions: obligatory (*wajib*), devotional (*margub*), permissible (*mubah*), abominable (*makruh*), and forbidden (*haram*).

Studying the philosophy of wastewater reuse in Moslem countries, Farooq and Ansari (1983) found that (1) an Islamic approach for recycling wastewater could serve as a highly useful technique for meeting the shortage of fresh water in all parts of the world, and (2) in Islamic law, water is classified into three categories of purity: *tahur* (water safe for drinking and cleaning), *tahir* (water safe for drinking but not for cleaning), and *mutanajis* (impure water). The last two categories can be transmuted into *tahur* water and thus may be used for all mundane as well as religious purposes if they are assimilated into the overall supply. This would be lawful from the Islamic viewpoint even without treating the water.

Bicciato and Faggi (1995) evaluated the privatization of irrigation in Sudan and concluded that Islamic renewal (*tajdid*) could be applied to solve the dilemma between development and social consent: the State wants to retain sole management of the national strategic resources, while the society, as an autopoietic system, reacts against any attempt to change its own structure.

Simpson (1984) noted while studying the cultural considerations of water and sanitation that Islamic and Hindu societies have categories of clean and dirty—purity and pollution—and structure behavior around them. These terms have a ritual or cultural meaning which is often not understood by public health experts and engineers. For example, flowing water in Islam is considered pure and stagnant water dirty, regardless of the pollutants the water contains. Some beliefs about the causes of disease seem fantastic to anyone acquainted with the germ theory of disease. Religious beliefs about water also abound: for example, drought is sometimes seen as punishment for sin.

Dasouqi et al. (1998) described the inheritance of earth by humankind and Allah's disposition of earth, water, seas and rivers, livestock, wind, and plants to all creatures. They did not present any specific Islamic approach to environmental protection.

In studying Islamic law regarding water, several legal and resource experts found that:

- The basic principles of the Islamic water code are broadly based and applicable to a variety of hydrological situations. Water is treated in Islam as a scarce natural resource belonging to the community and, therefore, the code opposes speculation, protects the rights of both nomadic and sedentary peoples, and attempts to establish an order for agricultural exploitation. Application of the code follows the spirit of fair dealings and allows for a wide variety of interpretations adapted to different techniques of water exploitation and systems of water distribution (Wilkinson, 1978; Caponera, 1973).
- Islamic water laws prevent water wells from being dug too close to one another (Hayton, 1976).
- Islamic water laws allow the development of modern water resources to interpose on existing traditional systems (Oosterbaan, 1984).
- Islamic law is based on revelations transmitted from Allah to man through the Prophet Mohammed. Its religious overtones are unmistakable

and Western planners must be aware that any plans that ignore or contradict this divine law are to be regarded as suspect.[2]

Some experts have highlighted aspects of the Quran's inimitability without emphasizing the Islamic approach to these aspects and their applicability in the modern day (e.g., Sabri, 1997).

3. ISLAMIC APPROACH TO THE ENVIRONMENT

As the result of an extensive search in the Quran and its interpretations, I suggest that a balanced tripod-type structure constitutes a suitable framework for the IATESM. In this structure, the head represents a nucleus consisting of all Allah's management rules and regulations. The three legs of the tripod represent (1) environmental resources (the elements), (2) the activities (utilization) of these resources, and (3) the impact resulting from these activities (see Figure 1).

The three legs of the tripod are interconnected and the status of an environmental element or resource directly relates to its utilization and, consequently, its impact.

The following paragraphs and Figure 1 outline the details and suitability of the proposed approach:

1. The Tripod Nucleus

At the head of the tripod are Allah's rules, i.e., the nucleus of the Islamic approach to environmental management. These include:

- Allah created all that exists in the universe in an ideal balanced environment, including the basic elements/resources of mankind, water, air, land, energy, and others.[3]
- The even utilization of these elements, as described in the Quran and the Prophet's teachings,[4] is the basis for proper management and represents a prerequisite to the sustainability of the environment in time and space, and in quality and quantity.[5]

[3] Sura Unis 10, aya 5, Sura Al-Hajar 15, aya 21, and Sura Al-Qamar 54, aya 49.

[4] Sura Al-Nisa 4, aya 170.

[5] Sura Al-Rahman 55, aya 7-9, Sura Al-Anaam 6, aya 141, and Sura Al-Aaraf 7, aya 31.

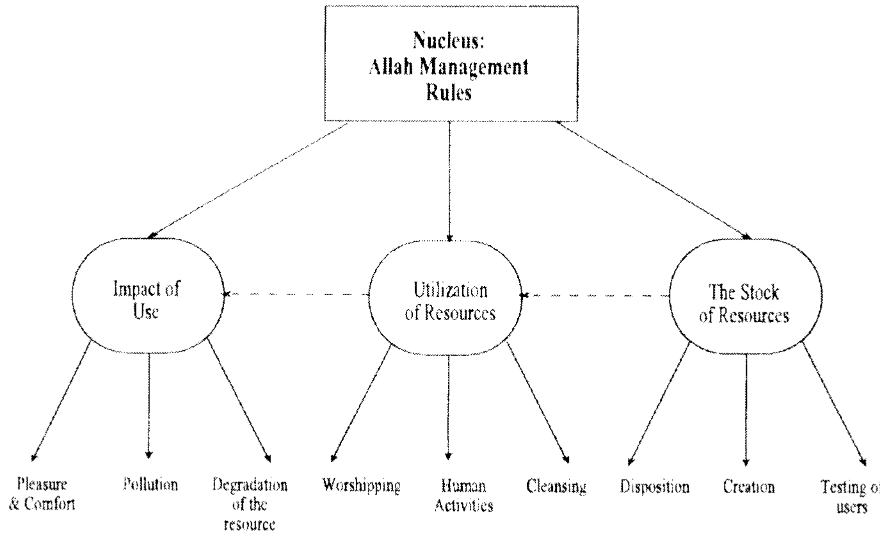


Figure 1. Schematic Description of the Islamic Approach Toward the Environment and its Management

– Allah rules over earth from heaven,[6] has absolute powers,[7] including supreme knowledge and judgment,[8] and is the creator of the universe and all that lies within it.[9] Allah's absolute characteristics negate the possibility of mistakes or doubt regarding the purity of His laws. Allah created mankind in its optimal form;[10] however, mankind is limited in its powers, knowledge, and judgment.[11]

6 Sura Al-Sajdeh 32, aya 5.
7 Sura Al-Ikhlas 112, aya 2
8 Sura Al-An'am 6, aya 80, Sura Al-Aaraf 7, aya 89, and Sura Taha 20, aya 98
9 Sura Al-Hasher 59, aya 23, Sura Ghafer 40, aya62, Sura Al-Zumur 39, aya 62, Sura Fater 35, aya 3, Sura Al-Raad 13, aya 16, and Sura Al-Anaam 6, aya 102.
10 Sura Ghafer 40, aya 64, and Sura Al-Taghabun 61 . aya 3
11 Sura Al-Bakara 2, aya 255

2. The Legs of the Tripod

The three legs that extend from the tripod head in figure 1 represent: (1) the creation of the stock of environmental resources or elements, (2) the utilization of these resources, or related human activities pertaining to them, and (3) the impact resulting from that utilization.

Each of the tripod's three legs, in turn, spurs another locally balanced sub-tripod, as follows:

Environmental resources, as the head to a local sub-tripod:

- Allah created those resources for humans and other creatures.
- Allah created from mankind different nations and tribes and distributed them all over the earth, directing them to civilize it and to cooperate with each other.
- Allah allocated these elements/resources in such a way that they constitute a challenge for individual Moslems, as well as nations and tribes, to obey His rules and to use these elements/resources in doing good deeds on earth.

Human utilization of these resources to fulfill life needs:

- Utilization of the environment's elements for living and for economic activities, including agriculture, housing, transport, navigation, etc.
- The resources as an inspiration for the worship of Allah and contemplation of the creation of the universe with all its components.
- Utilization of the resources for cleaning purposes and/or waste disposal.

3. The impact resulting from the utilization:

- Degradation and depletion of the elements or resources. This should encourage those who have firm beliefs and faith to conserve these resources and optimize their use.
- Destruction, intentional harm, and pollution of the elements, including mankind itself.
- Joy, comfort, and easiness in life and living is Allah's promise and attainable for those who obey His balanced laws, rules, and directions.

4. APPLICATION AND ADAPTATION OF THE APPROACH TO WATER

Here follows a discussion of the applicability and adaptability of the IATESM to water. The method used was to directly list the Quran verses that are closely related to each element, thereby diminishing the need for further explanation. One single reference, or source of Quran explanation, was used throughout this chapter: the translation of the book of *Al-Jalalein*[12].

The Arabic word *ma'a* can mean water or rain (precipitation), depending on its position in the sentence. The following sections will take each part of the proposed approach and apply it to water, as stated in the Quran:

1. Water as a Resource or Environmental Element

The following references were found in the Quran regarding water as a resource, either its creation, its distribution to all creatures, or its testing aspects.

a) Disposition of Water:

- Allah drives rain from the skies to the earth for the benefit of mankind.[13]
- Allah drives rain from the skies in specific quantities and distributes it over the earth.[14]
- Allah drives rain from the skies into the ground, where He can abate it,[15] ensure it moves through the ground, emerging elsewhere as springs,[16] or cause it to flow in valleys,[17] rivers and streams.[18] He could also cause it to fall as snow or hail.[19]

b) Creation, Excellence, and Directions for Water Use:

- Allah created mankind and all living creatures from water. [20]

[12] Tafseer Al-Jalalein, Fifth Edition, Dar Al-Ma'arefah, Beirut, Lebanon, 1990.

[13] Sura Al-Naba'a 78, aya 14, Sura Qaf 50 , aya 9, Sura Luqman 31, aya 10, and Sura Ibrahim 14, aya 32.

[14] Sura Al-Zukhrof 43, aya 11.

[15] Sura Al-Mouminun 23, aya 18.

[16] Sura Alzumer 39, aya 21, and Sura Al-Qamar 54, aya 13.

[17] Sura Al-Ra'ad 13, aya 17.

[18] Sura Ibrahim 14, aya 32, and Sura Al-Baqara 2, aya 74.

[19] Sura Al-Nur 24, aya 43.

[20] Sura Al-Anbea 21, aya 30, Sura Al-Nur 24, aya 45, Sura Al-Tareq 86, aya 6, Sura Al-Sajdah 32, aya 8, and Sura Al-Furqan 25, aya 54.

- Allah created rain and send it from the skies in abundance.[21]
- Allah created water in specific quantities and caused it to be distributed among creatures, including mankind.[22]
- Allah granted all creatures the right to drink.[23]

c) Water as a Testing Matter:

Water and other environmental resources were viewed by Allah as a blessing He bestowed on mankind. Peoples will be put to the test later on how they behaved in dealing with that blessing. In this regard, the following is considered:

- If man follows Allah's rule, Allah will send him plenty of rain.[24]
- Sending water and rain to give life to earth are signs from Allah to man to contemplate the creation[25] and declare His grace.[26]

2. Utilization of and Living Activities Related to Water

The following references were found in the Quran regarding utilization of and activities pertaining to water, either its use for cleaning and waste disposal, for the fulfillment of life needs, or for worshiping Allah and contemplating the creation.

a) Cleaning and Wastes:

Cleaning and waste disposal are among the main uses of water referred to in the Quran:

- Allah sends rain from the skies that channels into wadis and streams in specific quantities to assist in the process of waste disposal.[27]
- Allah sends rain from the skies for cleaning[28] and for purity purposes.[29]

[21] Sura Al-Shura 42, aya 28, Sura Luqman 31, aya 34 and 48, and Sura Al-Ankabut 29, aya 63.
[22] Sura Al-Muminun 23, aya 18, and Sura Al-Baqara 2, aya 60.
[23] Sura Al-Qamar 54, aya 28.
[24] Sura Al-Jin 72, aya 16.
[25] Sura Al-Rum 30, aya 24.
[26] Sura Fater 35, aya 3.
[27] Sura Al-Ra'ad 13, aya 17.
[28] Sura Al-Anfal 8, aya 11, and Sura Al-Nisa 4, aya 43.
[29] Sura Al-Maeda 5, aya 6.

b) The Fulfillment of Life Needs:

There are many life aspects related to water use referenced in the Quran:

- Allah provides water for creatures to drink.[30]
- Allah created agricultural species in males and females forms to grow agricultural products of various colors and produce food.[31]
- Allah provides water so that man can grow gardens and produce beans.[32]
- Allah sends water with the purpose of greening the earth and giving it life.[33]
- Allah created the seas and provided ships for transport purposes.[34]
- Allah created fish as food for mankind.[35]
- Allah described water as giving strength and strengthening hearts.[36]

c) Worshipping:

It is clearly stated in the Quran that worshiping Allah and contemplating the creation of environmental elements/resources—including mankind, earth, water, and skies—to affirm His powers and righteousness is necessary and required for directing Moslems to the right path in their lives and in the hereafter.

- Allah demanded that man ask Him for forgiveness of their sins and, in return, He would fill the skies with abundant rain for them.[37]
- Allah demanded that man praise Him and declare His glory for creating the skies and earth and for sending rain.[38]
- The creation of rain and driving it from the skies to the earth, and similar phenomena, are signs from Allah to mankind illustrating thinking and consciousness.[39]

[30] Sura Al-Nahil 16, aya 10, Sura Al-Hajar 15, aya 22, and Sura Al-Murselat 77, aya 27.

[31] Sura Al-Zumer 39, aya 21, Sura Al-Sajdah 32, aya 27, Sura Al-Haj 22, aya 5, Sura Taha 20, aya 53, Sura Luqman 31, aya 10, and Sura Fater 35, aya 27.

[32] Sura Al-An'am 6, aya 99, Sura Al-Namel 27, aya 60, and Sura Qaf 50, aya 9.

[33] Sura Al-Haj 22, aya 63, Sura Al-Zukhruf 43, aya 11, and Sura Al-Juma 62, aya 99.

[34] Sura Ibrahim 14, aya 32, and Sura Al-Anfal 8, aya 11.

[35] Al-Nahil 16, aya 14.

[36] Sura Al-Anfal 8, aya 11.

[37] Sura Hud 11, aya 52.

[38] Sura Al-Namel 27, aya 60, Sura Al-Ankabut 29, aya 63, and Sura Al-Jathia 45, aya 12.

[39] Sura Al-Baqara 2, aya 164, and Sura Al-Waqia'a56, aya 68.

3. Impact Resulting from Water Utilization

The following references were found in the Quran regarding the impact of water utilization, its availability and quality, including degradation and perdition aspects, as well as aspects of water use that bring joy, comfort, and pleasure to life.

a) Pollution and Perdition:

- Allah will cause the sky to withhold rain and the earth to swallow it in areas where man does that which is wrong and evil.[40]
- Allah will rain on those who conduct mischief showers of brimstones[41].
- Allah will send heavy rainstorms to land belonging to those who behave inappropriately.[42]
- Allah, acknowledging that man needs to eat and drink, demands that people not waste excessively.[43]
- Allah demands that people eat and drink of the sustenance provided by Him but that they are not destructive.[44]

b) Degradation and Depletion:

- Allah will punish the unjust and the unfaithful by drought and famine.[45]
- For those who forget Allah's rules and way, Allah will degrade their water supply.[46]
- Who will supply you with clear flowing water when the available one is degraded—Allah.[47]
- For those whose conduct is improper, Allah will destroy their resources and raise in their wake a new generation to succeed them.[48]

[40] Sura Hud 11, aya 44.
[41] Sura Al-Namel 27 , aya 58, and Sura Al-Shua'a 26 , aya 173.
[42] Sura Al-Baqara 2, aya 264 and aya 265.
[43] Sura Al-A'araf 7, aya 31.
[44] Sura Al-Baqara 2, aya 60, and Sura Al-A'araf 7, aya 31.
[45] Sura Al-A'araf 7, aya 130.
[46] Sura Al-Kah'f 18, aya 45, and Sura Younis 10 , aya 24.
[47] Sura Al-Mulk 67, aya 30
[48] Sura Al-An'am 6, aya 6.

c) Joy and Comfort:

- Allah promises that for those who remain on the path of righteousness He will bestow upon them rain in abundance.[49]
- Allah encourages man to eat and drink with joy, pleasure, and health following and as a consequence of their good deeds.[50]
- Allah promises heaven on earth to those who have faith in Him.[51]

5. APPLICATION OF THE APPROACH TO AQUIFER MANAGEMENT

Having presented the Islamic approach toward the environment and its sustainable management and adapting this to water in general, the next question that needs to be addressed is what implication this approach has for the management of groundwater, specifically when aquifers are shared by more than one party.

The application of the Islamic approach to aquifer management begins with faith in Allah and his unlimited capabilities, including knowledge, power, management, wisdom, justice, and mercy. In this regard individuals as well as groups—or sides—exploring, developing, using, and/or disposing of water from local or shared aquifer(s) need to seek Allah's approval and acceptance for their intended actions.[52] This could be attained by fulfilling and following closely Allah's directions and orders, such as (1) to secure and distribute sufficient drinking water for all creatures; (2) to forbid the use of water as a monopoly; (3) not to use water as a commodity to be bought and sold but to ensure its distribution among all creatures to fulfill their basic needs.

Allah can create water in specific quantities[53]—as precipitation in the ground and/or emerging through springs and flowing in valleys, streams, and rivers. Allah can diminish these waters if not used in a balanced way, according to His rules and directions.[54] In addition, Allah demands that the competition between water (aquifer) users results in the most beneficial use.

49 Sura Al-Jin 72, aya 16, and Sura Al-Nur 24,aya 39.

50 Sura Al-Tur 52 , aya 19, Sura Al-Mursilat 77, aya 43, and Sura Al-Haqa 69, aya 24.

51 Sura Al-Isra 17, aya 91.

52 Sura Qasas aya 77.

53 Sura Al-Zuhrof 43, aya 11.

54 Sura Al-Muminin 23, aya 18, Sura Al-Zumar 39, aya21, Sura Al-Qamar 54, aya13, Sura Al-Nur 24, aya43, Sura Ibrahim 32, aya32, and Sura AlRaád 13, aya 17.

Actions and behavior in this respect need to be constant and represent an ongoing test of faith and compliance with Allah's rules.

It should be noted that water (aquifer) allocation in Islam is based on the fact that domestic purposes (denoted by drinking) are of prime concern and a priority for all creatures. Selling water is forbidden in Islam, meaning that no profit is to be made out of drinking water supply services (they need not be provided for free). Then water can be allocated to agriculture for food production, then to other uses or users in order of importance.[55]

Allah defined the use of water (aquifers) either for the range of livelihood activities, for cleaning, or for worshipping and praising Him, such that these activities should be carried out in the best possible manner, just as Allah created mankind in the best possible manner. This concept of "the best possible manner" is continuous in time and space and demands constant evaluation of water use, supply conditions and their upgrade to ensure optimization.

Allah ordered us not to pollute water (aquifers) or waste it in unwise ways, indicating that He scorns polluters and wasters. For those who do not obey Allah rules, resource loss and droughts can be expected.

There is a clear link between the use of water (aquifers) and the impacts resulting from it: joy and pleasure to those who balance their use and preserve their resources and degradation, droughts, and famine to those who misuse and waste their water resources.

Thus, in Islam water planners, policy and decision makers, as well as individual Moslems, need to take into account at all times and in all places the most balanced and beneficial uses of water resources (including aquifers) in order to maintain their qualitative and quantitative sustainability.

6. SUMMARY

In summary, there is a clear Islamic approach toward the environment and its sustainable management that can be derived directly from the Quran and formulated in a balanced tripod-type structure. In this tripod structure, the top represents the nucleus and includes all Allah's management rules and regulations. The environmental resources, the activities of these resources, and the impacts resulting from those activities represent the three legs of the main tripod.

[55] Sura Al-Qamar 54, aya 28, Sura Al-Thariat 51, aya4, Sura Al-Nahl 16, aya 10, Sura Al-Shuaá 26, aya155.

Each of the main tripod legs represents the head of another locally balanced sub-tripod. The elements of the environment, or resources, sub-tripod consists of three themes: (1) creation of environmental resources, (2) disposition of environmental resources, and (3) testing. The utilization of the elements of the environment, or related human activities, sub-tripod covers: (1) fulfilling life needs, (2) cleaning and waste disposal, and (3) worshipping, praising, and declaring glory to Allah. The impacts and effects sub-tripod consists of: (1) degradation and depletion of environmental resources, (2) their abuse, destruction, and pollution, and (3) joy, comfort, and a pleasant life.

The proposed Islamic approach was applied to water. It was found, further, that it could easily be adapted to water resources management, and this extended to aquifer management as well.

REFERENCES

Al-Helou, M., Environmental Protection Law: Shariet Perspective (in Arabic), University Publishing House, Alexandria, 1995.

Ba Kader, A., Al-Sabagh, A., Al Glenid, M., and Izzi Deen, M., Islamic Principles for the Conservation of the Natural Environment (in Arabic, English, and French). A Joint Publication of the International Union for Conservation of Nature and Natural Resources and the Meteorological Protection Administration (MEPA) of the Kingdom of Saudi Arabia. Gland, Switzerland, 1983.

Bicciato, F., Faggi, P. Gezira Scheme between State and Market: Some Remarks on the Privatization of Irrigation in Sudan. GEOJOURNAL 1995 Vol. 37, No. 1, pp. 101-104.

Caponera, D.A. Water Laws in Moslem Countries. Food and Agriculture Organization of the United Nations, Rome, Irrigation and Drainage Paper No 20/1, 1973.

Dasouqi, L., Shatheli, H., and Brat, M., Islamic Approach for Environmental Protection, Arabic Center for Environmental Awereness, Cairo. 1998.

Farooq,-S: Ansari,-Zi Philosophy of Water Reuse, in Islamic Perspective. Water: The Essence of Life, Proceedings of the International Congress on Desalination and Water Re-Use, Manama, Nov. 29-Dec.3, 1981. Vol. 2, Int Desalination Environ Ass, Teaneck, 1981. pp. 273-281.

Farooq,-S; Ansari,-Zi Wastewater Reuse in Moslem Countries: An Islamic Perspective. Environmental Management (New York), 1983. Vol. 7, No. 2, pp. 119-123.

Hayton,-R.D. The Ground Water Legal Regime as Instrument of Policy Objectives and Management Requirements. Proceedings of the International Conference on Water Law and Administration, International Association for Water Law February 8-14, 1976, Caracas, Venezuela; Published by the Commission for the National Water Resources Development Plan (Coplanarh), Caracas, Venezuela, pp. 272-293, 1976.

Izzi Deen, M., Islamic Environmental Ethics, Law, and Society, in International Response: Africa and the Middle East, 1987, pp. 189-198.

Oosterbaan,-R.J. Modern Interferences in Traditional Water Resources in Baluchistan. Water International Vol. 9, No. 3, pp. 106-111, September. 1984.

Sabri, E., Highlights on the Inimitability of the Holy Quran (in Arabic). Al Ahram Publishing Center, Cairo, 1997

Simpson-Herbert, M. Water and Sanitation: Cultural Considerations. Water and Sanitation: Economic and Sociological Perspectives. Academic Press, Inc. New York P 173-198, 1984.

Wilkinson, J.C. Islamic Water Law with Special Reference to Oasis Settlement. Journal of Arid Environments Vol. 1, No 1, pp. 87-96, March 1978.

II

THE ISRAELI-PALESTINIAN CASE

Chapter 3

Overview of the Mountain Aquifer

A Shared Israeli-Palestinian Resource

Yoav Harpaz, Marwan Haddad & Shaul Arlosoroff

Water Resource Planning, Ramat Hasharon, Israel

College of Engineering, An-Najah National University, Nablus, Palestinian Territory and the Palestine Consultancy Group (PCG), East Jerusalem

The Harry S Truman Institute for the Advancement of Peace, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem

1. BACKGROUND

The most important groundwater resource shared by Israelis and Palestinians is the Mountain Aquifer. It underlies the central mountain ridge stretching along a north-south axis for some 150 km through Israel and the West Bank. The aquifer extends from the valleys of Yezre'el (Marj Bani Amr) and Beit She'an (Beisan), in the north, to near Beer Sheva (Beer Al-Sabeaa), in the south, and from under the Mediterranean coastal plain and the western foothills, in the west, to the Jordan Rift Valley in the east (Figure 1).[1]

The Mountain Aquifer constitutes a major water resource for Israel and the West Bank, both of which suffer from severe water scarcity. For Palestinians on the West Bank it is the principal source of water, needed to supply the growing population and to foster economic development; in Israel it accounts for almost one-third of total water consumption. As a result, the Mountain Aquifer is one of the focal points of the permanent status peace negotiations between Israel and the Palestinians.

[1] Locations in parentheses represent Palestinian names corresponding to the Israeli ones. Most of the numbers cited in this chapter are based on Israeli sources, as the Palestinians did not have the chance to explore the aquifer and collect data independently during the Jordanian and Israeli periods.

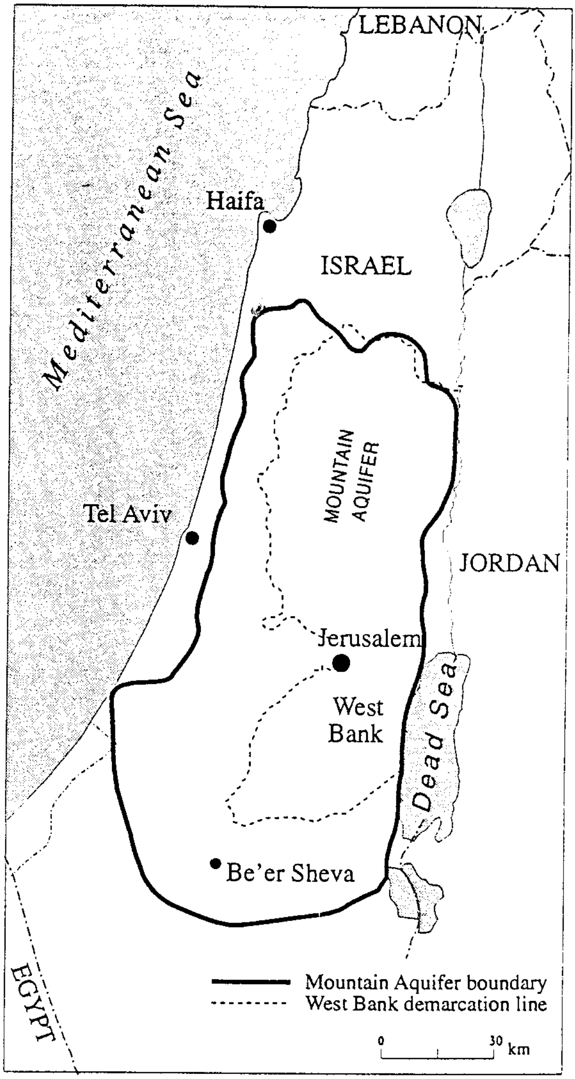


Figure 1. Location map

Precipitation on the mountains is the primary source of the aquifer's natural renewable replenishment. Rainwater infiltration occurs through the porous and fractured limestone rocks. The natural outlets of the subterranean waters are springs located along the western foothills, the Yezre'el and Beit She'an valleys and along the Jordan Valley.

The climate of the region is typically Mediterranean: mild wet winters and dry hot summers. Annual rainfall varies from over 600 mm in the mountainous area to 300-600 mm along the western foothills and 100-270 mm along the eastern mountain flanks and the arid Jordan Valley. The annual rainfall, however, varies substantially between years (Amiran, 1995). In 1991-92 over 1200 mm were measured in Jerusalem, compared with less than 200 mm in 1998-99; thus, the ability to store water from winter to summer and from years of plenty to drought spells is crucial. Although, as can be seen in Table 1, the annual potential evapotranspiration is normally greater than the average annual precipitation, occasional heavy rainfalls actually infiltrate the aquifer where they are stored and later withdrawn for human consumption. Therefore, under the local arid conditions, the Mountain Aquifer assumes strategic importance to both parties.

Table 1. Precipitation, Evaporation and Temperatures (Averages)

Region	Annual rainfall (mm)	Annual Evapotranspiration (mm)	Daily Temperature (^{0}C)	Annual Temperature Range (^{0}C)
Coastal Plain	400-600	1700	19	13-26
Mountains	500-700	1850	17	8.5-22
Jordan Valley	50-150	2300	23	11-40

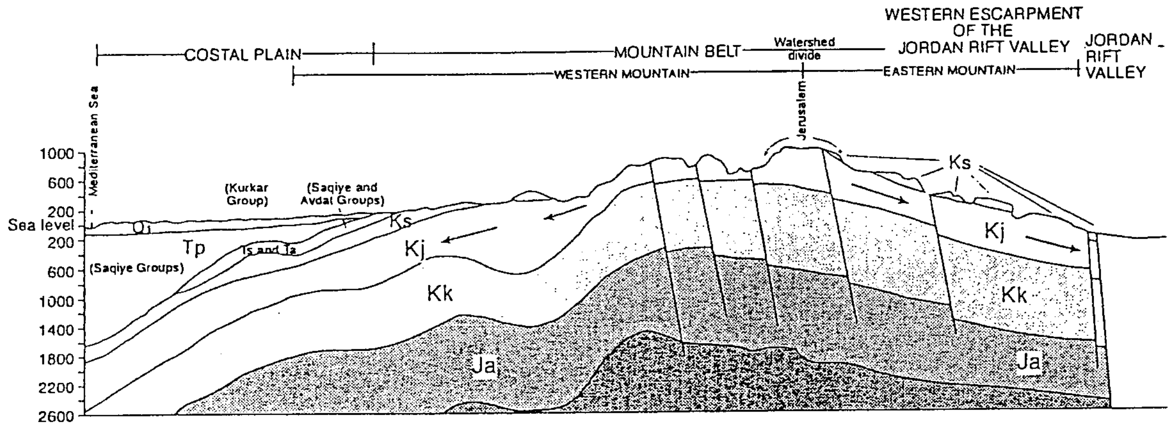
Sources: Haddad (1990), Orni and Efrat (1973).

The purpose of this chapter is to provide the reader with a general description of the hydrogeological features of this shared Mountain Aquifer.[2]

2. GEOLOGICAL SETTINGS

The rocks of the mountain aquifer belong to stratigraphic units, named the Avdat Group of the Eocene age and the Judea Group of the Turonian, Cenomanian and Albian ages (see Figure 2). The units are composed of a series of carbonate rocks (chalk, limestone, dolomite) with inter-bedded marls. At its base, the Judea Group is in contact with marls, clays and some sandstone of the lower Cretaceous. The Eocene is separated from the Turonian below by marls, chalk and calcareous shales (Cenonian to Paleocene).

[2] This chapter does not tackle, therefore, the differences between the two sides regarding the control over extractions and over allocations, as these are discussed elsewhere in this book.



Hydrogeologic units

Paleocene		Mount Scopus	Ks	Chalk, chert, limestone, marl. Limestone and chert layers are prolific aquifers. Well yields are highly variable and are controlled largely by cavernous zones in the limestone that are affected by geologic structure. Flowing wells common in areas of low elevation. Salinity increases in an eastward direction.
Cretaceous, Upper	Senonian			
	Turonian / Cenonanian	Judea	Kj	Limestone, dolomite, marl, shale. Limestone and dolomite layers are prolific aquifers in the Eastern and Western Mountain Basins
	Albain / Aptian	Kurnub	Kk	Sandstone, dolomite, marl, sand, shale, clay, sandy limestone. Upper part mostly consists of shale and carbonates forming aquiclude, lower past mostly consists of water bearing sandstone. High salinity in vicinity of Jordan Rift Valley.
Jurassic		Arad	Ja	Limestone, dolomite, sandstone, marl, shale. Limestone, dolomite and sandstone layers water bearing. Important source of water in Negev, north and south Wadi Arava, and south Jordan Desert Basins. High salinity in parts of region. Groundwater development is limited by drilling depths, high pumping lifts, and mineralization of groundwater.

Figure 2. Hydrogeogeologic Cross-section of the Mountain Aquifer
Source: Modified from EXACT (1998)

Structurally, the West Bank's mountain geology is formed of a central anticlinorial backbone (Judea anticline) and a smaller syncline in the north, both plunging towards the northeast. The anticlines have an asymmetric nature: the western flank slopes under the Coastal Plain, towards the Mediterranean, while the eastern flank dips strongly until it is dissected by the Jordan Rift step-fault escarpment (Weinberger et al., 1994). There, the calcareous rocks are in direct contact with the clay, marls, sands and alluvial deposits that fill the Jordan Valley "graben". Normal and transverse faults are apparent, showing vertical displacement of up to 300-400 meters.

The limestone rocks of the Judea Group are exposed over large areas on Judea-Samaria and the Hebron mountain range. Their full thickness can reach 900 meters.

3. THE AQUIFER

The groundwater of the Mountain Aquifer is contained in the water-bearing calcareous rocks – of Turonian, Cenomanian (upper and lower) and Eocene ages – which are mainly of karstic nature and possess high storage and conductive capacities. Existing wells draw water from the layers of Lower Cenomanian and Upper Cenomanian, as well as from the Eocene aquifer. A hydrogeological cross-section depicts in Figure 2 the geological units and underground flows.

These formations are exposed on the mountains and absorb the natural precipitation, which constitutes the natural replenishment of the aquifer. The total average infiltration to the Mountain Aquifer is estimated to be approximately 660 million cubic meters (MCM) per year (Harpaz, 1988). The groundwater divide coincides generally with the surface watershed. An additional 70-90 MCM/yr flow in the wadis (ephemeral streams) from the surface water divide down to the Mediterranean Sea or to the Jordan Valley and the Dead Sea. An estimate of the hydrological water balance of the aquifer is presented in Table 2. Apparently, the average recharge into the aquifer is less than 30% of the total annual rainfall over the recharge areas.

Table 2. The Mountain Aquifer Hydrological Water Balance (averages, MCM/yr)

Annual Precipitation
Evapotranspiration
Surface Runoff
Natural Groundwater Recharge*

* not including return flows
Source: Based on Haddad (1990)

From the areas of recharge on the mountains, the groundwater flows in the aquifer to the points of discharge outlets: natural springs, underground seepage and pumping wells. The major springs are located at the western foothills, in the northeastern valleys, along the Jordan Valley and the shores of the Dead Sea. Underground seepages are assumed to drain to the Jordan and Beit She'an (Beisan) valleys, and to the Dead Sea. Wells are mainly aggregated along the western foothills, around Jerusalem, in the Jenin area and Beit She'an faults, and in several areas on the eastern slopes (mainly the Nablus, Herodion, Jordan Valley and Hebron districts).

From the point of view of the hydraulic properties, the aquifer is considered highly permeable, non-homogeneous and non-isotropic. On the mountain ridge and below the limestone outcrops phreatic water table prevails, whereas further downstream confined conditions develop.

The axis of the main anticlines also determines the main watersheds dividing the underground flow to the west, towards the Coastal Plain, to the east, towards the Jordan Valley, and northeast, towards the Yezre'el and Beit She'an valleys. Accordingly, the Mountain Aquifer system may be divided into three sub-aquifers or basins (Figure 3).

3.1 The Western Basin

The Western Basin extends along the western flank of the central anticline, named the Yarkon-Taninim aquifer after its two principal natural outlets (located within pre-1967 Israel). It is comprised of limestone and dolomite rocks, which belong to Turonian and Cenomanian (upper and lower) formations of the Judea Group. The limestones and dolomites are of karstic and permeable characteristics capable of transmitting large quantities of water. The entire group attains a total thickness of 800-1000 meters.

The aquifer extends westwards, from the anticlinorial backbone of the West Bank and Jerusalem mountains (also hydrological divide) to below the Israeli coastal plain. In the north, the Menashe syncline forms the aquifer boundary; the Nevatim-Beer Sheva line is regarded as its southern boundary[3] (Weinberger at al., 1994; Gutman and Zukerman, 1995).

[3] The reason for determining the southern line here is that further south the water is brackish, and it is unclear to what extent this brackish water is linked to the freshwater.

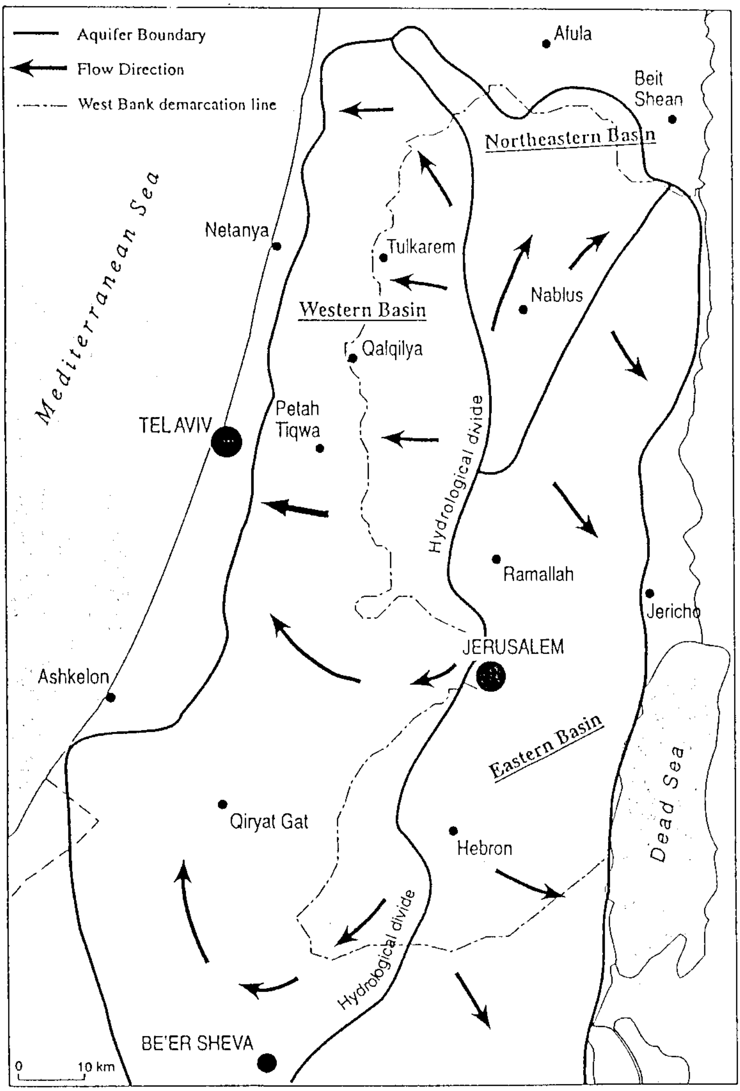


Figure 3. Flow Regime of the Mountain Aquifer
Source: Adapted from Gvirtzman (1994)

The exposed replenishment areas cover over 1800 km^2, of which 1400 km^2 lie within the West Bank territory, and the remainder in Israel. The average precipitation varies between 300 mm per year, in the south, and 800 mm/yr in the north. The underflow pattern descends from the mountains' backbone (water table elevation 450-300 m above sea level) to the foothills and deep under the Coastal Plain (pizeometric head elevation 25-15). There the streamlines make a northward turn to the large Yarkon (Auja) spring, and further down to Taninim (Timsah) spring near the coast of Carmel (elevation 10-15). Most of the area of the water-bearing rocks – about 2500 km^2 – is located between the mountains and the Mediterranean. On the mountains the aquifer is mostly phreatic but becomes confined in the foothills and further to the west (Gutman and Zukerman, 1995).

The waters are of high quality. But at several places along the way, the flowing groundwater comes into contact with bodies bordering brackish water. Hence, overpumping may lead to salinization in such places.

The two springs, which are the only draining outlets of the western aquifer, used to discharge naturally all the replenishing water, a long-term mean of approximately 350-360 MCM per year, of high-quality water. The outflow of Yarkon (Auja) spring – gauged by the British prior to the initiation of well pumping – amounted to about 250 MCM per year, and that of Taninim (Timsah) spring to around 100-110 MCM/yr.

Since 1950 heavy pumping of hundreds of wells along the foothills has supplied water to the population of Central and Southern Israel for domestic, industrial and agricultural uses. Palestinians in the West Bank have also withdrawn water, mainly from wells in the areas of Tul Karem and Qalqilya, which tap the same western basin.

During the 1970s-80s the aquifer was over-pumped by Israel – that is, the amount abstracted exceeded the natural replenishment. As a result, the groundwater table dropped considerably and the flow of the springs has declined. Outflows from Yarkon spring ceased entirely while discharges from Taninim spring fell to less than 50% of its historic annual flow. Salinity rose in some places and withdrawal became subject to strict monitoring and water management policy.

The Israelis also use the aquifer as a large storage reservoir for the National Water System, by regulating the groundwater levels and performing artificial recharge operations (Harpaz et al, 1968).

3.2 The Northern Basin

This groundwater basin is subdivided into two overlaying sub-aquifers: the Eocene limestone aquifer (Nablus-Jenin-Gilboa basin), situated in the Samaria syncline, and the deeper limestone-dolomite, Cenomanian, aquifer (North Samaria) of higher productivity. The recharge areas are situated in the West Bank. However, the natural outflow is through springs that are mainly located in Israel's Beit She'an (Beisan) Valley, in Marj Bani Amr (Yezre'el Valley) and, partly, on the mountains themselves. The average yearly replenishment of the two sub-aquifers is about 140-150 MCM (Harpaz, 1988).

3.3 The Eastern Basin

The eastern basin extends from the water divide line atop the mountain (elevation 600-800 m) down to the Jordan Rift Valley and Dead Sea fault line (350-400 m below sea level). The Nablus-Wadi Fara'a-Hardale line determines the northern hydrogeological boundary, whereas the southern boundary is assumed to be the Wadi Efe'e-Arad line. A series of asymmetric anticlines and synclines constitutes the dominant geological structure in the area. These are traversed by intensive faulting systems of west-east orientation. Here, too, the Cenomanian aquifer, made of limestone-dolomite rocks, could be divided into two sub-aquifers: upper and lower Cenomanian, separated by marls and chalk. Both are replenished by rain falling on the outcrops that spread over 2000 km^2 in the West Bank and Jerusalem area (Gutman and Zukerman, 1995).

Precipitation varies sharply: on the mountain ridge mean annual rainfall reaches 500-700 mm, whereas to the east, along the Judea Desert, it drops to 100-150 mm/yr. The natural replenishment according to Harpaz et al. (1995) is about 150 MCM/yr (up to180 MCM/yr by other estimates), which drain out through springs and underflow to the young formations (of Pleistocene and Holocene age) that fill the Jordan Valley (including the Dead Sea). Part of that flow emerges as brackish water. Some of the major springs are Fashkha, on the Dead Sea shores; Jericho group; Qelt and Fawar; Auja; Wadi Faria and Ein Gedi group. In general, the regional groundwater table declines sharply, following the steep ground surface slope, and becomes confined downstream.

Due to the aridity of the eastern desert and the presence of brines in the Jordan Valley "graben" and the Dead Sea vicinity, the groundwater descending from the mountains becomes saline in some places. Such is the case of Fashkha springs and in some deeply drilled wells (Hydrological Service, 1999).

Abstraction of groundwater by wells was initiated in the 1970s and has developed steadily since. The water supplies both Israelis and Palestinians. The settlements located in the Jordan Valley and on the mountain slopes receive their water from this aquifer, as do Palestinian villages in the Bethlehem-Hebron regions.

4. GROUNDWATER QUALITY

Most of the waters in the upper levels of the three basins – within the West Bank and Jerusalem area, where rain recharge is intense – are rated as of potable quality with only slight salt content: 50-150 mg chlorides per liter.

Along its flow paths the water picks up some salts from the rocks and reaches the maximum concentration near the drainage outlets. In general, water draining westwards is of better quality than the underground flow to the eastern outlets in the arid Jordan Valley (Hydrological Service, 1999).

Along the central part of the ***western aquifer***, on the mountain flanks and under the foothill strip, salinity levels vary around 50-150 mg/l of chlorides, except in several sites (Ayalon, Hartuv, Amatzia, etc.) where it rises to 300-400 mg/l. At the southern edge, where brackish water surrounds the Beer Sheva aquifer section, higher contents are encountered, 200-300 mg/l Cl. Along the western margins of the aquifer, deep below the Mediterranean coastal strip, rest bodies of brine and brackish water that are in contact with the freshwater. Near the northern Taninim spring, brackish water and seawater are encountered. The main constraint on increasing pumping from the aquifer is the danger of a salinity rise due to further lowering the water table.

The *northern basin*: Wells in the elevated areas of the Eocene aquifer indicate a recent rise in salinity levels – from the natural 140 mg/l Cl to 700 mg/l Cl – and a slight increase in nitrate content. Further downstream, along the Beit She'an Valley margin, salinity of half the springs is 500-1100 mg/l Cl, and in the wells it rises to 550 mg/l. The Cenomanian aquifer produces water of generally low chloride concentration and low nitrate levels.

Groundwater in the elevated sections of the ***eastern basin*** is of high quality. So are the outflows of the springs located on the sloping terrain. But, approaching the Jordan Valley, the water turns saline, between 500-2000 mg/l Cl, similar to the springs that emerge on the shores of the Dead Sea and to the salinity of several deep wells.

4.1 Anthropogenic Pollution

The Mountain Aquifer is vulnerable to pollution resulting from human activities, such as waste disposal (domestic and industrial), irrigation with partially treated wastewater, fertilizer and pesticide use, storage and transport of petroleum products and other chemicals, animal wastes, as well as solid waste landfills. Many towns, villages and refugee camps still use domestic cesspools to dispose of their sewage effluents. Most of the Palestinian and Israeli towns and villages, within or near the replenishing areas, still release their sewage effluents to ephemeral streams that traverse the outcrops and continue downstream to the western Coastal Plain or to the Jordan Valley. The highly permeable and fissured limestone rocks allow for rapid infiltration of pollutants onto the groundwater table (Michigan U. et al., 1998). That is why some adjacent wells and high-altitude springs were affected.

To date, over 90 percent of the wells show low nitrate concentrations, below the recommended standard of 45 mg/l for drinking water. In only a few wells contamination from human activities gave rise to higher nitrate levels, and on average only a slow evolution of concentration in certain groups of wells has been observed.

Massive contamination of springs and wells by organic or pathogenic pollutants has not been detected. However, it should be noted that the extensive sampling and analysis program is still incomplete.

Unless wastewater is recycled and put to use, and other land uses are controlled, future groundwater quality deterioration should be expected in all three basins. In addition to mitigation of probable pollution to groundwater, reclamation of wastewater can provide an important source of water for agricultural use. However, careful groundwater contamination studies should precede such projects.

5. GROUNDWATER UTILIZATION

The groundwater of the Mountain Aquifer is utilized extensively in the three basins by hundreds of wells and in the many springs. The springs are scattered all over the West Bank where most of them discharge rather small quantities of freshwater that is used for irrigation and domestic purposes. Several eastern springs are brackish and only partly utilized. Outflows vary considerably in accordance with climate fluctuations. In many cases springs are in close proximity to sources of pollution and, hence, may constitute health hazards.

An "exploitable potential" (or "safe yield") of a groundwater aquifer is defined as the quantity of water that can be utilized, from springs or by means of wells, subject to quality, economic or legislative constraints (Harpaz et al, 1995). It is generally understood that the actual exploitable potential is smaller than the replenishment of the aquifer, as some flushing of the aquifer must be assured and some reserves and water kept for the relatively dry season. In the case of the Mountain Aquifer, comprehensive hydrological studies are required to determine the potentials of the three sub-aquifers.

Along the Israeli foothills of the ***western basin***, a widespread drilling program commenced in the early 1950s. From Beer Sheva in the south to Benyamina in the north production wells have pumped intensively, supplying water for local uses and into the National Water System. During the 1970s-90s pumpage in the Israeli territory fluctuated between 300-400 MCM per year (except in the drought year 1990-91) - excluding the springs residual outflow. In the West Bank annual Palestinian withdrawal from the western basin is around 20-25 MCM.

The amount of mostly freshwater withdrawn from wells in the ***northern basin*** was estimated at 75 MCM/yr, of which some 65 shallow wells produce approximately 10 MCM/yr in the Jenin and Ras-Faria areas of the West Bank. The total springs outflow is estimated at an average of 70 MCM/yr. The Palestinians utilize only the small springs; the larger ones, discharging mostly brackish water, are used mainly in the Beit She'an and Yezre'el valleys for agriculture and fishponds.

Abstraction of groundwater by wells in the ***eastern basin*** was initiated in the 1970s, and has developed steadily since. Pumpage from wells amounted to 40-50 MCM/yr at the end of the 1990s. Natural springs' discharge and underground outflow are estimated at around 120-140 MCM/yr, most of which are saline. Most of the well water is supplied to Israeli settlements located in the Jordan Valley and on the mountain slopes. The Palestinians generally utilize fresh spring flow and shallow wells (about 55 MCM/yr), and recently also water from new deep wells.

Overall, Palestinian use of the aquifer water in the 1990s is estimated at approximately 120 MCM/yr, compared with 440-550 MCM/yr used by Israel. Table 3 summarizes the current uses of the aquifer's water by the Israelis and the Palestinians. Since the exploitable potential has not yet been calculated, we present estimates of the annual replenishment rates mentioned above. Apparently, the eastern sub-aquifer is quantitatively under-developed. In the Oslo B Agreement the two sides estimated that an additional 78 MCM/yr could be extracted for the Palestinians in the West Bank, and that 29 MCM/yr from the eastern aquifers should be made available to them during the interim period. The allocations proposed in the Oslo B Agreement are also presented in Table 3.

Table 3. Annual use of groundwater from the Mountain Aquifer (MCM/yr)

Basin	**Annual Replenish-ment**[1]	**Water Use during the 1990s**[3]			**Interim (Oslo B) Agreement on Freshwater Allocations**[4]		
		Israeli	**Pales-tinian**	**Total**	**Israeli**	**Pales-tinian**	**Total**
Western	350-360	300-400	20-25	320-455	340	22	362
Northern	140-150	100-110	45	145-155	103	42	145
Eastern	150 (180)	40	42	95	40	54	172[5]
Total	**640-660**[2]	**440-550**	**116-121**	**460-705**	**483**	**118**	**679**[5]

(1) Different from the exploitable potential.
(2) Regardless of the higher estimate in the eastern basin.
(3) Including unused spring flows.
(4) From Article 40 of the Oslo B Agreement, 1995.
(5) Including additional 78 MCM/yr proposed for extraction.

6. AQUIFER MANAGEMENT

The current extractions of groundwater from all the basins of the Mountain Aquifer approach the limits of its exploitable potential. Water-quality deterioration is already becoming a problem in many areas. Therefore, monitoring and control of both pumpage and quality is mandatory, if irrevocable damage to the water in the aquifers and to the supply wells is to be avoided.

Therefore, optimal exploitation of this vital resource requires that it be managed rationally, both quantity- and quality-wise. Since June 1967, only the Israelis have controlled the Mountain Aquifer. But as a result of the peace process the aquifer would become a shared resource that no party can manage on its own. Therefore, Israel and the Palestinians would have to cooperate in its management, if it is to be managed in an optimal manner.

In addition to the need for political agreements, joint management planning should be based on better knowledge of the aquifer properties. To that end there is a need for further hydrological research, a comprehensive monitoring network, open databases, and groundwater simulation tools to generate development and management options.

7. CONCLUSIONS

The Mountain Aquifer is a vital resource to both Israelis and Palestinians, for present and future generations alike. While the western and northeastern basins are fully utilized there is still some potential for additional exploitation of the eastern basin. This has been recognized in the interim agreement signed in 1995.

In some areas the aquifer contains brackish water. Therefore, if further exploitation continues, the aquifer will become susceptible to salinization because of the encroachment of underground saline water bodies. In addition, pollution from human sources is rapidly becoming a constraint on the effective utilization of the water. To prevent the aquifer's deterioration and loss of storage capacity it must be judiciously managed. A first step was taken in the Israeli-Palestinian interim agreement, in which a Joint Water Committee (JWC) and Joint Supervision and Enforcement Teams (JSETs) were established.

Yet, given the magnitude of the challenge it is doubtful whether these bodies will suffice. Hence, additional options for enhancing the cooperation in managing the aquifer need to be explored. In particular, the importance of establishing, cooperatively, better information systems and conducting additional studies and modeling efforts has to be stressed, as these are requisites for setting the ground for judicious cooperative management of the aquifer. These issues are discussed in several subsequent chapters.

REFERENCES

Amiran D., 1995. *Rainfall and Water Management in Semi Arid Climates: Israel as an Example.* The Jerusalem Institute for Israel Studies, Research Report No. 18, Jerusalem.

EXACT, 1998. Overview of Middle East Water Resources, USGS, Washington D.C.

Gutman Y. and Zukerman H., 1995. Flow Model of the Eastern Basin of Judea and Samaria Mountains, TAHAL, Tel Aviv (in Hebrew).

Gutman Y. and Zukerman H., 1995. Yarkon-Taninim-Beer Sheva Basin–Flow and Salinity Model, TAHAL, Tel Aviv (in Hebrew).

Gvirtzman H., 1994. Groundwater Allocation in Judea and Samaria, in J. Isaac and H. Shuval (eds.), Water and Peace in the Middle East, Elsevier.

Haddad M., 1990. State of the Environment in the Occupied Territories, Paper presented at the Conference on the management of the Environment in the Mediterranean, Nicosia, April.

Harpaz Y., Sterenau R., Mercado A., Schwarz J. and Bear J., 1968. Underground Water Storage Project, TAHAL and FAO, Tel Aviv.

Harpaz Y., 1988. The National Water Master Plan – The Water Resources Supply, TAHAL Tel Aviv (in Hebrew).

Harpaz Y, Schwarz J., Ben Shabat J. and Bieda U., 1995, Israel's Water Balance, EWRE and TAHAL, Haifa (in Hebrew).

Hydrological Service, 1999, Development, Exploitation and Situation of Water Resources in in Israel 1998, Jerusalem.

Michigan U., Hebrew U. and PCG, 1998, Environmental Protection of the Shared Israeli-Palestinian Mountain Aquifer.

Orni E. and Efrat E., 1973, *The Geography of Israel.*

Weinberger G., Rosental E., Ben-Zvi A. and Zeitoun D.G., 1994, The Yarkon-Taninim Groundwater Basin, Israel Hydrogeology: Case Study and Critical Review, J. Hydrology 161.

Chapter 4

Water Resource Management in Israel

Shaul Arlosoroff
The Harry S Truman Institute for the Advancement of Peace, The Hebrew University of Jerusalem, Mounst Scopus, Jerusalem

1. INTRODUCTION

By the early 21st century the economic demand for water will surpass supply within the territories comprising Israel, Jordan and the Palestinian Authority. To farstall the impeding scarcity the water resources have to be managed. The management tools are also the main ingredients for managing the shared groundwater.

This chapter addresses aspects of current and prospective water resources management in Israel. It is based on personal experience, research material and other documents, and discussions with water professionals in Israel. Most of the research was conducted prior to the dramatic political developments of the 1990s, namely the Middle East peace process and related events.

The 'numbers game' of predicting future water supply and demand, a topic of great interest in the literature, is not my concern here. Rather, I focus solely on Israel's water resource management options.

2. ISRAEL'S WATER LAWS

Water is one of the most important resources for Israel's development and economic growth. Therefore, following its establishment Israel was quickly faced with the challenge of formulating water policies and practices that were fair to all users at the time, while looking out for and maintaining the public's interests for the future. Such a challenge could only be met by a courageous legislative code, allowing the government to define rules, regulations and provisions to be imposed on its water users to meet the future demand with adequate quantities of water and to maintain its quality. In 1959 the Water Law was enacted by the Knesset (Israel's legislative body) after almost seven years of deliberations. It has been the cornerstone of water management in Israel since.

The Water Law constitutes an achievement in modern legislation pertaining to water. Its central theme is that water is essential for sustaining life, for economic growth and for production. Owing to its scarcity, it should be utilized by the entire public efficiently, so as to sustain development and projected growth and maintain the needed flexibility to reallocate for future demand. The way to achieve this end was agreed upon and has led to the expropriation of all private water sources and the concentration of water resources management in the hands of a government agency. This concept is expressed in Clause 1 of the law, which states: "Water resources are public property, subject to the control of the State, and designated for the needs of its inhabitants and the development of the country."

"Water resources" denotes all water sources, whether surface or groundwater, as well as drainage water, floodwater and human wastewater. In effect, comprehensive control of all types of water is consolidated by law in the Water Commissioner's Office, which acts in this matter as the trustee of the public. The Water Commissioner's Office is charged with allocating and reallocating the water in an appropriate manner, for the inhabitants' as well as the country's development needs, and safeguarding the resources for future generations.

Thus, water resources have ceased to be the subject of private property rights, and any right to the use of water – a right granted by virtue of the law to each and every person and resident in the State – is subject to the provisions of the law, based on licenses issued annually by the Water Commissioner's Office.

Parliamentary responsibility for water matters has curently been entrusted to the Minister of National Infrastructures. Until 1996, it was the authority of the Minister of Agriculture. It is the Minister who is charged with enforcing the Water Law and related by-laws and regulations.

The executive arm that implements the law's provisions is the Water Commissioner, appointed by the government.

A diversified system of legal powers was accorded to the Water Commissioner so as to furnish him with a discretionary framework regarding water allocations and reallocations, supervision of water use, monitoring the operation of water works, exercising sanctions in respect of non-fulfilment of legal provisions, and more.

In order to enable the Water Commissioner to fulfil all the tasks assigned to him by the provisions of the Water Law, and to supervise its implementation, an administrative system was set up called the Water Commission, with the Water Commissioner serving as its director-general.

According to the Water Law, it is forbidden to carry out any action using water, except individual use, without receiving prior permission or a license from the Water Commissioner. Production, supply and consumption of water, water recharge and the like may not be undertaken without the appropriate license from the Water Commissioner. This license prescribes a variety of conditions on whose fulfilment the very permission for performing said action is conditioned. The specific conditions relate to quantities used, qualities or discharge procedures and arrangements for production and supply of water. Special rules apply and attention is given to a range of issues, including efficiency of water use and pollution prevention. Annual licenses may be revoked by the Water Commissioner if all the provisions have not been fulfilled. The Water Law recognizes a number of different licenses (production, consumption, recharging, drilling, construction and others).

Concurrent with transferring control of water resources to public ownership, there is another important principle that permeates the Water Law, namely, the principle of involving the public in the decision-making process. The law obliges the relevant authorities to consult the public and to involve its representatives in the various procedures. This principle is manifested in the most important public body in the Water Law: the Water Board. The 39-member Water Board is appointed by the government to serve in an advisory capacity to the Minister and the Water Commissioner in matters of water strategy and policy making. Two-thirds of the board members are representatives of the public and one-third represents the government. The public representatives represent various groups of the nation's water producers, suppliers and consumers in the water users sector – agriculture, industry and domestic use. The consumers' representatives form at least 50 percent, and up to 100 percent, of the total number of board members.

The Water Board convenes, at the behest of the Minister, who serves as its chairperson, or the Water Commissioner, who serves as deputy chairperson. Important actions or changes to water sector management policy are brought to the board for prior deliberations. Every legislative matter published in accordance with the water laws is preceded by a board meeting, at which a wide spectrum of views is aired. Should the Minister act in contradiction to the board's advice, he may face a court ruling, which may order him to revoke the action and/or return the issue to the board.

Another body that involves the public in the decision-making process is the Tribunal of Water Affairs, established by the Water Law (Water Affairs District Court). It is vested with the exclusive judicial power to adjudicate in water affairs and expresses the full weight of the principle of involving the general public in decision making and resolutions pertaining to water policy and legal issues.

The Tribunal of Water Affairs is the body before which one can appeal decisions of the Minister and the Water Commissioner. It is composed of one professional judge and two public representatives, chosen periodically from a list compiled by the Minister, following consultation with the Water Board. The judge serves as president of the court. The Supreme Court will act in case of an appeal following the tribunal ruling.

To give a complete picture, it should be noted that in addition to the primary Water Law there are a number of other laws, which deal with water and sewerage related public health aspects, planning, pollution prevention and so on.

Two of these laws, passed in 1955, are the Water Metering law and the Water Drilling Control act. Both are essential bases for managing the aquifers.

The Water Metering law determines that Water Meters should be provided to each consumer separately, for the purpose of constant monitoring of the quantities of water used. Payments for water use are based on water meter records only. This costly operation was recognized in 1952 as a prerequisite to any serious demand management strategy.

The Water Drilling Contorl law is intended to protect groundwater resources, as they are of major importance. It intends to prevent the pollution, depletion or salinization of the aquifer due to unrestrained pumping.

3. WATER PRICING ISSUES

Around the world, water is generally utilized under a system of user rights. In some countries a landowner has the right to the water under his land, while in Israel a quota allocation system assigns the amount of water to be used on an annual basis (or a seasonal basis, in the case of farms).

Historically, water rights have been established much like land titles, in reaction to increased demand for water by farmers, cities, industries and power generation projects. However, riparian and other water rights were abolished by the Water Law (1959) in Israel, establishing an annual allocation and licensing system.

In 1995 the annual allocation system to urban centers was abolished. The authorities, however, imposed a financial sanction when "unaccounted-for water" (UFW)(water losses) exceed 15 percent of the total water quantity supplied. This figure was to be changed following the national experience on the reduction of the UFW in the cities and towns, already below 11 percent on average. The steep progressive block rate structure continues, of course, to be one of the main promoters of efficient use, which in recent years led to a tendency of many irrigating farmers not to use their total annual allocation.

Economists in Israel claim that despite past efforts in water conservation and relatively high water prices for agricultural use, efficiency of resource allocation in the water economy could still be significantly improved by greater reliance on a shadow and marginal price mechanism. The same would apply to the industrial sector and, to a lesser extent, to the domestic sector.

A significant impact on urban water use has not been observed since marginal pricing is not imposed in Israel. The marginal resource is seawater desalination which would cost up to three times the current average cost of water supplied by the national water system. Only interboundary regional transfers of water might cost less and delay the large-scale future desalination plants. Such transfers are presently an unrealistic political option, though this might change following the conclusion of the regional peace process.

Water is subsidized in Israel and has been so since the completion of the national water system in 1964. Water has been supplied to certain users below its real cost. "Rent seeking" has developed and become part of the political game.

The "rent-seeking" campaign is driven supported by the agricultural lobby who lowerd water fees and and increased water quotas. They wield political pressure on governments to increase supply from existing sources (causing at times over-pumping from ground and surface water resources), as well as attempting to force governments to boost investments in new or additional water resources, in many cases at subsidized prices.

With administrative allocations and water subsidies, full cost recovery by the suppliers is not assured. Lack of adequate cost recovery within the pricing system, neglecting mainly the capital components in the accounting procedures, leads to insufficient funds for replacement. In most cases private sector financial instruments would not, under these circumstances, be available for utilities or water corporations. Therefore, the water sector depends on government budgets for funds, whether for additional resources or even for operation and maintenance. In Israel, like many other developing countries, water pricing and investments became subject to macroeconomic and budgetary considerations, which are highly influenced by the political process.

In Israel a special fund was created to equalize water prices across all parts of the country. It is financed mainly by surcharges on the inexpensive water producers and users, and supplemented by the authorities, to reduce the cost to users, of expensive water supplies (mainly farmers, located at remote or higher-altitude sites). This fund has led to inappropriate accounting practices as users convinced the Water Commissioner's Office, which is responsible for the fund, that their costs were actually higher, and they consequently became non-contributors or even received financial support from the fund.

Presently in Israel the pricing concept is changing. Today's water prices already incorporate strong incentives for conservation and increased efficiency of water use in the domestic, agricultural and industrial sectors. Progressive block rates were first introduced in the 1960s. Since 1990 the upper block rate has risen to a level where many farmers do not use their full administrative allocations. However, the subsidy system still prevails for consumers in remote locations, and this does promote certain inefficient use. In all, the price structure is not ready to accommodate the future radical change in costs.

A state commission for the reform of the water sector[1] considered options for the shadow pricing of water resources and the gradual elimination of subsidies. It also examined proposing other means to compensate for the inevitable increase of water costs to groups of lower-income users and the social and economic implications for irrigating farmers.

When water is charged at the source (aquifer, lake, river, etc.), its opportunity cost (shadow price) should be adapted to the abstraction costs. Suppliers of water operating as controlled public utilities will then consider additional projects only if total (abstraction plus opportunity) cost can be recovered. The financial markets and similar instruments can thus be tapped. Subsidization, if it exists, is open and transparent, and the public can observe the purpose and costs of the financial support. In the future subsidies should be eliminated and direct support, in some cases, should replace the present system.

Israel is currently undergoing a gradual process of liberalization. Economically sound concepts are penetrating the previous, distorted, water-pricing system. The increase in the water price, mainly by elevating the upper block rate (above 80 percent of the annual allocation), means

[1] This commission, chaired by the author until 1997, is still active until Parliament will complete its work on the recommendations.

prices are becoming a constraint on excessive use, promoting investments and implementation of demand management techniques and crops.

Mekorot, the national water corporation (which supplies some 65 percent of Israel's water and operates the national water system) will become a legal public utility, operating as an autonomous entity with built-in improvements to its efficiency. An automatic formula for the updating of prices for water supplied by Mekorot has been introduced and approved by the Knesset Finance Committee, which has already caused significant changes in the agricultural and industrial water pricing system.

4. THE WATER MARKET: A POTENTIAL SOLUTION

Water in Israel is used within a system of allocations (annual or multiannual) while in most countries it is user rights that determine use. In many regions, a person who owns land (or cultivates it) has the right to the water flowing beside and under his plot. In other regions various quota systems allocate the amounts of water on an annual, monthly, weekly, daily or even hourly basis). Veteran users usually have the right to continue to use the resources. Riparian rights and other rights were obtained like titles on land, despite changes in population, prices (shadow costs of water), and changes in quality.

Throughout the world and the Middle East, the absence of adequate price mechanisms has led to substantial inefficiencies in water utilization. Even in Israel. Efficiency of water resource allocation and use can be substantially improved through increased use of price mechanisms. For example, trading water or using a system in which urban/industrial demand is met by "buying water" from the farmers could reduce inefficiency. Irrigation water in Israel was, and is today, subsidized when supplied by the National Water Company.

Presently, water in Israel for the urban sector is not subsidized: city users pay costs at gate, plus distribution costs, plus sanctions for overuse (or unaccounted-for water), plus effluent charges. Marginal quantities at "C" rate used by many households pay over $1.2/m^3 (inclusive of sewerage charges),Industry would pay if it is located within the utility limits approx. 40 USCents.

The system proposed by the commission could lead to a significant improvement of the sector as a whole. Here is a brief outline of suggested changes:

First, water would be charged at its shadow price (or opportunity cost). Suppliers would operate as controlled public utilities, new projects will be established if rates match marginal costs and if financial markets will support the investments. Price mechanisms will thus promote the total efficiency of the sector and possibly eliminate the "rent-seeking" impact and potential political conflicts.

Second, the new system would enable transfer of water among various users—mainly from agricultural consumers to cities, to the Palestinian Authority and to Jordan—with minimum conflict with the farmers, who will sell part of their allocation.

The water market will facilitate short- and medium-term solutions for Israel. It could also serve to improve the nation's water relations with the Palestinians and Jordan. The parties will voluntarily trade water under the oversight of an agency like the Water Commission, with the expectation of profiting from the trade. Such trading will alow the urban sector in Israel to profit in the long run through, as it may delay the need for desalination, thereby savings water desaltion costs. Most parties in the region will benefit by obtaining water at costs lower than other alternatives or by exporting or selling water at a price that is higher than its marginal value.

One option would involve the exchange of water based on the shadow price at the transaction site. The assessment of the adequate shadow-price could be done using an economic simulation model like the one developed by Harvard/Kennedy School/ISEPM with local experts. The simulation is needed because shadow-prices are not available and are subject to constant changes. Other options are available for setting trading costs, like the NWC Accounting System. Following the basic agreement on water allocation between Israel and Jordan (as well as for Jericho and Gaza) water will be traded under economic rules. The supervisory agency will monitor the market mechanism and could act as mediator to transfer the revenues from sales to the contributors (minus transaction costs). Prices will be updated centrally as they fluctuate according to supply and demand.

Revenues from transactions could be used for investments to improve and expand the water transfer costs or to decrease transaction costs. The economic model should assist in the appraisal of alternatives. Different trading mechanisms can be implemented. One option is joint management by the parties—Israel and the Palestinian Authority, Israel and a Jordanian agency, or the three together with or without an international agency like the World Bank, acting as a facilitator and as a funding source for transactions and investments.

5. THE ISRAELI WATER SYSTEM: SUPPLY AND DEMAND MANAGEMENT (PRESENT AND FUTURE)

There are three major problems of water resource management in Israel that influence Israel's potential to assist the Palestinians or other neighboring countries:

- Lack of adequate storage (annual and seasonal)
- Supply and demand ratios, which lead to overpumping from existing resources (especially when winter rains are below average)
- Water quality deterioration (as aquifer water tables are kept at low levels).

Israel is presently utilizing more than 90 percent of its renewable freshwater resources. I use this term, rather than the broader "economic water resources," in order to avoid the complex task of setting the actual cost of water against its incremental production values (mainly in the agricultural sector). A short description of the events during the period 1989-1992 as well as in 1999 will clarify a few of the complexities of water management planning and forecasting of supply and demand which make economic analysis highly problematic: following a period when rainfall precipitation dropped below the multi-yearly averages, a serious depletion of operative water storage developed. The two main aquifers, as well as the Sea of Galilee (Lake Kinneret) dropped to their lowest levels – to the "red lines" set by the Water Commissioner at the recommendation of limnological and hydrogeological experts. There was never unanimous agreement as to where the "red lines" really are, what would happen if water levels fell below these lines, or the risks involved with intervening to restore the proper level. During the early 1970s, the Water Commissioner ordered the preparation of a document entitled "Extreme Conditions in Israel's Water Supply." The research, which took a decade to complete, produced basic data to aid the decision-making process. With the significant changes that have taken place in regional and local conditions, however, the document is being revised. Up-to-date data could play an important role in assessing the economic shadow prices of water under various climatic conditions, and will be used to set the levels of the "water abstractions levy" that the government decided to impose in 1999.

Under the serious hydrogeological conditions that prevailed, the Water Commissioner enacted and enforced administrative measures reducing water allocations and increasing water rates.

In the winter of 1991-92 nature surprised forecasters and doomsayers with Israel's rainiest season on record. As a result, the water level in the Sea of Galilee rose, the Degania dam filled up, its gates were opened and the surplus overflowed into the Dead Sea. Aquifers rose to levels last recorded 20 years earlier. These events underscored Israel's lack of water storage facilities and its inability to store water between rainy and dry years. From a "red line" situation, the hydrological cycle changed within one year and its impact was felt until 1999.

During the summer of 1992 the relatively high agricultural rate of the upper block, the depressed world prices for cotton and citrus products and the late rainfall all contributed to a significant reduction in irrigation demand. With changed marginal values of water, farmers did not use their complete allocation through the fall of 1996. Also the shadow values of water fell, significantly.

All of the above may partially explain why it is difficult to use the expression "economic demand for water" in discussions on Israel's water system. Other reasons, including socioeconomic and political factors, are beyond the scope of this study, but one short example may illumine the complexity: over the course of Israel's history, following World War II, immigrants were sent to settle in the remote south or in the northern mountains. Water supply in these regions cost much more than in the *densely populated* center of the country. The government decided to create incentives for settlement in these areas by providing many services—water, power, telecommunications, roads, health and education—at equal cost throughout the country. The incentives, made possible through general taxation and an elaborate cross-subsidy system, were intended to enable the settlers to enjoy a standard of living consonant with the national average. It has always been politically difficult to remove the incentives from the production factors and switch to a reform policy where the incentives will be paid directly to the users. The policy is, however, moving gradually toward smaller subsidies, a process clearly demonstrated by the water rate changes since 1990.

6. WATER RESOURCES AVAILABLE FOR DEVELOPMENT (IN ORDER OF PRIORITY)

Overall, Israel has five options to address increasing water scarcities. These are presented here by order of priority, based (inversely) on costs.

6.1 Water Conservation—Demand Management/Efficient Water Use

6.1.1 General

This endeavor includes continued efforts (technological as well as economic credits and incentives) to further reduce water use in industry and urban centers as well as to improve the efficiency of water use in agriculture. Incremental costs of water saved range from \$0.15-\$0.40/m^3. The best judgment for now would lead to a skewed conservation curve with an average cost of approximately \$0.25-30/m^3. The figures in irrigation and the industrial sector as quoted assume increased production per unit of water in real terms; they reflect some changes in the basic production cycle, i.e., adapting to more economical cropping patterns and changing industrial processes. The levels of direct and indirect water production through savings and improved efficiency of water use are very important as they represent permanent demand reduction. Israel has gone a long way in its efforts while its neighbors, the West Bank/Gaza, Jordan, Syria and Lebanon, could still benefit significantly from such efforts to shrink demand and mitigate the need to develop new sources.

The term "efforts" is quite a bit more complicated than it appears. It means large-scale application of complete metering and allocations, adequate technology (drip, sprinkler, automation), changes of industrial water processes ("cascading," new cooling methods, etc.) and the application of demand-management policies and technologies in the cities. Training, public education and effective extension systems must accompany the promotion and implementation instrument. Incentives are essential as the "trickle down" system will not work by itself. Finally, the efficiency of pricing mechanisms and the market system can play a dominant role in the operation. A comparison of prevailing prices for irrigation water between Jordan and Israel, for example, illustrates and partially explains the gap in the two countries' agricultural yield per cubic meter, and the potential for decreasing agricultural water demand, while the effective market for the agricultural products is effective thus hurting Israeli farmers, who are paying much higher prices for their main inputs.

Israel could play an important role in the application of demand-management policies throughout the Middle East and thus help to delay the need for expensive future projects in the area. Water conservation should be the top-priority short-term strategy within the proposed plans for regional cooperation. However, if only one partner invests and applies rigid demand-management policies the impact will be limited. Overall demand for water will rise beyond the supply capacity and may lead to regional conflicts.

6.1.2 Urban water conservation

The urban demand is increasing rapidly and is the main cause for the future water scarcity.

Unaccounted-for water (UFW) causes significant water and financial losses to urban utilities and municipalities. UFW has been substantially decreased in Israel, but remains a serious problem in Jordan, the West Bank, Gaza and other Middle Eastern countries. In Jordan, for example, UFW rates in various cities are above 50 percent and represent critical water and financial losses. Leakage is estimated to account for a half of the total UFW which is (approximately 30m^3 per capita per year) meaning that 3 million m^3 could be recovered per 100,000 urban users each year. If multiplied by \$0.50/m^3 (the minimum marginal costs of future water supply), the utility's financial losses equal approximately \$15 million per one million urban residents per year. There is no doubt, given the experiences in Israel and many other countries, that these losses can be reduced to more reasonable levels—savings that may be reinvested in further conservation and maintenance efforts. **The national average of UFW in Israel was reduced to approximately 10 percent.**

Studies and research conducted in Israel and the USA show that the costs of water saved through leakage control vary significantly, from \$0.15-35/m^3. These activities are essential to utilities' financial viability. Urban demand management addresses demand reduction at public use, household and utility levels and, with a large-scale application, should reduce the cost of water in the Middle East as a whole – significantly – and will delay the water problems for many years.

Demand management efforts in Israel, Singapore, California and the Boston area, as in other regions with water conservation kits, have produced significant results. The retrofitting kits (including toilet flush reduction, two-volume flushing, regulated shower heads, flow regulators in kitchen and bathroom sink taps, leakage control as well as improved irrigation in gardens and parks) achieve demand reductions of 15-25 percent (sometimes 20-40 percent) at an approximate cost of \$0.10-15/m^3. Retrofitting is effective for both households and commercial buildings (Singapore stands as a very successful model of this strategy).

These efforts could "produce" tens to hundreds millions of cubic meters of water in each country at one of the lowest marginal costs available in the region. If the total urban population in Israel used demand management appliances, the water savings could have reached 100-150 million m^3 in the crisis year of 1999. However, it must be stressed that if sewage effluent is totally and efficiently reused, the end result of demand management is mainly accounted for in economic terms as incremental operation and management savings associated with the water wastage (water supply and waste treatment) and a smaller decrease in total net water availability. In addition to domestic and commercial use, city and residential parks and household gardens should be refitted with drip irrigation and small automated irrigation systems that would save millions of additional cubic meters.

One cannot underestimate the importance of urban and domestic water demand management strategy. As the growth of water consumption in the region is concentrated in cities and towns, this water conservation strategy will generate permanent savings at low marginal costs, and might delay the forecasted future crisis.

6.1.3 Water Demand Management/Effluent Reuse in Production Sectors

Israel has endeavored to establish a system of water demand management for its existing industries while new industries are currently installing "closed cooling" systems and pre-designed "cascading" facilities. The price mechanism as well as effluent charges are gradually being enforced and are contributing their share to industrial water management. Many of the industries are located in the urban sector and are subject to the additional utility costs.

An additional revision of the data based on the value of incremental water savings in the industrial sector indicates that the value per saved unit of water ranges between $0.10-50/m^3. In most cases the lower figure is attributed to basic water management practices and the upper limits indicate the savings involved with air cooling and reuse of in-house effluent after complete secondary or tertiary treatment of its wastes.

The average cost of water saved in previous (quite modest) efforts was in the $0.15-25/m^3 range. The freshwater allocation for Israeli industry is approximately 7-8 percent of the total use and therefore the additional potential savings are relatively small. However, the environmental impact of industrial wastes could alone justify higher levels of investment in treatment facilities, as in-house treatment and reuse reduces potential pollution of streams and water resources.

Reuse of wastewater effluent should be analyzed in the context of industrial and urban conservation. When effluent charges are enforced and subsidies are removed, market forces typically produce the optimum results. Israel will probably demand that the Palestinian Authority assures adequate effluent treatment and disposal policies in order to ensure the safety of the sensitive jointly shared Mountain Aquifer underlying the West Bank. As relatively high levels of treatment will have to be adopted, it is reasonable to assume that local reuse for irrigation purposes will be the most cost-effective solution, mainly in areas where aquifer pollution is not expected. Drip irrigation of horticulture tree crops and vegetables is preferred in these conditions, above potable aquifers and when the fields surround most, if not all, the towns and cities. It is essential that the design and implementation of adequate sewage systems are given top priority when the external funding instruments become available for the Palestinians; Israel has already completed the system.

The economics of urban water conservation and reuse are strongly linked to whether the effective and efficient use of effluent irrigation is a viable option. Treatment and transfer costs could determine whether a river or a marine outfall is the most economical option and under what conditions farmers would be ready to trade freshwater for treated effluent (i.e., at what price and ratio of exchange, under what investment-sharing plan between the city and farmers and whether "bridging" funds are provided by the authorities). So there is a clear linkage between urban demand management activities (not the reduction of unaccounted-for water, which is a separate issue) and effluent quality, effluent reuse and trade-off policy and legislation. As chemical pollution of the effluent water will make it inadequate for irrigation, the city has a direct interest in avoiding contamination of the waste flows and to decrease salt input in the waste stream.

6.1.4 Increased Efficiency of Irrigation Systems

Israel has been involved in improving irrigation efficiency since the 1960s and offered accelerated financial support and credits for implementation of this policy during the 1970s. These efforts were partially supported by the World Bank Agricultural Credit projects.

To date, gravity irrigation has been eliminated, most farms have been redesigned and modern sprinkling, drip and automation systems have been installed. Old pipes have been replaced and the concept of measuring the value of water by its incremental contribution to yields has been developed. These changes led many farmers to alter and greatly improve their cropping patterns. There is still a great deal that can be done with improved soil and extension systems and further applied research. The trend is toward higher-value crops, especially as a result of the fluctuations in world prices for cotton (a major irrigated crop), citrus, oil seeds, export vegetables and others. Pricing and credit mechanisms would play a dominant rolc in this subsection, as well as the availability of incentives and proper technology. However, the most important policy mechanism is the enforced reduction of freshwater allocations while connecting the farmers to wastewater reuse systems,

6.2 Reuse of Sewage Effluents

Here again, Israel has already come a long way. Nearly the entire population (both urban and rural) enjoys sewage services and almost all of the effluent undergoes extensive secondary treatment (activated sludge or lagoons). An additional 20-30 percent of the present annual effluent will be incorporated into the total national reuse system. Additional significant investment in the inter-regional wastewater reuse system may capture 60-70 percent of the incremental water quantity to be allocated for urban and industrial use in the future. Therefore this resource will become the major avenue for exchange with fresh water resources and will enable Israel to sustain its irrigated agriculture.

The additional costs of further collection, treatment, storage and distribution (to farmers' fields as well as in the changes of the primary and secondary irrigation systems) will be approximately $\$0.40\text{-}60/m^3$ with an estimated average of $\$0.50/m^3$. Responsibility for the cost will be split between the urban sector and the agricultural sector. The concept of the "polluter pays" has become law; its scope will change the real economic costs of the water sector in the future.

These figures apply to the present situation within Israel. However, in order to better understand the dimension of the problem, one can estimate that between 2000-2010 an urban population of over 10 million will use approximately 1.0-1.2 billion m^3 of water annually (including industrial use) between the Mediterranean Sea and the Jordan River (this region includes Israel and the Palestinians). Thus, it is necessary to plan for the adequate treatment and reuse of approximately 700-800 million m^3 of effluent per year. Planning must be done to safeguard the aquifers, which are vulnerable and indispensable sources of potable water, and to assure the proper conveyance of the effluent to the new sites. International funding efforts must play an important role in the budgets for sewage investments as well as for effluent irrigation, especially with regard to the Mountain Aquifer, safeguarding its long-range quality as the main source for high-quality potable water for the Palestinians and Israelis.

6.3 Desalination of Brackish Water

I am ranking this option third because existing data support the idea that reverse osmosis (RO) of brackish water may cost less than the development of other marginal or regional water resources. It includes the possibility of using reverse-osmosis to improve groundwater contaminated by salinity and/or other pollutants which accumulate in aquifers used for urban supply.

Brackish water is available from the Mountain Aquifer, the Coastal Aquifer and the Fossil Aquifer in the Negev (as well as from other sources along the valley of Jordan, the Dead Sea and the Arava).

On the basis of available data, RO of brackish water of a quality of 2000-4000 TDS (or less) with a reduction ratio of 1:2 or 1:3 removing pollutants and sodium nitrates to a potable level should cost (including the price of pumping and piping to the nearest network) approximately \$0.40-60/m^3, with an approximate average of 50 cents/m^3. Israel's brackish water supply could reach 150-250 million m^3/year in the next 10 years. It may involve still larger quantities if Coastal Aquifers continue to deteriorate in quality or if more remote sub-aquifers are connected to the water system. Local desalination-reducing aquifer pollutants would cost between \$0.25-40/m^3, which means that in the future potable water quality within the coastal urban centers will likely be maintained by local RO of the well water within cities or in the vicinity. Pilot projects to analyze and demonstrate its application will be designed and installed over the next five years.

6.4 Development of Other Local Water Sources (Non-Desalinated)

Other local water sources include the Fossil Aquifer in the south, deeper groundwater resources, rainwater collection projects, additional multi-yearly storage arrangements (such as increased winter pumping from the Sea of Galilee and Yarmuk during rainy years for aquifer recharge) the use of additional storage in Adasiya/Mukheiba, the Jordan and/or the Netofah Valleys. Total feasible quantities will not exceed an additional 100-150 million m^3/year (which will be shared with the Jordan when stored in the Yarmuk or Jordan Dams). Cost estimates vary between \$0.55-75/m^3, with a possible average cost of approximately \$0.60-65/m^3, If dams are built an additional NWC enlargement will be needed. In this analysis I do not assume increased rainfall through cloudseeding. The potential benefits of such an operation are inconclusive and far too indeterminate to estimate the results of present or future efforts or its costs per cubic meter. In the Jordan-Yarmuk watershed, this issue is directly linked to additional operative storage.

6.5 Seawater Desalination (Local and Regional Solution)

With newly developed technology in Israel and elsewhere, seawater can now be desalinated on a large-scale commercial basis. This option, the most expensive solution, is ranked before regional projects only due to the political complexity associated with regional transfers. Seawater desalination involves regional considerations as well. The basic questions are economic implications, timing, and whether incentives or subsidies can be justified in order to increase water supply in the region by desalting sea water. A desalination program will boost water quantities, mitigate environmental problems and improve water quality through mixing operations. Such a plant is operating on the Gulf of Eylat, producing water for less than $0.80/3m.

There are some benefits from economy of scale associated with large-scale desalination. The three main options are a single RO plant, multi-stage distillation (MSD) plants, or various multi-purpose power and desalination. Only detailed designs and a complete bidding process (an international process, including BOT) will enable the planning and financial process to be concluded. Dual purpose nuclear-, hydro- or gas-powered plants (e.g., Gulf or Egypt to Israel gas pipelines) and desalination could be environmentally and economically preferable.

Recent data from the most efficient large-scale RO-sea-water desalination plants and tenders and Multi-Stage Distillation (MSD) lead us to assume that the present real costs ex-plant are approximately $0.06-08. At current energy costs of about $0.05-06/kwh and total capital return of 8-9 percent per year, the costs of desalted sea water in smaller plants (of approximately 15,000-25,000 m^3/day) would be approximately $0.80/$m^3$ in the network. Plants of 150,000-250,000 m^3/day might produce water at approximate costs of $60-70/$m^3$ (1999 costs). These forecasts are based on improved processes presently under accelerated research and development, such as hydrostatic pressure (interconnections between the Mediterranean and the Dead Sea or Jordan River or the "Red-Dead" project); hybrid systems (multi-stage distillation/RO and power grid); and other combinations of cogeneration and hybrid MSD/RO units. All costs above are ex-plant and significant additional costs will be attributed to the piping and pumping linkages, up to the final destination.

It appears that large-scale desalination has economic feasibility only if Israel, the Palestinians and Jordan increase significantly the efficiency of water use in all sectors. Entities must invest in comprehensive efforts to increase water product value in agriculture and in industry and maximize urban water conservation and demand management (up to the economic intersection between desalination plus distribution costs and incremental costs of conservation). In addition, desalination plants are necessary to take advantage of economies of scale and serve two or three separate entities.

To conclude, I would like to reiterate that the Middle East is a water-scarce region, and scarcity could lead to poverty, social or political problems and disputes Any amount of water to be shared between Israel and its neighbors – the Palestinians, Syrians and Jordanians – decreases the potential allocation for the other groups. Comprehensive development of resources combined with rigid demand management strategies and effective wastewater reuse systems could prevent water from becoming a cause for conflict.

Indeed, water could become the window of opportunity and cooperation in the region, as it represents financial aspects while the others constraining the Peace process, are much more political and sensitive, and harder to solve. Collaboration in Water resources management can thus become a major contributor toward confidence building and a basis for cooperation and joint execution and management.

SOURCES

Arlosoroff, S., *World Bank internal documents.* 1993.

Becker, N., N. Zeitouni, M. Schecter, *Reallocating Water Resources Through Market Mechanisms.* University of Haifa, Israel, 1994.

Fishelson, G. The Allocation and Marginal Value Product of Water in Isreali Agriculture, in: J. Isaac and H. Shuval (eds.), *Water and Peace in the Middle East.* Elasevier, 1994.

Fishelson, G., University of Tel Aviv. Papers presented in various meetings at the Hebrew University Faculty of Agriculture, papers prepared as part of the JFK/Harvard/ISPEM Economic Model for Water in the Middle East.

Goldberg, D., *Legal Aspects of World Bank Policy as International Waterways,* Water Resources Development, World Bank, 1991.

Isaac, J., H. Shuval, (eds.), *Water and Peace in the Middle East.* Elsevier, 1994.

Just, R., J. Horowitz, S. Netanyahu, *Problems and Prospects in the Political Economy of Trans-boundary Water Issues.* University of Maryland, 1994.

Kislev, Y., *The Economics of Water Resources - Principles and Their Application.* Center for Agricultural Economic Research, Rehovoth, 1991 (Hebrew).

Kislev, Y. & Rosenthal, G., The Watershed. *Riveon Lekalkala* 46(1), pp. 106-135 (Hebrew).

Chapter 5

The Need for Joint Management and Monitoring of the Water "Usage" Cycle

Karen Assaf
Currently Advisor to the Palestinian Water Authority, Al Bireh, Palestine[1]

1. THE WATER USAGE CYCLE

Economic development in the Middle East has a twofold impact on water availability. On one hand, the increasing consumptive use of water due to the very high population growth and the extreme need for development - as for irrigation, industrial or domestic use - results in full use of existing resources and in the pressing need for new sources. Also, the corresponding increase of waste products from industrial, domestic and agricultural activities could potentially have serious effects on the water quality of the receiving bodies with the possibility of restricting their actual or future utilization as supply sources. Water contamination in this Palestinian-Israeli area, which in the past was a matter of concern mainly in relation to the endangerment to human health, has now also become a matter of environmental concern. Therefore, water resource management practices in Palestine and Israel should aim at the economic use of water and the control of pollution as two closely interrelated goals.

Economic utilization of water and pollution control are basic tools to avoid irreversible deterioration of water sources which may impair the future development of existing and potential areas. Water use and pollution control

[1] This paper was originally written at ASIR (the Arab Scientific Institute for Research and Transfer of Technology in the West Bank) before the establishment of the Palestinian Water Authority in April 1995. Upon review of the article for publication in this book, the author found that the ideas and concepts of that time still stand now, as written.

cannot be considered independently of the entire set of managerial activities - long term planning, economic instruments, standards and regulations, research and technology, training and education, and, of course, the existing political, institutional and legal framework.

The approach to water resources management in this region should evolve together with the social and economic development of the area as the growing demands of water for sectorial use and waste products disposal increase the stress on the available supplies of adequate water quality. Every cubic meter of water deemed unusable due to poor quality, or improper utilization, is in reality a direct loss in the water supply of the region. The problem is for the Middle Eastern scientists, engineers and international development and donor agencies to deliver the limited available water where it is needed, at an affordable price, and of a suitable quality. The access to sufficient and reliable sources of clean water is crucial to public health, socio-economic development and welfare for every country in the region.

Water resources management encompasses assessment of all available water resources and water resource utilization in all its forms as well as water protection and conservation methods. Water management - especially in this semi-arid area - essentially means the formulation and implementation of a sustainable socio-economic development policy with corresponding regulations and guidelines. These management areas can be conceptualized or divided into three components - water supply, water utilization and water discharge. Palestinian and Israeli joint water management decisions should deal with the concept of water resources in all three phases in what can be called the *"water usage cycle"* which should be visualized from the very beginning of any planning phase as non-separable elements of a process (see Table 1).

Table 1. Definition of the "Water Usage Cycle" as a Water Resource Management Concept

Water Supply Component Allocation of Water Resources	Referring to water extraction, regulation, distribution and maintenance techniques that aim toward an efficient and integrated management of water sources in the Middle East.
Water Utilization Component Demand management: domestic, industrial and agricultural use.	Referring to the sectorial uses of water, seeking for more efficient production processes that minimize water requirements. Emphasizing the efficient use of water by all end-users and the need to minimize water use per unit of end product.
Water Discharge Component Pollution control of water resources.	Referring to a controlled management of waste disposal in the entire Middle Eastern region in order to avoid pollution and to combat environmental and health hazards due to deteriorating water quality before and after use.

Thus, rational water management in this region should be founded upon a thorough understanding of all the types of water available and its movement. A major objective should be to view hydrological processes in relationship with the environment *as well as human activities*, emphasizing the multi-purpose utilization and conservation of water resources to meet the needs of economic and social development throughout the area.

Resolving the water problem in this area calls for a shift towards a multi-disciplinary approach to the assessment, planning and rational management of water resources. An integrated approach to water resource management requires a sense of teamwork in finding the appropriate solutions and developing the manpower skills needed to manage water resources effectively. Stress should be placed in such an approach on systems management aimed at the reduction of the negative side effects of water resources development.

It must be realized that water management decisions are only as good as the information on which they are based, so that great attention must be paid to the availability, accuracy and completeness of water resource data and information in the region. The problems of water resource use and control in the region are highly complex, but by advancing on many fronts - especially the sharing of information and experience - the opportunity exists for improving the chances for sustainable development in this semi-arid region. Modeling, database management, information synthesis and exchange should be made *by all* involved in Middle East water policy planning as a long-standing commitment toward increasing the scientific bases for integrated water resources planning. Through information networks between Middle Eastern and international scientific research centers and training institutions, a more rational attitude can be encouraged towards water use and control that combines a sound understanding of water availability and movement with integrated planning and integrated management.

Applying more science and technology, rather than bureaucracy, can help mitigate some of the effects of people's indifference to and abuse of the limited water resources in the area. Public awareness must be a priority for the conservation of water and for the recycling and disposal of wastes. However, without an understanding of the need for the application of new techniques, without a commitment from Middle East policy makers and international donors for the conservation of water and installation and maintenance of water systems, and without the involvement and general support *of all the people* who use the water and the soil, such efforts are likely to fail.

2. RESPONSIBILITIES OF THE PALESTINIAN NATIONAL WATER AUTHORITY

Naturally occurring water resources in Palestine and the demand for their usage is currently a critical political, economical and technical issue. Palestinian water usage, management, protection and conservation constitute a top priority strategic package that must be freely developed during the proposed interim peace period and thereafter. With ever-declining safe and sufficient water sources, it is imperative that Palestinians manage their most valuable natural resource - water - if a continued reliable and sustainable water supply is to be expected in the future. The fact is that water problems in Palestine are caused not so much by a shortage of fresh water as by its uneven distribution due to practices during the occupation.

Proper management of Palestinian water resources requires consideration of both supply and demand. The goal should be to promote water use and management in such a way that the Palestinian society's needs are met while at the same time Palestinian water sources are protected. Therefore, it is essential that at the out-set of the Palestinian National Authority policies be introduced and implemented to stimulate responsible management and conservation of Palestinian water resources by well-informed decision-makers as well as the consumers in all demand sectors - urban, rural, agricultural and industrial. In order to be on a equal footing with other countries in the Middle East, a Palestinian information system should be set-up upon which to base water management decisions and a data management system needs to be initiated in order to absorb all new water data as well as historical data (once it is made available).[2]

Water availability is essential to Palestinian socio-economic development and food security - just as it is in every other country in the Middle East region. The agriculture component of the Palestinian economy is the largest user of water and takes the "lion's share" of total water utilized in Palestine, in both the West Bank and Gaza Strip. This fact is also true for Jordan and Israel.

It has been reported that about 73% of Palestinian water usage each year is for irrigation. Presently, industry utilizes only about 2% and the remaining 25% is used for domestic and commercial needs, such as household and institutional drinking, washing and for limited sewerage systems. On the other hand, the water used for irrigation from Palestinian water resources in the agricultural sector cover only about 5% of the cultivated area in the West

[2] This is now being done through both national and multilateral programs within the Palestinian Water Authority.. For example, the EXACT program for Regional Water Data Bank(s) under the Multilateral Working Group on Water Resources.

Bank and less than 30% of the Gaza Strip. The remaining cultivated areas in Palestine meet their water demands from rainfall.

During the coming-to-power of the Palestinian National Authority and the forthcoming of the Palestinian Water Authority,[3] economic utilization, protection and conservation of water should constitute the fundamental goals of every measure or action undertaken in pursuit of a rational management of water resources. With the establishment of a Palestinian National Authority, issues must be addressed that relate to water utilization techniques in the framework of minimizing the negative secondary effects during all phases of water supply, - i.e., distribution, utilization and disposal - *"the water usage cycle"*. These water management goals should include a set of techniques, structural measures and related policies required to achieve an efficient allocation, distribution, operation and utilization of water resources, as well as adequate environment, cultivation, health and pollution control.

The following objectives should constitute the basis for the rational development of Palestinian water resources:

- assessment of water resources availability,
- assessment of all the possible uses of water resources,
- development of managerial activities dealing with both administrative and non-structural measures,
- initiation of water protection and conservation techniques, and
- review of agricultural practices and policies.

Palestinians have the professional capacity to control the water resources available to them. Currently, the rapid growth of the Palestinian population, together with the expected extension of irrigated agriculture and industrial development, are sure to stress the quantity and quality aspects of the natural system of water resources in Palestine. Because of the limited water resources and the increasing problems associated with expected limitations, Palestinians must realize that they cannot follow a "use and discard" philosophy with water resources - or any other natural resource - just because they are now becoming their own keeper and the Israeli occupation is no longer stepping on their rights. As a result, the need for a consistent policy of rational management of Palestinian water resources needs to become among the greatest priorities.

During this expected era of increased infrastructure development in Palestine, education and training, social and cultural components, and research should be built into all programs and projects. It is now time that

[3] The Palestinian Water Authority was officially formed in April 1995.

Palestinian universities, research and development institutes and organizations should be aided to their utmost capacity to initiate programs, courses, seminars and/or conferences emphasizing proper water utilization and water conservation - stressing water demand management, rainwater harvesting, dry-farming of rainfed crops, methods and techniques of using refined sewage waters, irrigation with brackish water, desalinization, etc. It should be recognized that there exists varying cultural traditions (e.g., urban versus rural), social structures and degrees of economic development or scientific and physical infrastructure and these differences - even within the small area of Palestine - can affect the choice, use and sustainability of different water resource options.

The development of Palestinian water resources has as its aim - in common with Palestinian development generally - the enhancement of the conditions of human life and must be recognized as an integral part of the social and economic programs. It must always be remembered that the development goals chosen by "the Palestinian governing authority" for their people are not realizable in the absence of water adequate in quantity and quality.

To date, supply-oriented and resource-oriented water management dominated the scene in Palestine with emphasis on structural measures to cope with supply of water and water-related services. Now the time has come to make a Palestinian policy for water resources development, planning and supervision to include non-structural measures such as data collection and analyses, legislation and regulation, economic incentives and penalties, as well as public participation.[4]

Water resource planning in Palestine should include adequate links and coordination with other Palestinian national master plans - such as agriculture in general, forestry, economic and industrial expansion and urban planning. This type of inter-disciplinary approach should aim at a more efficient operation of the existing water schemes as well as providing the infrastructure for new systems.

In summary, both the supply and demand management stages of water resource development in the Middle East region will have to run concurrently in order that the concept of water supply will not exclude the processes of collection, cleansing and discharge of wastewater which must be directed and seen as being under the same planning umbrella as water resources development.

[4] Since the establishment of the Palestinian Water Authority, intensive and extensive institutional development programs have been initiated, aimed at developing the management tools necessary for a sound and sustainable integrated water management policy.

Finally, water management policies must be introduced by the Palestinian National Authority that reinforce the country's capacities to solve its own problems. Good management of Palestinian water resources must be based on a sound understanding of scientific principles. But, at the same time, the successful application of integrated water management techniques will require a flexible and positive response to social, cultural and environmental dimensions that will accompany the expected striving for improvement in the standard of living of the Palestinian population during the upcoming intensive development phase in Palestine after the debilitating occupation.

REFERENCES

Abu Maile, Yousef. (1993). The Quality of Groundwater in the Gaza Strip. Department of Geography, The Islamic University of Gaza, Gaza Strip.

Al-Khatib, Nadar and Karen Assaf. (1992). Water Supplies and Demands, in Isaac, J. and H. Shuval (eds.) Water and Peace in the Middle East 58: 55-68 (1994). Amsterdam: Elesevier.

As'ad, A.K., K. Assaf. M. Haddad. T. Nassereddin. R. Koning and P. Roark. (1994). Water Conservation in Palestine. Report contracted to the World Bank through the Center for Engineering and Planning, Ramallah, and presented to the multi-lateral water meeting in Muscat, Oman. April 1994.

Assaf, Karen. (1999). "Palestinian Participation in Efforts Towards Regional Cooperation in the Water Sector", presented at Regional Conference of the International Water Resources Association (IWRA) entitled "Water and Environmental Cooperation". Jerusalem (Bethlehem). June 1999. To be published in Water Science and Technology.

Assaf, Karen. (1999). Co-author, as Member of Committee on Sustainable Water Supplies for the Middle East, Book entitled "Water for the Future: The West Bank and Gaza Strip Israel and Jordan", National Research Council, Washington, D.C., released by National Academy Press in March 1999.

Assaf, Karen. (1998). Co-author, as member of Multilateral Team of the EXACT Program for Middle East Water Data Banks Project, publication entitled "Overview of Middle East Water Resources: Water Resources of Palestinian, Jordanian and Israeli Interest", compiled by U.S. Geological Survey from contributions by the Palestinian Water Authority – Dr. Karen Assaf and Mustafa Nuseibeh, the Jordanian Ministry of Water and Irrigation – Dr. Hazem El-Naser. and the Israeli Hydrological Service – Dr. Shmuel Kessler and Dr. Meir Ben-Zvi, 1998.

Assaf, Karen. (1996). "Use of Artificial Recharge as the "Safety Deposit Box" for our Future Strategic Planning for Water Resource Optimization", in International Seminar on Water Management, An-Najah National University - Nablus, March 8-9, 1996.

Assaf, Karen. (1985). Section on Water Resources. In 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, October 1985.

Assaf, Karen. (1992). Replenishment of Palestinian Waters by Artificial Groundwater Recharge as a Non-Controversial Option in Water Resource Management in the West

Bank and Gaza Strip. In Isaac, J. and H. Shuval (eds.) Water and Peace in the Middle East 58: 301-314 (1994). Amsterdam: Elsevier.

Assaf, Karen. (1994a). Environmental Problems Affecting Palestinian Women Under Occupation. In Dr. Tamer Mayer (ed.) Women and the Israeli Occupation: The Politics of Change. London: Routledge Press.

Assaf. Karen. (1994b) The Hydrogeological Conditions in the Palestinian Territory and the Need for Information Management Systems and Training in the Water Sector. Report for UNESCO, Paris.

Assaf, Karen. (1994c). Palestinian Water Resources: Water Quality. In Our Shared Environment (Israelis and Palestinians Thinking About the Environment in the Region in which They Live). Paper presented at Israel/Palestine Center for Research and Information (IPCRI) Environmental Symposium, Jerusalem, 12-14 December.

Assaf, K., N. Al-Khatib, E. Kally, and H. Shuval. (1993). A Proposal for the development of a Regional Water Master Plan. IPCRI, Jerusalem, October.

Assaf, K. and S.A. Assaf. (1984). The Chemical and Hydrological Status of the Wells in the Arab Development Society Project. A publication of Birzeit University Research Center, contracted by the Swedish Save the Children Organization.

Assaf, K. and S.A.Assaf. (1986). The Water Situation in the West Bank and Gaza Strip. In Water Resources and Utilization in the Arab World. Kuwait: The Arab Fund: 93-116. Part of this paper was also presented at the Conference on Arab Waters.

El-Khodari, Riyad. (1991). Water Resources in the Gaza Strip. Shu"un Thnmawiyyeh, Arab Thought Forum, Jerusalem, October, 68-72. (In Arabic).

Haddad, Marwan. (1992). Environmental Conditions in the Occupied West Bank. In Proceedings of Workshop on Environment, Land and Water Establishment, Jerusalem.

Haddad, Marwan. (1992). Consumption of Water in the West Bank: Past, Present and Future. Department of Civil Engineering, An-Najah University, Nablus. (In Arabic).

Shuqeir, Adnan. (1993). Summary of the Environmental Situation in the Occupied Palestinian Territories. Paper presented at the First Regional Conference on the Regional Conditions for Successful Environmental Practices in the Arab World, Yarmouk University, Irbid, Jordan, April 3-5.

UNDP (and the Palestinian Technical and Advisory Committees). (1994). An Institutional Framework for Water within the Palestinian National Authority. Recommendations of a workshop based on World Bank 1994 Report Water Conservation in Palestine. 21-24 April. Vol. 1: Summary Report; Vol 2: Annexes.

Zarour, Hisham, Jad Isaac, and Violet Qumsieh. (1993). Hydrochemical Indicators of the Severe Water Crisis in the Gaza Strip. Proceedings of the International Symposium on Water Resources in the Middle East: Policy and Institutional Aspects. Urbana, Illinois: 24-27 October. 207-217.

Chapter 6

The Turonian-Cenomanian Aquifer

The Need for a Joint Monitoring and Management Programme

Yona Kahane
Israeli Center for Waterworks Equipment (ICWE)

1. GENERAL BACKGROUND

1.1 Introduction

A bilateral agreement between Israel and the Palestinians on the monitoring and management of the Turonian-Cenomanian (limestone) aquifer—which does not recognize any likely political boundary—is vital for conservation of the resources and quality of the aquifer and for planning its future development.

Moreover, it may be assumed that the need for this agreement and its inherent procedures will assume greater importance in the future as resource demands and environmental stresses increase. However, numerous problems have to be overcome before such an agreement on management of the aquifer can be reached.

In general, joint management of the aquifer as a whole, including water use in the overlying area, is likely to lead to the best results from the economic aspect. Any constraints (such as political ones) will either be inoperative or render the system less beneficial.

Active, ongoing communication at the technical level on such matters as measurement of flows, pumpage, and fluctuations in water levels and qualities are vital for fostering the trust, understanding and cooperation required for joint management.

There are also other issues or constraints—both political and technical—that have to be resolved in order to develop and protect the aquifer; these include the desire to exert sovereignty (a major factor in determining the allocation of water between the two parties), the boundary of the planning area, upstream versus downstream withdrawals, and joint development of the water resource. Another major factor determining resource management is the difference in the present and future state of economic development of the respective territories.

Assuming that the two parties are agreed as to the need for joint monitoring and management of the resource, an institutional framework could be set up. This may consist of an ad hoc group with limited decision-making powers restricted to specific issues, or it may be a permanent body. This framework must be vested with the powers and resources required for implementing project programmes, for monitoring and for defining the terms under which the parties are to operate.

Experience accumulated in the past with transboundary rivers indicates the effectiveness of delineating the programme area to encompass only the immediate problem, with its various hydrological, climatic, and withdrawal parameters as well as ancillary aspects. It is assumed that the institutional structure and procedures will provide the necessary inherent flexibility to deal with unforeseen problems. In this connection, it is most important that the institution responsible for the programme not be saddled with the need to deal with political or other non-technical issues.

1.2 National Boundaries and Water Management

The current approach to water management is based to a large extent on recognition of the integrity of the hydrological relationship within the relevant "drainage basin". In the case of a groundwater aquifer that extends beneath the territories of more than one political entity, and where both entities are desirous of sharing the aquifer, these entities should jointly formulate pumpage, storage, distribution, development and conservation programmes for the entire basin. Only such basin-wide programmes will enable optimal utilization of the aquifer.

The promise of greater benefits by maximizing economic returns is very likely to be moderated by the strong desire of each party to maintain control over its own destiny.

Joint planning and development require that each entity be flexible in exercising territorial sovereignty over the aquifer since the flow regime cannot be significantly changed, nor can either entity extract unlimited quantities of water with impunity. Here it should be stressed that water resources, whether surface water or groundwater, may be used by the upstream entity in a manner that will reduce flows to the downstream entity and even endanger its source of water.

Certain upstream activities may provide little or no direct or tangible benefits (and may even cause loss or damage to, and impose costs) on the downstream party. Incentives for cooperation may in some cases be the offer of payment or some other form of compensation. On the other hand, certain activities may, in many cases, benefit both parties and promote more efficient management of the aquifer. Both parties would in this case share the resulting costs proportionally.

1.3 Selecting the Programme Area

In the case under discussion, the groundwater aquifer and the area that contributes to it or is directly affected by it is the logical and optimal unit for technical and hydrological planning for integrated water resources development and monitoring. Moreover, certain beneficial activities—such as artificial recharge, cloud seeding, pollution prevention or integration with other water supply systems—can be carried out effectively only on a completely "aquifer-wide" basis.

In selecting the programme area, due consideration should be given to the interrelationship of surface water and groundwater through natural and artificial recharge and drainage, as well as to the potential accumulation of contaminants. Recognition of the costs and benefits to each party as a consequence of joint or independent management is an important first step in assessing each party's interests in joint management of the aquifer. It is proposed to investigate this issue as a follow-up to the present study.

The bipartisan alternative will provide a firm basis for cooperation only if both parties agree that this is the best option. Selection of the management course should take into account the hydrologic and economic incentives likely to stem from integrated development opportunities where a project implemented by an upstream party provides benefits to both the upstream and the downstream parties. Obviously, the basic incentive for cooperation is that each party will gain some net benefit.

Cooperation aimed at obtaining optimal utilization of the water resources of the aquifer is obviously a desirable goal. Optimum system development and optimum national development, however, are not necessarily compatible. Exploitation of water resources is likely to develop not only as a result of advances in technology, but more importantly, at a rate commensurate with population growth and the growth in urban water demand, socioeconomic developments, and the consequent reordering of each party's priorities.

Moreover, a major problem encountered in formulating an overall, integrated optimum water resource exploitation programme is that the planned development proposed by one party may be in advance of the economic and social requirements of the other party. This may result in an unnecessary cost or burden to the economy, as well as a significant "lock-in" effect, which may limit future economic and social development options. The approach may be well intentioned, but it may be unwise to build projects far in advance of actual need.

Water resources planning is a dynamic rather than a static concept. Many factors enter into the planning process: the time scale, the present and future economic environment, demographic considerations, political attitudes, institutional rigidities, and the changing pattern of the resource itself.

Water resources planning is a social necessity, since water is a limited and vital resource for the domestic, municipal, industrial and irrigation sectors. Moreover, supply variability often requires substantive measures in order to afford protection against pollution, drought and floods. The issue becomes doubly difficult for bipartisan water resources where more than one planning agency is involved, where two or more cultures and economic systems must be harmonized, or where two or more peoples are required to share a common perspective, often from quite different vantage points or points of origin, as upstream or downstream, less or more affluent, industrial or agricultural, etc. All these considerations must somehow be accommodated with differing sensitivities regarding sovereignty over that portion of the aquifer as well as differing viewpoints as to the shares that can be regarded as fair.

1.4 The General Approach

In what follows, aquifer monitoring requirements under normal conditions as well as in crisis situations (droughts and pollution) are outlined, taking into account the above-mentioned considerations.

- It is assumed that a joint institution will be set up to manage the aquifer either in its entirety, seeking an overall economic optimum, or—following a (political) allocation—with each party seeking its own optimum within an agreed-upon framework.
- It is recognized that in the foreseeable future (say, 20-30 years) most of the available fresh water will be required to meet the domestic water demand of both parties. Consequently, additional water will have to be supplied from other sources and demand management programmes applied. This scarcity of fresh water will have an immediate impact on the water supply distribution system, waste water reuse, pollution control, etc. Clearly, the development path must be considered, as well as the "ultimate" situation.
- It is assumed that full cooperation will be practiced based on mutual knowledge of the relevant data and information, joint control and agreed-upon standards and processes.

2. MONITORING

2.1 Data Collection and Fact Sharing

2.1.1 Introduction

Proper management of an aquifer depends on the collection, interpretation and evaluation of data. This is of particular significance for international water resources. Reluctance to provide hydrological data, as well as related data necessary for cooperative or joint planning, may frustrate even preliminary appraisals of the management potential of such systems. Not only must there be a simple sharing of the data but there must also be a readiness to submit for joint review the techniques and procedures used in their collection and primary analysis.

The better the data, the greater the potential for resolution of conflicts between opposing objectives and better management of the resource. Therefore, the first step to be taken in initiating a joint or cooperative plan of action for the utilization of shared water resources is to draw up an inventory of the hydroclimatic, land and other resources of the basin, as well as data for other socioeconomic factors—including water demands, demographic data and future growth trends and development plans.

The commitment of aquifer partners to share technical and economic information is essential. Technical, social, economic, legal and other pertinent data are the basic elements needed for each party's agency, or for any external agency involved with the project or programme, in order for the parties to be satisfied that the solution proposed is equitable and feasible. Moreover, such sharing should engender mutual trust and facilitate the process of joint planning. Without acceptance of this premise, there can be no true cooperation or collaboration; reluctance to share data may lead to a vicious circle of data denial, setting of contradictory priorities and policies (e.g., on pollution control), and other provocative outcomes.

2.1.2 Type and Scope of Data Collection

The physical data required consist of information on hydrology and climate, topography, cadastral survey, geology, soils, sedimentation and vegetation. The socioeconomic data required include basic statistics and projections on population and its distribution. income, employment and production (including agriculture, forestry, and manufacturing), water supply, pollution sources and public health. The first category deals solely with physical resources, while the second is concerned with society's activities in relation to these resources.

Water resources are fluid, dynamic and in constant flux, both quantity- and quality-wise. Hence, while appraisal of essentially static resources, such as land, forests or minerals, can be made, fairly accurately, at any point in time, water resources must be monitored continuously in order to provide a sound basis for their management. Groundwater flow assessments, for example, give the amount of water traversing a section of an aquifer at a particular time. Similarly, an inventory based on a single measurement is meaningless for such items as population distribution, income, employment and production. And the same is true of functional data relating to agriculture, forestry, industry, floods, water supply, pollution sources and special events or circumstances.

Cooperative data collection, sharing, and joint evaluation are essential to ensure that the parties to an agreement have confidence in the management of the programme. They need to agree that the data provides a sound basis for determining water availability, as well as for the purposes to be served by the management programme.

2.2 Required Hydrological and Hydrogeological Data and Information

Hydrological data, although only one of the many categories of data required, are the most essential for the formulation of water resource development projects and programmes. The principal data records required are those pertainaing to precipitation, evaporation, groundwater (levels and quality), surface water, soil moisture, water quality and sedimentation, and static and dynamic water tables.

The process of fact finding and evaluation has the significant merit of concentrating on the engineering, scientific, economic and environmental data involved. With agreement at the technical level by joint study teams appointed for the purpose, the progressive steps from the technical level to the policy/political and decision-making processes may be expected to become both more feasible and more acceptable.

2.2.1 Groundwater

The groundwater data collection system should be designed to furnish efficient and accurate monitoring of groundwater level fluctuations and provide advance warning against excessive drawdowns of water levels or increase in water heads, either of which may result in excessive losses of water through downstream springs.

A network of about 20-30 wells should be set up to serve as observation wells for joint control. The wells should be located so as to represent adequately the water levels in the aquifer at representative "strategic" points and enable periodic monitoring (monthly or quarterly) of water levels and water quality (mainly salinity profiles along the wells, as well as other pollution and age indicators like lithium).

The network of observation wells designed to represent the dynamics of the groundwater in space (including sub-aquifers) will provide warnings and indications as to groundwater reserves (or deficits). This network is likely to become the main management tool.

In addition, water level data from all pumping wells should be collected by the respective hydrological services. These will be processed, following an agreed procedure, into hydrographs and groundwater level maps. The maps may then be jointly reviewed and will provide the basis for development of a programme for aquifer management, backed up by period checking of the validity of the joint network of observation wells.

The data from all the pumping wells, which should be available for review, consist mainly of water levels and pumpage as well as data regarding salinity and other significant changes in quality (such as those caused by contaminants).

2.2.2 Other Water Outlets: Springs and Surface Runoff

Spring flows and runoff should be gauged continuously to enable the preparation of comprehensive water balances for the region (say, once every several years) and to enable correlation of hydrological and climatic phenomena. These measurements, too, must be carried out by the hydrological services of the two parties.

2.2.3 Potential Pollution Sources

In addition to the above-mentioned data, potential sources of pollution must be identified and monitored. These include oil storage facilities, polluting industries, and solid and hazardous waste disposal sites, landfills, sewage facilities and wastewater treatment plants.

2.2.4 Sewage Flows and Reclaimed Waste-waters

Reclaimed waste-water is both a source of water and a potential pollution hazard that requires joint monitoring. Control of this hazard requires information on sewage treatment plants (the level of treatment applied), waste-water storage facilities (their location, size and characteristics), and the quality of the treated plant effluents where these are used for irrigation (the areas and crops irrigated and the quantities applied) or for other purposes.

The data should also specify where and how much of the treated, and/or untreated effluents are used for purposes other than irrigation, are delivered to river courses and wadis, or are treated in septic tanks and disposed of through infiltration pits. Information is also required on industrial wastes and effluents (their volume, composition, in-plant treatment, if any, and disposal).

2.2.5 Water Use

Joint management requires that data be available on water use—by quantity and sector, normal and minimum requirements (see section 3 below, "Drought Management")—and on potential crises and their management. The data required, in general terms, are:

- *Domestic, industrial and agricultural use*—the present situation and the forecast for the future (by stages); demand distribution in space, time and quality (fresh water and sewage effluents); and volumes and rates of flow. Future projections should relate to the application of rigid demand management measures.
- *The distribution systems*—mainly the interconnections, backup possibilities and delivery potential in periods of crisis.
- *Data on newly constructed wells and wells that have* been shut down—their location, absolute levels, structure, and relevant hydrogeological data.

2.2.6 Required Tools

The institution of a comprehensive monitoring programme calls for the setting up of a computerized data base that will provide ongoing availability of all the data and information required. The detailed information fed to the data base will be collected and processed, in the main, by the respective hydrological services, with the exception of the data from the joint network of observation wells; a telemetric system is proposed for these data so that both parties would simultaneously receive the data.

The data base will be constantly updated by both parties. The updating and review can be performed jointly by coordinated use of telemetry, aerial photography and satellite data. The data base will necessitate use of compatible hardware and software and an open communication system at the technical level. Periodical (seasonal and annual) reviews and analyses should be carried out and published jointly.

Sounding, measuring and data processing should be carried out in accordance with agreed criteria, standards and equipment. In this respect, special attention should be paid to water quality analyses, both in situ and in laboratories. For the sake of compatibility, identical procedures and routines should be applied by both parties in the sampling, handling and analysis of samples. This will therefore require formulation of common regulations, training of personnel, and setting up of the necessary organization by both parties. Statistical samplings should be sent once a year to both laboratories to check compatibility.

3. DROUGHT MANAGEMENT

3.1 Introduction

The area overlying the Turonian-Cenomanian aquifer is prone to significant variations in annual precipitation rates due to its geographical location. The phenomenon of drought is well known to the region and should be taken into account in planning and management. Moreover, the water resources currently used in the region are being exploited to the maximum or beyond, and both parties may be inclined to pump excessive quantities from the aquifers before stringent demand limitations are imposed.

Given the demand forecast for the region, both parties will normally operate in a state of "near emergency" while supplying practically all the water required for domestic use. Thus the sensitivity of the system, as well as its vulnerability, is extremely high.

It should be noted here that drought is a "creeping phenomenon", since it often develops gradually. Prediction of the onset as well as the end of a drought is a difficult if not impossible task.

Although the occurrence of drought is a known phenomenon, its usually unpredictable nature and gradual development over time has often led to a lack of preparedness by national governments, water-use sectors and individuals. Governments often respond to drought through crisis management rather than through preplanned programmes (i.e., risk management) due to lack of an overall drought plan. Experience in Israel and elsewhere indicates that hastily prepared assessments and response procedures may lead to ineffective, poorly coordinated and untimely responses.

The effect of drought on the society can be very serious indeed, and it is of the utmost importance for all parties to formulate efficient drought and water management policies.

3.2 Main Characteristics of the Turonian-Cenomanian Aquifer

The Turonian-Cenomanian and Eocene limestone aquifers drain to the west (estimated flow: 300-320 MCM/year), to the east and south-east (estimated flow: 150-250 MCM/ year), and to the north-east (estimated flow: 150 MCM/ year). The main and known outlets are the Yarkon and Taninim springs, the Bet Shea'n springs, and 'En Feshcha and other prings along the eastern section.

The most important and problematic section of the aquifer is the Yarkon-Taninim sub-aquifer, which is in contact with sea water and/or other extremely saline or brackish water bodies. Saline and/or brackish water is also found in other parts of the aquifer, requiring a stringent pumpage regime. The eastern sub-aquifer is less utilized than the others, and less date is available on it, thereby requiring additional work and studies.

The following discussion relates therefore to the Yarkon-Taninim section of the aquifer. Under natural conditions—i.e., before the commencement of widespread drilling and intensive pumping in the early 1950s, the western catchment of the Yarkon-Taninim aquifer discharged through two springs—the Yarkon and the Taninim. These springs rose in the past from the confined section of the aquifer and together had an average flow of about 300-320 MCM/year of high-quality water. This prompted the British Mandate authorities to construct a large water-supply project delivering water from the springs to Jerusalem.

As a result of the intensive pumpage from the aquifer, water levels dropped and spring flows declined. Flows to the sea also declined; outflows from the Yarkon spring ceased almost entirely, while discharges from the Taninim springs fell to less than 50 percent of their historic annual flow.

Outflows from the Yarkon springs were fresh, whereas some of the outflows of the Taninim were brackish; nevertheless, all the water pumped from all these sections of the aquifer are potable. In view of the clear evidence of saline water bodies in close proximity to the fresh-water body close to the production wells, the Israeli authorities instituted a water management policy aimed at preventing a considerable drop in fresh-water levels in the vicinity of the Taninim springs, which still yield on average about 40 MCM/year. In the early 1960s, the Israel Water Commission established a criterion which stated that water levels in the Menashe 1 observaion well, which is located immediately to the northwest of the main pumpage area of the Taninim aquifer, should not fall below +9.00 m. The pumpage regime in this part of the aquifer was set so as to ensure that this water level was maintained at all times to ensure against penetration of brackish water into the sensitive karstic aquifer.

In 1985 an additional observation well, Menashe 3, was drilled. This well lies between the Menashe 1 observation well and the outflow area of the Taninim springs. It was found that the aquiferous strata of the Menashe 3 observation well, with a water level several hundred meters beneath the ground level, contains brackish water. The water level and the location of this well support the wisdom of the earlier decision regarding the permissible minimum water level in the Menashe 1 observation well.

On the basis of the experience accumulated in Israel from the follow-up of pumpage regimes, the pattern of groundwater levels, and the existence and movement of the saline water body (mainly in the northwest section), hydrogeologists are generally agreed that water levels in the Yarkon section of the aquifer should be maintained at a higher level than those maintained in the Taninim section. It is considered that fresh water will continue to flow northward in the aquifer and that if there is any intrusion of brackish water to the peripheral flow areas, these too will flow north to the Taninim section and be discharged there. The main use of the springs is for environmental and fishpond purposes, where salinity levels are much more flexible.

Water levels in the areas of pumpage from the Yarkon-Taninim aquifer rise in the winter months by about 0.5 m in a dry year to 5 m in a wet year, with an average rise of about 3.5 m. The lowest water levels are generally recorded in early September, following on the end of the intensive pumpage season for irrigation. The highest water levels are generally found in April or May in a wet year and in March or even in February in a dry year. Aquifer flows and the months in which maximum and minimum water levels occur are dependent on two main factors: rainfall and pumpage—both quantity- and time-wise.

Operation of the Yarkon-Taninim aquifer is not constrained by any maximum water level, but the loss of water increases in direct and continuous relationship with actual water levels. Outflows from the Taninim springs at the presently accepted pumpage levels increase by about 6 MCM/year with each 1 m rise in the average annual water level. "Loss" of water from this aquifer is considered to begin when outflows are higher than the pumpage allocated to consumers, together with the outflow required for nature and landscape conservation purposes (though this conservation requirement has not been formally defined). The Yarkon springs (which dried up many years ago) renew their flows when water levels at the location of the springs (the Rosh Ha'Ayin area) are above 15 m; but there are apparently active outflows even at lower water levels. The aquifer may serve, to some extent, as a storage reservoir for water pumped from Lake Kinneret, as long as its levels near the Yarkon area are below the dam crest.

In view of the fact that water losses from the Yarkon-Taninim aquifer increase moderately with the rise in water levels, and that the available storage capacity is small in relation to the expected volume of spill from Lake Kinneret, it was realized that operation of the Yarkon-Taninim aquifer for supply to the National Water System should be determined conjunctively with the operating regime of Lake Kinneret if and when economically justified, whereas the coastal aquifer of Israel is operated at lower priority.

3.3 Defining Drought

When dealing with matters of drought policy and water management, it is important to have an objective definition of drought in a given situation. Lack of specific, comprehensive and integrated criteria for dealing with drought situations may lead to indecision and inaction by managers and policymakers.

There are many definitions of drought. For all practical purposes, it seems clear that a universal definition is neither helpful nor warranted because every region has its own unique physical and socioeconomic make-up—i.e., the definition of drought is location-specific. Drought criteria, therefore, should have specific local significance and purpose. Drought solutions and the impact of drought differ significantly as between, for example, point source supply for drinking purposes and interconnected multi-source supply for domestic use and irrigation.

In general, it seems useful to distinguish between meteorological, agricultural, hydrological and socioeconomic aspects of the drought phenomenon. On the other hand, these different aspects of drought cannot be studied in isolation. As a basis for the development of drought policy, the above-mentioned aspects of drought must be studied in an interrelated and integrative manner.

The possible influence of human behavior on the occurrence of drought and its severity has been discussed by many authors. Drought may result if in the economic development of a region, man creates a demand for more water than is normally available. This very aspect of water management seems to deserve further study in relation to the current water shortage situation in our region. The impact of drought must be seen as dynamic, basically the result of interactions between supply and demand. The relationship between the supply of water, which can be expressed in physical as well as in organizational terms and the demand for water (socioeconomic criteria) is clearly not static and may vary considerably with time. The economic benefits of water and the potential trade-offs play an important role in each situation.

In the case at hand, the parties differ in almost every aspect relevant to the impact, and therefore the definition, of drought, and drought management such as the socioeconomic context and the possibility of linking up with another water supply system (and consequently, backing up its storage capacity potential) differ.

Hence the definition of a drought may differ for the portion of the aquifer underlying Israel from that underlying the West Bank. Moreover, this definition may or may not fit the situation over the aquifer as a whole, depending on how it will be managed. In Israel, a drought situation will be declared in a certain region, if and when it is not possible to supply water according to allocations from the aquifer itself or from a local backup system (e.g., another aquifer or the National Water Carrier). The storage in the aquifer may be enhanced by recharge in order to serve in what may be considered climatic droughts. But such a definition may not fit the West Bank if operated independently.

For the limestone aquifer, the definition of drought depends on the form of management to be chosen, the relations between the two sections of it, and its relation as a whole to other water supply systems. In any case, the definition of an emergency situation will have to be based on hydrological and other indicators from both parts of the aquifer.

A meteorological drought may be defined by the extent to which the shortfall in total rainfall exceeds a predetermined value (say the standard deviation), and/or there is a significant delay in the occurrence of rainfall and/or there is poor distribution of the rains in time and space. As far as non-irrigated agriculture is concerned, all the above-mentioned possibilities are likely to lead to an emergency situation. However, marketing mechanisms could always use other interconnected basins and aquifers as an alternative source paid for by the party concerned.

Delayed rains should activate the first warning lights so that certain adequate agrotechnical activities may be undertaken or avoided altogether (e.g., supplementary irrigation, cancellation of seeding).

Supplementary irrigation is possible only if adequate water reserves and the necessary water distribution systems exist. In the case at hand, significant irrigation with fresh water will be possible only during the transition period leading to the full domestic use of the available waters.

For irrigated agriculture (during the transition period) and domestic and industrial use, the definition of drought may also be connected with meteorological drought. However, rainfall is relevant in this case both for its direct impact and as source routed through the aquifer.

Consequently, the availability of water will depend on antecedent conditions, such as storage built up in previous years, previous shortage of water in the aquifer (and related adverse effects), as well as the probability for rehabilitation during future wet years—a policy with built-in risks.

In Israel, several meteorological droughts passed virtually unnoticed or barely noticed because of the "dampening effect" of the groundwater reserves and the unique national system, which has three interconnected basins with flexible management systems using each as the basis for actual storage quality and risk taking.

Socioeconomically speaking, the population depending on the mountain aquifer, as well as the demand per capita,[1] is bound to grow. The constant "near emergency" state is bound to create a very high sensitivity to drought due to lack of water reserves and a very high level of vulnerability. In Israel, as in other countries, first priority is given to domestic demand, with industry second and agriculture third.

Consequently, with the first signs of an apparent drought (late rains or rains well below the average for the corresponding period) irrigators are warned of possible restrictions; subsequently, the warning may be removed or imposed more stringently. Serious droughts may bring about a reduction in irrigation allocations and appeals to save domestic-urban water; and extreme droughts may bring about actual restrictions in industrial and domestic-urban use.

Thus the present agricultural use serves as a buffer that cushions the drought effects for the other sectors, as well as being the potential trade-off partner for treated sewage effluent.

Once all the fresh water has been consumed domestically the agricultural buffer will no longer exist, resulting in greater vulnerability of the system. However, as domestic demand grows, so does the availability of treated sewage effluents.

Good management of a drought calls for coordinated efforts to curb the demand, together with groundwater management. Clearly a drought and its management cannot be formulated "mathematically", even when the institutional setup is known. Drought management calls for a continuing process of consideration by experts, authorities and the public, based on extensive data and information, and the authority to impose the necessary measures.

3.4 Drought Management Policy

Given the inability to forecast aquifer replenishment accurately, drought management becomes unavoidably a programme of risk-cost assessment action (or inaction) that might be taken to increase supply or reduce demand. In the case of the aquifer under discussion, the likely courses of action are:

- *Pumping reserves*, if and when they exist (estimated maximum volume: twice the annual safe yield). However, during consecutive droughts this option is not likely to exist. Since 1948 there were about 4-6 droughts in

[1] The issue of the reasonable demand per capita subject to the implementation of a rigid demand management policy and wide-scale investments should be the topic of a seperate study.

which this reserve was not available, not taking into account other years in which reserves were almost non-existent.

- *Purchase of water from adjacent water supply systems.* A "market mechanism" could play an important role here and serve as a major component in joint management in general.
- *Resort to less costly alternatives*—a range of voluntary and mandatory water conservation measures aimed at reducing system demand. These measures, however, will involve both direct costs (e.g., incentives, public investment and information programmes to encourage conservation, and compensation instruments for revenue loss from reduction in water sales) and indirect costs (most of which are difficult to quantify, such as the aesthetic effects of reduced irrigation in gardens and parks, shutting off of public fountains, and possibly inherent long-term damage to the landscape). Most costs can be avoided by gambling on the return of normal conditions, with the risk that more drastic (and costly) measures may be required if rainfall is delayed for a longer period.

The "do nothing" strategy in the case at hand may cause irreversible damage to the aquifer due to saline water encroachment and the consequent reduction in the safe yield.

With an increase in drought severity, water conservation targets will have to be made more stringent and mandatory restrictions on outdoor water use implemented. Such a strategy has been implemented in California, Israel and other countries.

Principal policy features concerning drought and water management may be grouped in three categories: organization, response and evaluation.

- *Organizational* features consist of planning activities that provide timely and reliable assessments, such as early drought warning systems and procedures for a coordinated and efficient response, such as pre- and drought declarations.
- *Response* features include assistance measures and associated administrative procedures to assist individual citizens or businesses experiencing economic and physical hardship because of drought; incentives, market mechanisms, and enforced water limitations are integrated into the response strategy.
- *Evaluation* features consist of assessment of the organizational procedures and drought assistance measures in the post-drought recovery period.

3.5 The Role of Demand Management and Water Conservation[2]

Water shortages are possible even in the most carefully planned and constructed water supply systems; and shortages are possible, despite multi-basin interconnections and options to purchase and transfer water.

Because demand management can be used to produce a significant decrease in water use level, it can reduce the vulnerability of a water supply system to meteorological and/or hydrological drought. Another aspect of demand management is that it can minimize the disruption and cost associated with water shortage. An orderly programme of voluntary and mandatory reductions in water use can progressively allocate more water to the most important uses while maintaining the integrity of the distribution system (protecting it from de-pressurization and resultant contamination). Demand management strategy is relevant to all sectors: domestic, commercial, industrial and irrigation. Only a comprehensive implementation policy which includes full cost recovery and progressive rates as well as wide-scale installation of water-saving techniques, will lead to a significant drop in water demand.

Water use has implications for water quality in at least two ways.

1. Excessive withdrawal of quantities of water from the aquifer may affect the quality of the remaining water, as in the case of withdrawal in the vicinity of brackish, saline or contaminated sections of the aquifer.
2. As more households, firms, farms, and other entities use additional water, larger quantities of water will be produced and disposed of. If the water is not properly treated and reused, or discharged adequately, it will sooner or later cause pollution and deterioration of the resource, with a high-risk situation, especially in karstic formations.

Since the two types of potential water quality deterioration worsen with increasing water use, improvement will follow the implementation of a demand management strategy.

[2] May also be phrased as "increased water use efficiency".

4. POTENTIAL POLLUTION CRISES AND THEIR IMPLICATIONS

4.1 Introduction

The following is a brief general discussion of the potential pollution crisis and its implications. The section is limited to treatment of the aquifer and to issues of well pollution. The discussion is not related to the implications of pollution on the water supply network, such as the need for backup connections and means to face shortages due to contamination.

4.2 Pollution Sources and Infiltration of Groundwater Aquifers

The potential point sources of groundwater pollution are infiltration from septic tanks, cesspools, pit latrines and other sanitation facilities; breakage and subsequent leakage from sewage systems; infiltration from waste-water ponds/storage and from irrigation with treated and/or untreated waste water; seepage from treatment plants; leachates from solid concentrations and disposal sites; leachates from pesticides and fertilizers; leakages or spills from oil and fuel installations, gasoline stations, fuel tankers, storage tanks for toxic materials, animal sheds, etc.

Non-point sources are mainly related to irrigation and agricultural cultivation, herbicides, insecticides and fertilizers, as well as other human and industrial activities.

Contaminated water, originating from all of the above and other sources, unavoidably reach the aquifer. Even small amounts of some of the contaminants may endanger the aquifer due to their toxicity. Significant and dangerous amounts may reach the groundwater due to inadequate planning, lack of awareness of environmental aspects, and failures in construction and operation.

As discussed below, certain pollutants—namely, microbial ones—may decay and die off if exposed to the atmosphere or detained for a sufficiently long period in the ground; others may to some extent be temporarily adsorbed by the soil or the rock formation. The contaminants may also be significantly diluted in the aquifer if there is a long enough time (or path) before they reach a withdrawal point. Hence the sensitivity of potable water supply depends on the rate of infiltration of contaminants to the groundwater, and the path they have to move through before reaching the wells or springs.

The limestone aquifer is highly sensitive, especially in its higher, mountainous part. The main reasons for this sensitivity are the lack of deep overlying soil cover over most of it; the karstic, fractured, unsaturated zone, which fosters high infiltration rates and low filtration rates; and the karstic nature of the aquiferous formation, which allows high rates of groundwater flows that may lead to a short detention time and path connecting the source to a point of use.

This is the most sensitive part of the aquifer (although other parts are also vulnerable) and it is bound to experience dramatic changes, with population growth and increasing per capita consumption and economic activity. Consequently, massive increases in the volumes of sewage water and industrial and other wastes may be expected.

Lack of adequate infrastructure to meet these expanding situations and a newly-founded institutional setup may lead to severe, even critical, pollution events in the next few years.

4.3 Microbial Pollution

4.3.1 The Range of Microbial Pollutant Hazards

The estimate of pollution hazards for specific wells is based on, among other things, defining the hazard range of microbial pollutants under given hydrogeological conditions. Estimate of this range is based on ensuring a sufficient period of detention to enable the decay or die-off of pathogenic pollutants in the soil or in the ground. The estimates cited in what follows are based on the German Standard, which specifies a minimum detention period of 50 days. In this period, bacteria as well as most viruses die off.

At present, there are some 870 wells pumping from the Turonian-Cenomanian limestone aquifer, of which some 550 supply potable water.

The degree of vulnerability of a well to a nearby pollution source is determined by, amongst other things, the lithological characteristics of the section from the soil horizon down to the aquifer. Accordingly, production wells may be classified according to three principal criteria as follows:

1. A direct hydraulic contact between the soil surface and the aquifer.
2. Different variants of the indirect hydraulic connections.
3. Wells with an overlying watertight soil structure or a suitable technical structure, which do not allow the passage of pollutants from the soil surface to the aquifer in periods of time shorter than 50 days.

On the basis available lithological data, it appears that of the existing wells in the aquifer, some 170 wells (31%) are well protected against pollutant intrusion, as against 240 wells (44%) that have been classified as having almost direct contact between the soil surface and the aquifer. The remaining wells (25%) have an indirect hydraulic connection.

From theoretical analysis, based on mathematical models, and on the basis of field experience (preliminary survey), it was found that the safety range required for limestone formations varies from a few hundred meters in areas where the aquifer is overlain by a deep clay top soil to about 2 km in areas where the aquifer is exposed, mainly in upstream sections of the aquifer. It appears that the depth of the unsaturated section in limestone strata has little significance with regard to the security range.

4.3.2 Preventive Measures

Clearly, by far the best way to deal with contamination of the aquifer is to prevent its occurrence. The most important preventive measures are:

- Optimum disposal means—i.e., adequate sewage collection, treatment and disposal (and, where possible, reuse of adequately treated sewage and other waste waters for irrigation purposes for certain crops), with waste-water treatment systems forming an integral part of all urban and rural water supply plans.
- Pre-treatment of industrial wastes by each individual industry to the level acceptable for its collection and disposal through the public sewage system or reuse.
- Suitable siting of industries, industrial parks, and other potential pollutant sources, as well as proper design of their sewage systems, treatment plants, and storage and disposal facilities; establishing the required provisions to prevent, and take the necessary steps in the event of, accidental contamination (leakages and spills).
- Provision of adequate safety zones around water withdrawal points.
- Setting up of adequate on-line monitoring systems to detect potential problems, using automatic analysers of indicative elements.
- Establishment of an ongoing programme of tests, experiments, and studies in order to constantly improve the preventive programme.
- Setting up of an organization to supervise the implementation of pollution control measures, able to act swiftly in the event of accidents. The joint management agency or mechanisms could well serve this objective.

4.3.3 Corrective Measures

The corrective measures to be taken in the event of pollution incidents, should these occur, will generally be as follows (this listing does not necessarily imply the order of their importance or implementation):

- Pinpointing the exact location of the pollution source. In some cases this may in itself be a complex and costly operation.
- Warning the public and advising on emergency means to be und(e.g., boiling all water for drinking or related purposes).
- Provision of an alternative supply source (pre-design and interconnection is usually essential).
- Disinfection of the water withdrawn, of the supply system, and of the wells (chlorination facilities to be at hand).

A detailed plan should be drawn up for all potential contingencies and the necessary means provided for its implementation (instrumentation, manpower training, monitoring and control systems). However, not all of the above-mentioned means (and/or others) may always be necessary.

Treating a pollution event is always likely to be difficult to handle and may cause disease (morbidity and mortality) and involve loss of water (due to the need to flush the system), as well as being costly.

4.4 Spillage or Leakage of Oil and Oil Products

The sources of potential fuel contamination are either of an ongoing nature, including leakages from oil installations (tanks, gasoline stations, and pipelines), or of an accidental nature (spills from tankers, pipeline failures, etc.). The potential damage from fuels reaching the aquifer is enormous. Theoretically, one cubic meter of heavy oil or fuel, for example, will render 200 x 106 MCM of potable water unfit for consumption (according to EPA or WHO standards).

Clay layers (or heavy soil), which may arrest or delay infiltration of various contaminants, such as raw sewage, to the groundwater body do not have similar retarding effects on the downward flow of fuels. Clearing fuels that reach the groundwater—if this is at all possible in karstic formations—may require the wasting of large amounts of water, may delay the delivery of potable water from the contaminated well (or wells) for a considerable period of time, and is likely to be very costly.

Cleaning of an unsaturated zone, where some fuel is likely to remain, may prove to be an even more complex and long drawn out process, extending possibly over several years.

4.4.1 Preventive Measures

Leakage of fuels, or related products, into the ground appears to be unavoidable. The objective should be to reduce leakage as much as possible and facilitate dilution of the substances to an acceptable concentration before they reach the water supply source or system.

The most important preventive measures are:

- Appropriate siting of potential contamination sources: far enough from wells and/or springs, and overlying deep heavy top soils (see "Corrective measures" below).
- Provision of adequate safety measures at fuel storage facilities (special "beddings"), pipelines (materials, installation and testing gas stations), and industrial plants; and automatic control transmission, in real-time, of flow inputs and outputs.
- Setting up monitoring facilities to detect leakages and spills at all oil storage and handling sites. The importance of quick detection of oil leaks or spills cannot be overemphasised. Quick response, such as removal of contaminated soil before deeper infiltration takes place, may save a lot of money and trouble.
- Availability of trained personnel, materials and equipment.

Since potential oil contaminators may be situated far from wells or springs, the leakage—even a large volume leakage—may go undetected for some time.

In this context, it should be borne in mind that in limestone formations observation wells for detecting such leakages, as well as for other monitoring purposes, are extremely expensive, especially where the depth is great, as is the case in most of the Turonian-Cenomanian aquifer.

To minimize the need for observation wells for the detection of leakage of oils or other contaminants, other monitoring means should also be used, such as shallow boreholes (where an adequate topsoil exists) and maintaining accurate oil balances in pipelines and tank storage facilities by ongoing, accurate metering and real-time control and transmissions to a control room equipped with a computer and printed reports.

4.4.2 Corrective Measures

The following corrective actions will generally be taken in the event of oil leakages and spills:

- Pinpointing the exact location of the pollution source.
- Removal of the contaminated top soil before deeper infiltration occurs.
- Warning the authorities and the public and issuing advice as to the cautionary measures to be taken.
- Provision of an alternative supply source.

- If the pollution reaches a well, it may be advisable to pump continuously in order to contain the pollution within the cone of depression of the well (or well field), if this is hydrologically feasible. This may involve a considerable loss of water as well as energy and will require the installation of provisional pipelines to deliver the water to suitable disposal sites—which do not overlie a fresh-water aquifer. This would be a very extreme and costly measure.
- Undertaking the cleaning—flushing of the unsaturated zone, which is a very costly and lengthy operation and may take several years.

Specific and suitable regulations should be issued or laws enacted, and a well-equipped and trained organization set up, empowered to enforce the regulations or laws and to carry out the necessary control measures and responses to calls, accidents and other hazards.

4.5 Other Sources of Contamination

Other contaminants that may infiltrate to the aquifer are the leachates from solid storage and disposal sites; animal manures; fertilizers, pesticides and other chemicals used in agriculture; and chemicals used in industry.

The means to combat pollution from these sources are similar to those described in the preceding subsection.

High priority should be given to preventive measures, such as use of environmentally friendly products, efficient irrigation (reducing deep percolation losses of leachates), maintaining adequate distances of potential contaminant sources from water bodies and wells, appropriate siting of disposal plants, and adequate treatment of sewage discharged to public sewage systems.

It should be noted that a deep, heavy topsoil is one of the desirable properties for the siting of potentially contaminating activities. However, since such locations are also the obvious sites for agricultural use, a conflict may exist between agricultural sector interests and demands for the appropriate location of potential polluters, such as industrial parks.

5. CONCLUDING REMARKS

Following the increase in urban and other populated areas, an increase in per capita water consumption, and the increase in economic activities, it is expected that sewage quantities and the number of treatment plants and water reservoirs will increase. Consequently, the number of wells likely to be polluted will also rise considerably, mainly in those areas not well protected from the penetration of pollutants as a result of the properties of their geological section.

Data on the incidence of pollution events indicate that these estimates are far from being hypothetical. In the last 10 years, some 900 exceptional pollution events were recorded.

Partial data available from the Ministry of Health of Israel point to a higher incidence of pollution in private wells than in those wells operated by Mekorot. These were mainly local pollution events, and the consumers mainly affected were those supplied with water from wells within the immediate vicinity of the polluted wells. A source of pollution close to a well also endangers other wells, since the pollution may affect further downstream and also put those wells too out of operation.

Monitoring for the purpose of warning of pollution events in a karstic aquifer is in itself costly because of the expense involved in drilling into rocks to the required depth. Hence, stringent prevention measures and local monitoring systems are required, especially when potential pollution areas are located over exposed limestone.

Chapter 7

Legal and Administrative Responsibility of Domestic Water Supply to the Palestinians

Taher Nassereddin
Palestine Consultancy Group and West Bank Water Department Ramallah, P.O. Box 19622, Jerusalem

1. INTRODUCTION

The most important aim of the Palestinians in the Palestinian Territories is to have sufficient water to assure their economic and social development both now and in the future. The Israelis currently control the domestic water supply to the Palestinians, particularly in the West Bank. They supply 26.92 MCM yearly to the Palestinians in the West Bank, while the Palestinians themselves supply their Palestinian customers with 15.7 MCM yearly. The Israelis supply to the Palestinians at a percentage of 63% out of the total water consumption in the West Bank. This high percentage comes as a result of denying Palestinians the right to drill new groundwater wells. Controls are exerted firmly on the Palestinian population and few permits are issued while rapid development of water resources takes place to supply the needs of the Israeli settlers. The Israeli Mekorot Water Company has been given the very important role of drilling new wells in the Palestinian Territories in order to sell the domestic water to the Palestinians.

2. PALESTINIAN WATER SUPPLY AND CONSUMPTION IN PALESTINIAN TERRITORIES

The natural water resources in the Palestinian Territories are very limited; future population growth will place severe demands on an already weak reserve. The scarcity of water resources is creating a major constraint on economic development. This scarcity has occurred as a result of the Israeli occupation in the last 29 years which prohibited the Palestinians from drilling new wells in the West Bank.

The total Palestinian water supply in the year 1996 as shown in Table 1 is 246 MCM. The water supply is either from wells and springs or from the Israeli Mekorot Company. As shown in the table the supply from wells is 172.7 MCM, from springs 56 MCM and from Mekorot 17.3 MCM. The water consumption of the West Bank is 178 MCM while in the Gaza Strip is 123, the total being 301 MCM for the year 1996. As we can see from Table1, water consumption by Israelis is approximately 55 MCM for the year 1996. Israeli settlements on the West Bank consume 45 MCM, pumped from 43 wells drilled by the Israelis over the last 29 years. We can see that the percentage of the Israeli consumption within the Palestinian Territories is high, more than 22% of the total consumption of the Palestinians.

Table 1. Summary of Water Supply and Consumption in Palestine 1996

Location	Water supply MCM/a				Water consumption MCM/a			
	Wells	Springs	Mekorot	Total	Dom.& Ind.	Agri.	Isr. Sett.	Total
West Bank	64.7	56	12.3	133.0	44.2	88.8	45	178
Gaza	108	---	5	113	48	65	10	123
Palestine [(1)]	**172.7**	**56**	**17.3**	**246**	**92.2**	**153.8**	**55**	**301**

[(1)] The West Bank and Gaza.

Table 2. Water Abstraction from Wells in the West Bank

Purpose of Water Use	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Domestic	14.45	17.56	19.46	21.39	21.39	23.44	23.05	22.64	25.25	27.87	29.70	30.80
Agricultural	34.31	28.28	32.82	36.15	35.09	37.70	34.10	31.46	36.31	36.92	36.80	33.9
Total	48.76	45.84	52.23	57.54	56.48	61.14	57.15	54.10	61.56	64.79	66.50	64.7

Note: These figures exclude domestic consumption from inside Israel.

It can be seen in Table 2 that consumption by the Palestinians on the West Bank over the years 1978-1996 for agricultural purposes is nearly constant, as a result of the prohibition for drilling new agricultural wells in the area. Over the same time period we see that consumption for domestic purposes has increased as a result of population growth and that there were no severe restrictions on drilling new wells for those purposes.

The water supply of the Palestinian population is from groundwater, which is derived from four basins: western, eastern, northeastern and coastal basins.

2.1 The Western Basin

This area includes the whole western side of the central anticline west of the main hydrological water divide line which flows toward the Mediterranean Sea. This basin has an estimated mean average safe yield of about 362 MCM/year (Oslo 2 Agreement); the Palestinians are using 25 MCM/year while the Israelis are using the rest.

2.2 The Eastern Basin

This includes the whole eastern side of the central anticline, east of the main hydrological water divide line which flows eastward toward the Dead Sea and the Jordan Valley. The safe yield of this basin is around 172 MCM (Oslo 2 Agreement).

This basin is drained through several springs located on the western edge of the Jordan Valley such as Auga spring (12 MCM/year), Samayah wells (2 MCM), Fashkha springs (50 MCM) and other springs.

2.3 The Northeastern Basin

This area is located in the large syncline of the north central part of Nablus mountains. The basin's total yield is around 140 MCM, draining toward the Israeli territories, especially to the Beit Shean area. The safe yield of this basin is around 145 MCM/year (Oslo 2 Agreement); the Palestinians are using 23 MCM and the rest is used by the Israelis.

2.4 The Coastal Basin

This basin is a part of the basin area located on the coastal basin of Israel. It has been severely overpumped for many years by the people of Gaza, resulting in a serious lowering of the groundwater table, in many years to a point below sea level. This has led to the intrusion of the saline water from various sources. In addition the Israelis have established a number of agricultural settlements in the Gaza Strip and drilled several new wells which extract 4 MCM/year from the already overexploited coastal basin.

Israel, both before and after 1967, has drilled several wells in the catchment area of the coastal aquifer inside Israel and along the border of the Gaza Strip. The abstraction from these wells reduced the groundwater flow towards the Gaza Strip.

The current situation in the Palestinian Authority areas is very adverse because of the dire water shortage in the West Bank, particularly during the summer months. But the situation in the Gaza Strip differs from the situation in the West Bank. The water used for drinking and agricultural purposes in Gaza is very saline, reaching in some areas over 1500 PPM. The adverse situation in the West Bank is noticed in the cities of Bethlehem, Hebron and Jenin. These cities do not get continuous supply; some parts of these cities do not get water for two to three weeks at a time.

3. THE MAIN DOMESTIC WATER SUPPLIERS IN THE WEST BANK

There are three main domestic water suppliers in the West Bank: the Israeli Mekorot Company, the Municipality of Jerusalem and the Palestinian municipal village councils and water utilities of the West Bank. The Mekorot Company supplies the Palestinians from two sources: The first is from inside Israel supplying approximately 11.1 MCM/year; the second is from the West Bank, supplying 14.6 MCM/year as shown in Table 3.

The areas supplied from the first source are Jerusalem Water Undertaking, six villages west of Ramallah, four villages west of Yabad, Salfit and 1.7 MCM to the internal net of Hebron. The areas supplied from the second source are Hebron, Bethlehem, Halhul + Beit Fajjar + Beit Omar, four refugee camps and 91 villages. The Municipality of Jerusalem supplies 1.02 MCM/year to Al-Azareyah, Abu Dees, Sawahreh, Anata and Attoune. The Palestinian municipalities of the West Bank are supplied 15.7 MCM/year, which in turn supply the rest of the West Bank, including the larger cities of Nablus, Tulkarm, Qalqilya, Jenin, etc.

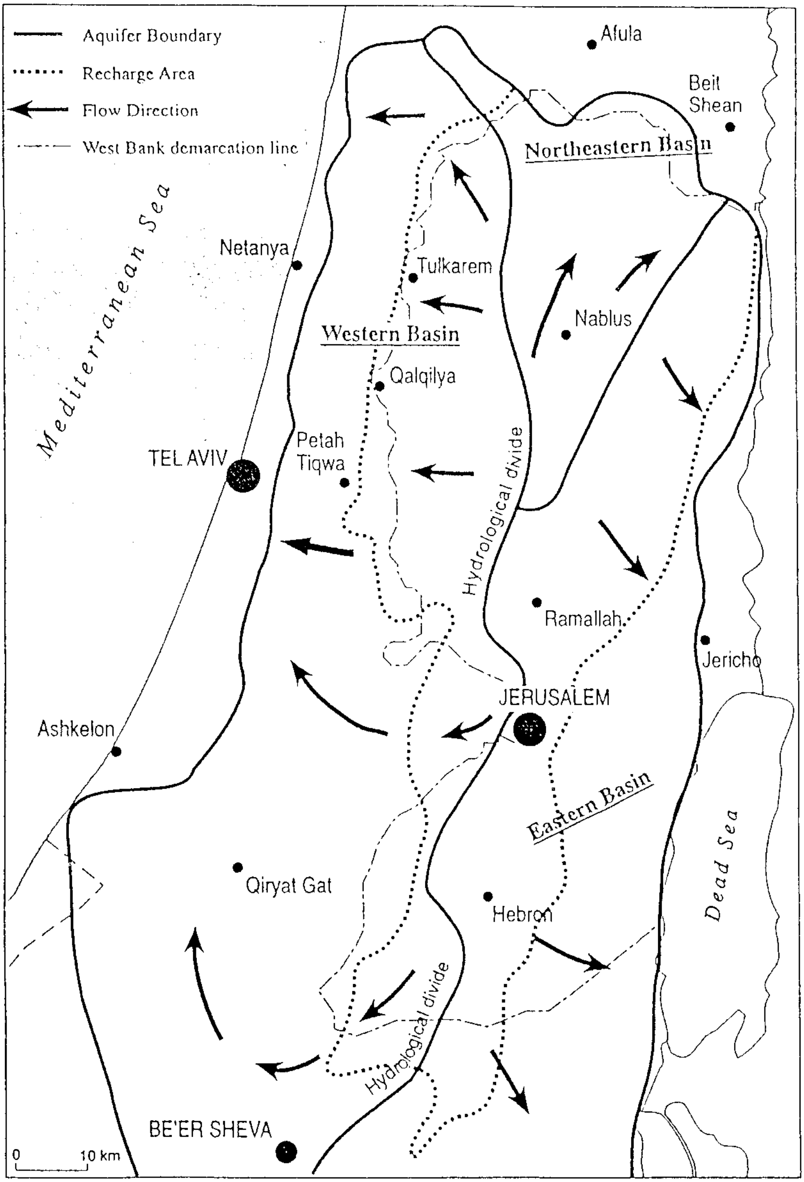


Figure 1. The Western, Northern, Northeastern and Eastern Basins of the Mountain Aquifer
Source: Adapted from Gvirtzman (1994)

4. DISTRIBUTION OF WATER SUPPLYING IN THE WEST BANK BY POPULATION AND NUMBER OF LOCATIONS

The population of the West Bank according to the Palestinian Statistics Department is comprised of 1,571,575 persons; 1,378,061 persons are supplied with water while 2,935,514 persons are not supplied as in Table 4. As of the 508 villages in the West Bank, 329 villages are supplied and 179 villages are not. The villages which are not supplied receive water by tanks or from cisterns which are filled with rain water.

Thirty-five percent of the localities in the West Bank are not served (Figure 2).

5. CONCLUSIONS

Most of the Palestinian population is supplied through the Mekorot Company or through Municipality of Jerusalem. This indicates that the Palestinians have not enough sources to supply themselves.

Table 3. The Main Domestic Water Suppliers to the Palestinians in the West Bank

Suppliers	Location of Sources	Quantities MCM	Areas Supplied
Mekorot	Inside Israel	11.1	Jerusalem Water Undertaking + 6 villages west of Ramallah + 4 villages west of Yabad + Salfit + 1.7 MCM to the internal net of Hebron
Mekorot	West Bank	14.6	Hebron + Bethlehem + Halhul + Beit Fajjar + Beit Omar+ 4 refugee camps + 91 villages
Municipality of Jerusalem	West Bank	1.02	Al-Azareyah + Abu Dees + + Anata + Sur Bahir (Attoune)
Municipalities and Village Councils of the West Bank	West Bank	15.7	Municipality of Nablus + Tulkarm + Jenin + Anabta + Tubas + Qalqilya + all municipalities and villages not supplied by Mekorot and Municipality of Jerusalem

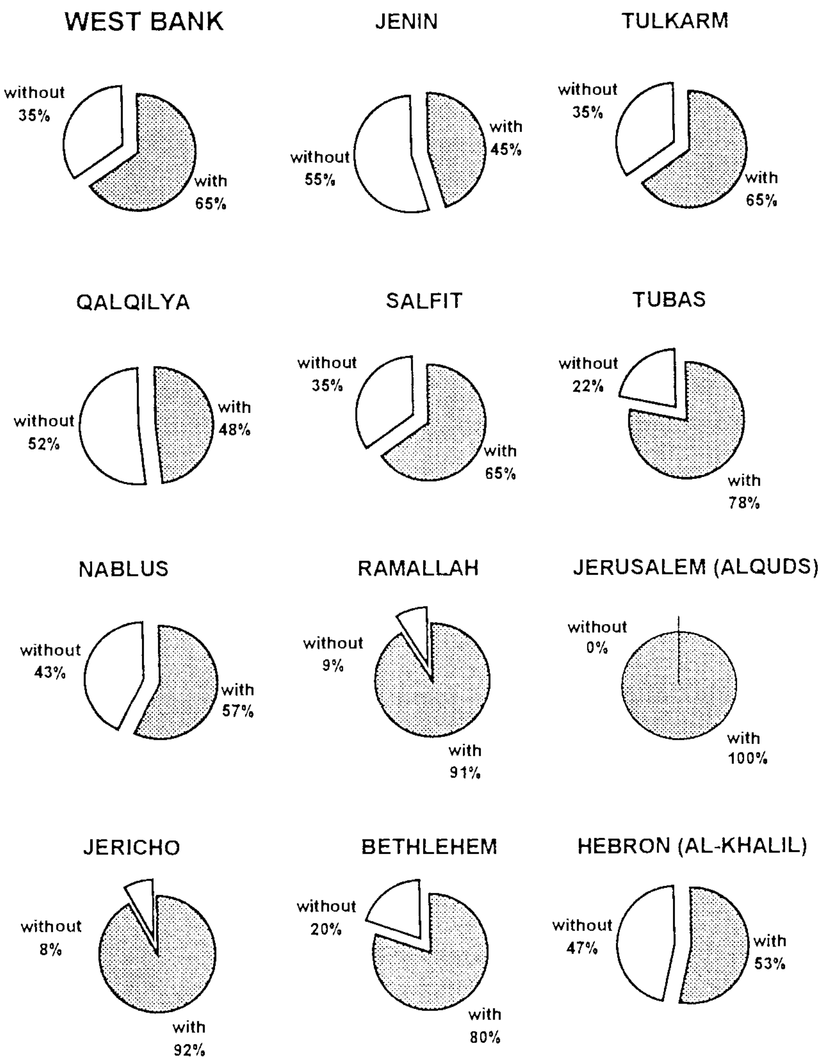


Figure 2. PWA / WBWD Communities with/ without Water Supply in the West Bank 1/1997

Table 4. Distribution of Water Supply in the West Bank by Population and Number of Localities Served

District	Population Served			Number of Villages Served		
	Served	Unserved	Total	Served	Unserved	Total
Jenin	112.923	65.247	178.170	34	41	75
Tulkarm	86.452	23.858	110.310	15	23	38
Qalqilya	50.497	14.891	65.388	16	17	33
Salfit	33.100	11.174	44.274	14	7	21
Tubas	22.578	8.931	31.509	7	2	9
Nablus	178.137	139.798	217.935	32	24	56
Ramallah	225.873	8.517	234.390	85	8	93
Jerusalem	254.387	0	254.387	23	0	23
Jerico	27.599	484	28.083	12	1	13
Bethlehem	110.430	2.583	113.013	40	10	50
Hebron	276.085	18.031	294.116	51	46	97
Total	**1,378,061**	**293,514**	**1,571,575**	**329**	**179**	**508**

Prepared by West Bank Water Department – Planning Division.

Thereby it is recommended that the wells in the West Bank currently controlled by the Israelis be handed over to the Palestinians and more wells should be gradually drilled in the area to replace water supply from inside Israel. The wells to be drilled should cover the water needs of the population of the Palestinian people on the West Bank.

The new wells should be drilled in the eastern, western and the northeastern basins. It is also recommended that the Palestinians should rehabilitate their current internal water nets in all the areas and control all leakages and illegal connections.

SOURCES

Gvirtzman H. (1994). Ground Water Allocation in Judea and Samaria, in: J. Isaac and H. Shuval (eds.), Water and Peace in the Middle East, Elsevier, 1994.

Oslo 2 Agreement. Agreement dated September 18, 1995, between the Palestinian National Authority and Government of Israel.

Palestinian Department of Statistics, 1996.

Water and Environment Studies Center. An-Najah National University. 1996. Middle East regional study on water supply and Demand Development.

West Bank Water Department. Open files of the West Bank Water Department.

Chapter 8

Israeli-Palestinian Bargaining over the Mountain Aquifer

Sinaia Netanyahu, Richard E. Just & John K. Horowitz
Ben-Gurion University of the Negev, Beer-Sheva, Israel
University of Maryland, College Park, USA[1]

This chapter presents a simulation of a bargaining game that models coordination of water policy between Israel and the Palestinian Authority over the Mountain Aquifer (MA). Because data availability for modeling the Israeli-Palestinian bargaining problem is limited, the simulation examines a broad range of economic circumstances that define the bargaining environment. That is, the effects of variations in these circumstances on the essential bargaining problem is examined from a game theoretic perspective. In particular, the sensitivity of the Nash bargaining solution (NBS) is examined with respect to (1) demand elasticities, (2) pumping costs, (3) pumping externalities (intercountry extraction costs), (4) user costs, (5) side-payments, (6) reservation utilities, and (7) initial resource allocation.

1. MOTIVATION

The Oslo Peace Agreement, which outlines the transfer of administrative authority to the Palestinians, will necessitate cooperation in the use of the

[1] This research was supported in part by Grant 58-319R-4-046 from the Research and Scientific Exchange Division, Foreign Agricultural Service, United States Department of Agriculture and in part by the Bi-national Agricultural Research and Development Fund, BARD Grant No. US-2637-95R. However, the views expressed herein are solely those of the authors and should not be construed to represent those of the USDA, agencies therein, or BARD.

MA. Ideally, the multi-dimensional nature of water sharing considerations should be addressed.

To explore the application of bargaining theory to the MA cooperation problem, note that the eastern and western parts of the MA are hydrologically disconnected basins. Thus, the implications of sharing and pumping in the Yarkon-Taninim (YT) Basin can be studied independently from over-pumping and leakage among the seven sub-aquifers of the Eastern Mountain (EM) Basin. This chapter focuses on this latter problem.

The springs in the Israeli YT Basin are gravity fed from rainfall accumulated in the higher Palestinian part of the aquifer. Water can be pumped in the lower elevations at less cost than at higher elevations. In the higher elevations where Palestinian water supplies are pumped, extraction can be quite costly and these costs are an increasing function of the amount pumped in the entire basin. In other words, pumping costs increase as the amount of water remaining in the aquifer decreases. These are the central concerns in the bargaining problem.

Unlike the problem of solving for economic efficiency, the outcomes of bargaining depend on initial allocations, reservation utilities, and whether side payments are considered. For example, according to the Coase theorem (1960), initial allocation should not alter efficient use of resources if contracts are enforceable and bargaining cost is negligible. Nevertheless, the results of this chapter show that initial allocations are important because of the implications they have for reservation utilities.

The level of the reservation utility determines the utility level below which a rational player is not willing to cooperate. The smaller are bargainers' reservation utilities, the larger is the potential set of individually rational outcomes. For example, Figure 1 compares the set of individually rational payoffs of type 1 players who have low reservation utilities to the set of individually rational payoffs of type 2 players who have high reservation utilities. Clearly, type 1 players have an individually rational set (area $o_1a_1b_1$) larger than that of type 2 players (area $o_2a_2b_2$).

Also, the greater the reservation utility asymmetry between players, the greater is the inequality of outcomes. For example, Figure 2 compares the individually rational set for players in Scenario 1 where Player I (Israel) has a low reservation utility to the individually rational set for players in Scenario 2 where Player I has a high reservation utility. Increasing Player I's reservation utility results in (1) a smaller individually rational set ($o_2a_2b_1$ instead of $o_1a_1b_1$) and (2) a reduced frontier (a_2b_1 instead of a_1b_1) which possibly produces an outcome more favorable to Player I than to Player PA (the Palestinian Authority) relative to the frontier in Scenario 1.

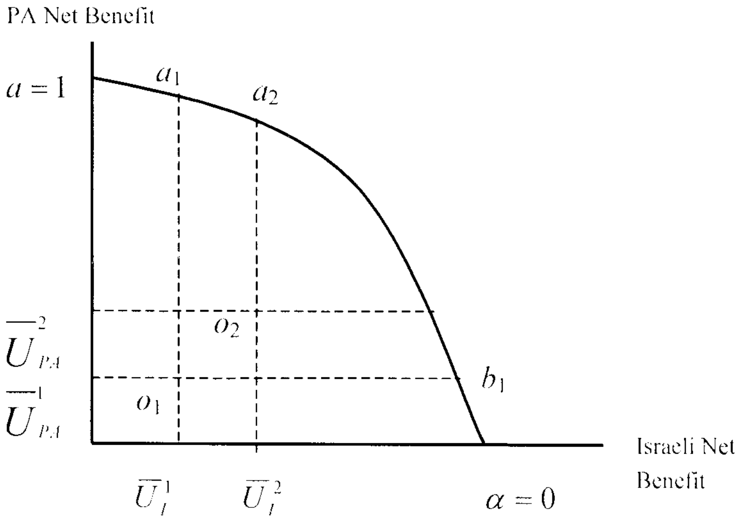


Figure 1. The Effect of Reservation Utilities on the Feasible Set

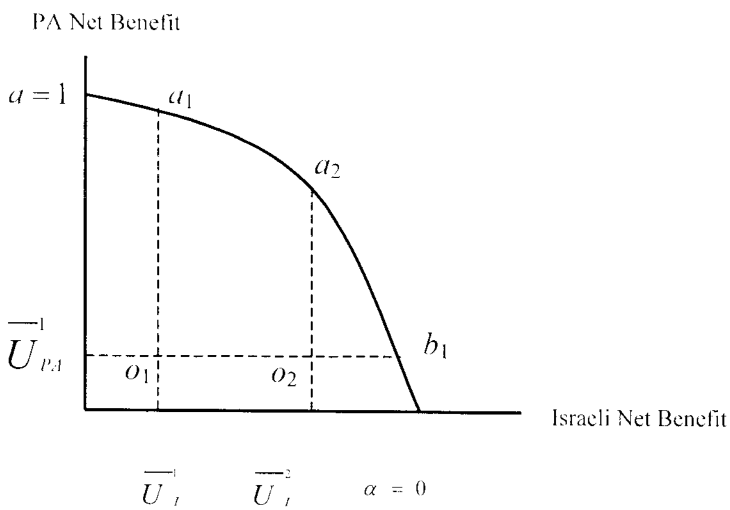


Figure 2. The Effect of Reservation Utility Asymmetry on Feasible Set Inequality

In spite of widely differing reservation utilities, however, side payments can have dramatic effects on equity. Many have suggested that cooperation can be achieved with a side payment (e.g., Markusen 1975). Side payments can be granted by the victim according to the "victim pays" principle. However, side payments by the victim are associated with the reputation of a weak bargainer (Maler 1990). Side payments can also be offered by the exploiting party as a bribe to gain agreement with continuing resource allocation at the status quo level. One objective of the simulation model in this paper is to examine the implications of introducing side payments in the Israeli-Palestinian water problem.

The remainder of this chapter presents the simulation model and then reports the results of the simulation.

2. THE MODEL

In this section, a Nash bargaining framework is developed to demonstrate potential gains from cooperation. Well-known results from game theory show that the only bargaining solution that satisfies particular standard and reasonable assumptions is the Nash bargaining solution (Nash 1953).[2] The Nash bargaining solution maximizes $[u_i - \bar{u}_i][u_p - \bar{u}_p]$ with respect to the variables over which bargaining occurs where u_i and u_p are the utilities or benefits achieved for the respective parties (i denotes Israelis and p denotes Palestinians) and $\bar{u}_i$ and $\bar{u}_p$ are reservation utilities below which the respective parties prefer no agreement. The payoffs of the reservation outcome reflect the status quo.[3]

Parameters of the game are fitted to observed data where data are available. Because of lacking data, other parameters are set at assumed levels based on available information or judgement and then sensitivity analysis is performed. The results identify which parameters are crucial in determining gains from cooperation and, thus, those on which further empirical work should focus. The parameters of the game are defined as follows. To represent the cost of extracting water from the aquifer, suppose the short-run marginal cost of Palestinian pumping follows a linear function of the quantity pumped and that the extraction cost reflecting the effect of Israeli pumping on

2 These axioms require that the parties are rational, treated symmetrically, and that the result be independent of irrelevant alternatives and unaffected by linear transformations of each parties preferences.

3 Over-pumping has adverse long-run consequences on future pumping possibilities. Therefore, countries' long run utilities in the absence of cooperation may be substantially less than the utility they would get if cooperation leads to appropriate consideration of user costs.

Palestinian marginal cost is proportional to Israeli use. Thus, Palestinian short-run marginal cost follows $\alpha_p + \beta_p(q_p + \theta q_i)$ where the intercountry extraction cost is $\beta_p \theta q_i$.

This Palestinian cost function can represent the substantially increasing marginal cost found by Isaac et al. (1994) where pumping at 20 million cubic meters per year (mcm/yr) costs \$.16 per cubic meter (cm) but pumping at 135 mcm/yr incurs a cost of \$.34 per cm. The parameters α_p and β_p are determined proportional to the values that reflect these two cost-quantity pairs when Israeli pumping is held at its current level of 362 mcm/yr.[4] While the spillover coefficient θ that determines intercountry extraction cost is not known, a value of .2 seems reasonable for illustrative purposes (an additional unit of Israeli pumping raises Palestinian pumping cost 20 percent as much as Palestinian pumping raises Palestinian pumping cost). Sensitivity results then investigate changes in the assumption on θ.

For Israelis, a constant short-run pumping cost of \$.15 per cm is assumed because this is a realistic current pumping cost and Palestinian pumping apparently has little effect on water availability at the lower-elevation YT springs, at least at historical levels of Palestinian pumping. For both parties, however, a user cost is considered that occurs if the present level of pumping beyond the maximum sustainable yield (MSY) continues. This user cost for party j is assumed to follow

$$UC_j = \frac{p_j(q_i + q_p)q_j}{rS}$$

where p_j is pumping cost for player j, r is the real interest rate, and S is total aquifer capacity. This user cost is an approximation based on the assumption that future pumping levels follow the steady-state amount (see Burt 1964 and Feinerman and Knapp 1983). Because the real-world user cost is unknown and because at least part of the user cost should be the same for both players, the term $p_j/(rS)$ is converted to a common parameter c_f, which is estimated by solving for the user cost that, if internalized, drives aggregate pumping down from the current level of 382 mcm/yr to the maximum sustainable yield of 350 mcm/yr (at equilibria determined from demands specified below). Because the aquifer water supply is renewable as long as the maximum sustainable yield is not exceeded (otherwise sea water encroachment causes irreversible damage), the maximum sustainable yield is used to represent the maximum economic yield.

[4] The parameters that actually fit Isaac's data are inflated by 50 percent because his data apply only to total pumping from one subaquifer. The resulting current marginal pumping cost for Palestinians is \$.24 per cm.

Integrating the current marginal cost functions including extraction cost and then adding the user cost obtains the Palestinian social cost function,

$$c_p(q_p, q_i) = \alpha_p q_p + \beta_p(q_p^2/2 + \theta q_p q_i) + c_f(q_i + q_p)q_p,$$

and the Israeli social cost function,

$$c_i(q_i, q_p) = \alpha_i q_i + c_f(q_i + q_p)q_i.$$

Fitted parameters of the cost functions are α_p = .023 and β_p = .0023 for Palestinians, and α_i = .15 for Israelis. The fitted value of the user cost parameter is c_f = .007.

To represent utility of the two parties, linear demands of the form

$$p_j = \gamma_j - \delta_j Q_j,\ j = i, p$$

are assumed where p_j represents the marginal value of water and Q_j represents total water consumption from all sources including YT water. The associated benefits of water consumption (consumer surpluses) are

$$b_j(Q_j) = \gamma_j Q_j - \delta_j Q_j^2/2,\ j = i, p.$$

The parameters of demand are fitted to observed YT water use data, Q_i = 362 mcm/yr and Q_p = 20 mcm/yr, and marginal values of water as determined by marginal costs specified above at observed water use levels. Actual water prices paid by both Israelis and Palestinians are higher but differences are presumably explained by transportation costs, implicit taxes imposed on household use in municipalities, etc. The parameters of (1) are determined by fitting elasticities at current use levels to a weighted average of elasticities reported by Fisher (1994) for agricultural, industrial, and domestic demands. The resulting elasticity of demand is .407 for Israel and .440 for Palestinians. The fitted parameters are γ_i = .519, δ_i = .000211, γ_p = .785, and δ_p = .00420.

With these specifications, Palestinian and Israeli consumer benefits less the cost of pumping from the aquifer are given by

$$u_p = b_p(Q_p) - c_p(q_p, q_i)$$

$$u_i = b_i(Q_i) - c_i(q_i, q_p),$$

respectively. These net benefits ignore the cost of supplying non-aquifer water, Q_p - q_p, but such costs are largely overhead costs and are, in any case, unaffected by bargaining over aquifer water. To consider bargaining to determine the quantities used by each party, Israeli and Palestinian reservation utilities are represented by the status quo,

$$\bar{u}_i = b_i(\hat{Q}_i) - c(\hat{q}_i, \hat{q}_p),$$

$$\bar{u}_p = b_p(\hat{Q}_p) - c(\hat{q}_p, \hat{q}_i),$$

where $\hat{Q}_i$ = 1745 mcm/yr, $\hat{q}_i$ = 362 mcm/yr, $\hat{Q}_p$ = 130 mcm/yr, and $\hat{q}_p$ = 20 mcm/yr. Note that the cost functions considered in the reservation utilities do not include the user cost. Thus, as observed in the status quo, the parties do not restrict their aggregate water extraction to the MSY.

3. SIMULATION RESULTS

Using these reservation utilities, the Nash bargaining solution is for Palestinians to pump 20.3 mcm/yr and for Israelis to pump 329.7 mcm/yr (Table 1, Case 1). The resulting marginal cost for water extracted by Palestinians is \$0.225 per cm. This solution entails an 8.4 percent reduction in total water use (from 382 mcm/yr to 350 mcm/yr). Palestinian use increases by 1.5 percent while Israeli use decreases by 8.9 percent from the current non-cooperative outcome.

These results raise the question of why Israel would be willing to participate in an agreement that so seriously reduces its water use from the YT Basin. One answer lies in user cost savings that could not be realized if water use continues to exceed the maximum sustainable yield. The major saving from cooperation is that overall use levels are brought into line with sustainable yield so that adverse future consequences of over-pumping are avoided. From a short-term perspective, Palestinians appear to be the major benefactor of cooperation because their pumping costs are otherwise higher with over-pumping. However, overall use by the Palestinians is low compared to Israelis regardless of bargaining. Because Israelis are the large user, they benefit much more from reducing the user cost that would occur if over-pumping continues and damages the aquifer.

To evaluate the sensitivity of results to assumed parameter values, Table 1 presents the effects of changing values of assumed parameters. To understand the implications of Table 1, it is important to understand that the model is calibrated to fit actual observed data with the specified parameter values in each of the 15 experiments before simulating the bargaining outcome. That is, the observed equilibrium is reinterpreted in each case with the particular parameter values of the case. This explains, for example, why an increase in Israeli pumping cost causes an increase in Israeli water allocation.

As an example, Figure 3 shows the case where the observed equilibrium has Israel using water quantity Q_I and the Palestinians using water quantity Q_P. With this "observed" data, the demand for water can be inferred from pumping cost by noting that marginal value is equal to marginal cost at equilibrium. That is, with a given pumping cost, the demand must be equal to the pumping cost at the observed quantity. Thus, a given demand elasticity or slope will imply a demand represented by D_I if the Israeli pumping cost is \$.15 per cm but a higher demand D_I^* if the pumping cost is \$.30 per cm. Similarly, where the Palestinian demand is shown originating from the right-hand axis, a Palestinian quantity of Q_P and a Palestinian pumping cost of, say, \$.25 per cm is sufficient to infer a Palestinian demand such as D_P based on a given demand elasticity.

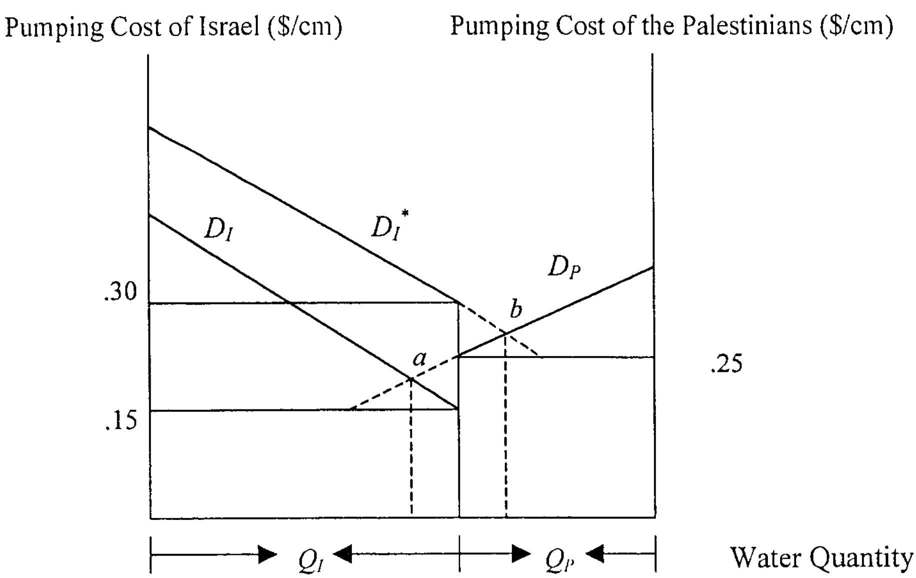


Figure 3. Model calibration

Now consider simulating the bargaining outcome. Considering for illustrative purposes the case where side payments are introduced and pumped quantities cannot be changed, the bargaining outcome will have the same consumption quantities as maximizing the sum of consumer surpluses. With cooperation, consumption would then be chosen to equate the marginal values of Israel and Palestinian consumption, i.e., by setting consumption where the respective demands cross. Thus, when Israeli pumping cost is lower than Palestinian pumping cost, Israeli consumption is decreased from the non-cooperative case to point *a*. With an increase in Israeli pumping cost beyond the Palestinian pumping cost, the consumption allocated to Israel with cooperation is increased above the non-cooperative outcome to point *b* because the inferred marginal valuation of water by Israel is higher. The fact that the parameters of the underlying economy, e.g., the levels of demand, are not observed but rather must be inferred by the parameter values in each case thus explains why the effects in Table 1 may seem counter intuitive compared to the typical case.

3.1 Outcomes With No Side-Payments

Table 1 shows that water quantities in the Nash bargaining solution are highly robust to changes in assumed parameters. Comparison of Cases 1 and 2 of Table 1 shows that water allocation is not highly sensitive to changes in the assumed Israeli demand elasticity. A higher elasticity implies that Israelis lose less by reducing consumption so slightly more consumption is given up. A higher elasticity implies a lower reservation utility because the consumer surplus triangle becomes flat and thin. According to the Nash bargaining solution, Israelis thus capture less of the benefits from bargaining. On the other hand, a higher Palestinian demand elasticity as in Case 3 increases the Palestinian water quantity because relatively more surplus is gained by increasing quantity above the initial point.

Sensitivity analysis of the results with respect to the assumed current pumping costs are represented in Cases 4 and 5. If the Israeli pumping cost is actually twice as high as the assumed $.15 per cm, then it exceeds the Palestinian cost. At demand equilibrium, the pumping costs represent the marginal value of water for the respective parties. Thus, if the Israeli marginal value exceeds the Palestinian marginal value, then there is a benefit from transferring consumption to Israel. Accordingly, this case, which is the only one where Israeli cost exceeds Palestinian cost, is the only case where Palestinian pumping declines from the present use of 20 mcm/yr. Note also that the Israeli reservation utility is quite high in this case because the inferred demand for water is greater if the observed consumption is based on a higher marginal value.

Table 1. Alternative Nash Bargaining Solutions for Israeli-Palestinian Sharing of the Yarkon-Taninnim Basin[1]

	Demand Elasticity		Average Pumping Cost		Short-Run Spillover Coefficient	Future User Cost	Use		Marginal Cost	Utility		Gain		Payment
	(I) ($/cm)	(P) ($/cm)	(I) ($/cm)	(P) ($/cm)			(I) (mcm/yr)	(P) (mcm/yr)	($/cm)	(I) ($)	(P) ($)	(I) ($)	(P) ($)	(I to P) ($/cm)
1.	.407	.440	.150	.202	.2	.0070	329.7	20.3	.225	12.38	1.16	.126	.318	0
2.	814	.440	.150	.202	.2	.0036	329.2	20.8	.226	6.18	1.23	.063	.322	0
3.	.407	.880	.150	.202	.2	.0072	329.5	20.5	.226	12.35	0.74	.129	.321	0
4.	407	.440	.300	.201	.2	.0136	330.8	19.2	.224	24.86	1.02	.249	.315	0
5.	407	.440	.150	.404	.2	.0071	329.2	20.8	.453	12.36	2.47	.126	.644	0
6.	.407	.440	.150	.187	.4	.0076	328.3	21.7	.212	12.26	1.15	.135	.681	0
7.	.407	.440	.150	.202	.2	.0141	329.0	21.0	.227	10.92	1.01	.357	.334	0
8.	.407	.440	.150	.203	.2	.0070	328.0	22.0	.229	12.38	1.16	.226	.226	-.056
9.	.407	.440	.300	.201	.2	.0136	330.2	19.8	.225	24.86	1.02	.282	.282	.206
10.	.407	.440	.150	.203	.2	.0070	327.5	22.5	.230	11.76	1.10	.730	.398	0
11.	.407	.440	.150	.204	.2	.0070	327.0	23.0	.231	0.00	0.00	11.5	1.50	0
12.	.407	.440	.150	.201	.2	.0070	331.1	18.9	.223	12.4	0.93	.134	.522	0
13.	.407	.440	.150	.204	.2	.0070	327.0	23.0	.231	9.91	1.16	2.58	.342	0
14.	.406	.440	.150	.373	.2	-.0350	141.4	208.6	.559	-23.1	113.	31.1	2.40	0
15.	.406	.440	.150	.248	.2	.0072	290.4	59.6	.0318	9.77	11.8	.132	.927	0

[1] Note that (I) denotes Israel and (P) denotes the Palestinians. Case 1 is based on the current use pattern in the YT Basin with the exception that the MSY constraint of 350 mcm/yr is considered. Other cases make changes from this base case. Case 2 increases the Israeli demand elasticity. Case 3 increases the Palestinian demand elasticity. Case 4 increases the cost of Israeli pumping. Case 5 increases the cost of Palestinian pumping. Case 6 increases the intercountry extraction cost coefficient. Case 7 increases the user cost. Cases 8 and 9 generalize cooperation by allowing a side payment for pumping YT water. Cases 10 and 11 consider noncooperative game theory results that correspond to reducing reservation utilities proportionally by 5 percent and 100 percent, respectively. Cases 12 and 13 incorporate the asymmetric impacts of Israeli impatience and Palestinian risk aversion on the applicable reservation utility by lowering first the Palestinian reservation utility (Case 12) and then the Israeli reservation utility (Case 13) by 20 percent relative to Case 1. Case 14 changes the initial allocation to an equal 50-50 sharing and Case 15 allocates initial water use to the Palestinians at a level three times higher than it actually is.

In Case 5, the assumed current Palestinian pumping cost function is doubled which causes more water consumption to be transferred to the Palestinians in accord with the higher valuation of water implied thereby (from the current observed equilibrium). Accordingly, the estimated Palestinian reservation utility is roughly doubled. The higher reservation utility permits the Palestinians to gain relatively more.

In Case 6, the spillover effect of Israeli pumping on Palestinian cost is doubled. As expected, the cooperative effect is to reduce Israeli pumping because it has a higher extraction cost externality. Palestinian pumping climbs to 8.5 percent above the status quo. The Palestinian surplus gain in this case is high even though the reservation utility is low because of the strength of the high user cost with cooperation.

Case 7 roughly doubles the user cost. The effect of this change comparing to Case 1 is to penalize Israel relatively more because it carries the bulk of the responsibility for contributing to user cost, i.e., because about 95 percent of current pumping from the aquifer is by Israelis.

3.1 Outcomes With Side-Payments

The next two cases introduce the possibility of side payments into the bargaining solution. That is, bargaining can occur not only with respect to how much each party should pump but also with respect to whether one party should pay the other for the right to increase use from the current status quo. Case 8 introduces this possibility into Case 1. Because pumping costs and the implied marginal valuation of water is higher for Palestinians, they are willing to pay Israel for the right to increase pumping ($.056 per cm). Accordingly, this case obtains the highest Palestinian use—a full 10 percent above the status quo—with Israeli pumping 9.4 percent below the status quo. On the other hand, if Israeli pumping cost is higher than Palestinian pumping cost as in Case 4, then cooperation entails Israelis paying Palestinians as much as $.206 per cm to reduce Palestinian use below the status quo. This is Case 9. Interestingly, introducing a side-payment results in each party receiving the same magnitude of gain from Nash bargaining (a typical result in Nash bargaining).

In general, the total utility outcome (reservation utility plus surplus gain) for Israelis is quite stable with respect to parameters that affect Palestinians directly and total Palestinian utility is quite stable with respect to parameters that affect Israelis directly. Overall, Israeli gains from cooperation amount to only about 1 percent of initial surplus except in Cases 7 and 8 where gains reach 3.3 and 1.8 percent, respectively. Israelis gain relatively more in Case 7 because they capture most of the gains from a greater reduction in user costs by the fact that they use more water from the aquifer. Overall, Palestinian gains from cooperation amount to more absolutely (in most cases) and relatively. Their gains range from a minimum of 19 percent of initial surplus (Case 8) to as much as 59 percent of initial surplus (Case 6). In many cases, their gains are around 26-28 percent. A property of the Nash bargaining solution that leads to this outcome is that Palestinian welfare can be raised relatively easier than Israeli welfare because of the sheer magnitude of initial use and welfare received by Israelis.

3.2 Reservation Utilities: Implications of Risk Preferences and Impatience

To this point, the cases considered in Table 1 correspond to the standard NBS. Alternatively, the NBS can be used to represent the outcomes of strategic bargaining where the reservation utilities are modified appropriately. To consider the potential implications of risk preferences and impatience for the Israeli-Palestinian MA problem, suppose countries have symmetric preferences with respect to time and risk. Then the strategic bargaining outcome can be represented by the NBS where the reservation utilities are reduced proportionally. For example, the proportional reduction drives both reservation utilities to zero as discounting becomes extreme or the ratio between the probability of breakdown to the delay in making an offer goes to zero (see Netanyahu et al, 1998).

Cases 10, 11, 12, and 13 of Table 1 illustrate the implications of such variation in the reservation utilities. The base case (Case 1) assumes implicitly that players are risk averse (the discount factor is one) and therefore the logarithm of the discount factor, r, approaches zero. Compared to Case 1 of Table 1, Case 10 reduces both reservation utilities by 5 percent. The result is a further Israeli transfer of water to Palestinians. If both reservation utilities are decreased to zero, even further reallocation from Israel to the Palestinians occurs (see Case 11). This is the case where the highest level of water transfer takes place from Israel to the Palestinians. This outcome of high water transfer corresponds to the case where the ratio between the probability of breakdown of negotiations and the delay in making an offer, δ, approaches zero—perhaps an unlikely scenario. In contrast, as noted earlier, great patience can be modeled by imposing no discounting (a unit discount factor) which results in the outcome under Case 1.

The reason that water transfer increases in the case where reservation utilities decrease (i.e., where the probability of breakdown decreases relative to the delay) is that the size of the pie over which negotiation is occurring increases. When the pie is enlarged by equal proportions of current Israeli and Palestinian use, relatively more of it comes from current Israeli use because current Israeli use is much greater than current Palestinian use. Thus, the tendency of the Nash solution to equate incremental benefits causes a greater transfer to Palestinians.

In contrast to these cases of symmetric risk preferences and patience, Cases 12 and 13 incorporate the asymmetric impacts of Israeli impatience and Palestinian risk aversion on the reservation utilities directly without changing other parameters in the model. Case 12 simulates a scenario where the impact of the Palestinian attitude toward risk is larger than the impact of Israeli impatience. If the impact of Israeli patience on the reservation utility is less than that of Palestinian risk aversion, then the applicable Palestinian reservation utility is lower. This assumption leaves the outcome less advantageous for the Palestinians. Specifically, reducing the Palestinian reservation utility by 20 percent relative to Case 1 lowers the Palestinian water allocation by 6.9 percent. In this case, the Palestinians forgo a water use of 1.4 mcm/yr for holding high risk aversion preferences.

Case 13 simulates a scenario where the impact of Israeli impatience on the outcome is greater than the impact of Palestinian attitudes toward risk. If Palestinians are risk neutral and Israelis are impatient, then the applicable Israeli reservation utility is lower. The outcome is less advantageous for Israel. Specifically, reducing the Israeli reservation utility by 20 percent relative to Case 1 lowers the Israeli water allocation by .82 percent but increases the Palestinian water allocation by 14.73 percent. An impatient Israel is willing to transfer water in the amount of 2.99 mcm/yr to the PA as compensation for reaching an immediate agreement.

3.3 Initial Allocation of Water Resources

Case 14 of Table 1 changes initial water allocation to an equal 50-50 sharing. Given the specification of this model, an initial equal sharing is clearly unattainable by a Nash bargaining solution because it implies a negative reservation utility for Israel. However, it is of some interest in assessing the dramatic difference between a purely equitable outcome and an individually rational outcome. In other words, the difference between Case 1 and Case 14 suggests the extent of conflict that is likely to be encountered in negotiations.

Finally, Case 15 considers an initial water use from the western aquifer by the Palestinians three times higher than the actual status quo (i.e., an increase from 20 mcm/yr to 60 mcm/yr). This increase in initial allocation corresponds to what researchers believe is necessary in the short run for the PA to supply adequate quantities of water to the Palestinian population. The purpose of this case is to compare the negotiated outcome under Nash bargaining to arguments that can be advanced on the basis of need. The outcome of this simulation suggests that such an initial allocation for the Palestinians would cause Israel to bear virtually all of the quantity reduction in moving toward sustainable management. That is, Palestinian use would drop only from its initial allocation of 60 mcm/yr to 59.6 mcm/yr while all the remaining reduction would come from Israeli use.

4. CONCLUSION

Overall, the solutions in Table 1 are remarkably insensitive to assumed parameters. Except for the latter two unrealistic cases, water use for Israelis does not vary more than 1 percent among all cases while Palestinian use varies by less than 15 percent even though parameters are doubled. While reservation utilities and final utilities are sensitive to some of the parameters, the water allocations are not. Thus, by and large, the implications of Nash bargaining are relatively clear even though data are sparse.

In further reflection, it is important to keep in perspective the contribution of game theory to understanding shared aquifer problems. Problems of shared aquifers are not limited to efficiency considerations (i.e., economic efficiency given ecological constraints). Equity is also an important issue. The modeling approach of this chapter does not attempt to solve the problem of allocation of water rights. Instead, it assists in analyzing the sensitivity of a bargaining model to economic parameters. While results show that the impact of such parameters on the scheme of water allocation is robust, it is equally important to note that gains from cooperation remain highly inequitable.

Highly inequitable bargaining outcomes have low political feasibility. Alternatively, introducing side payments to the model yields an equal distribution of surplus gains between the parties. While adding side payments attains full equality of absolute gains from bargaining, such an outcome may be politically unacceptable if countries have highly unequal stakes in the water resource.

REFERENCES

Burt, O.R. 1964. Optimal Resource Use over Time with an Application to Ground Water. *Management Science* 11: 80-93.

Coase, R.H. 1960. The Problem of Social Cost. *Journal of Law and Economics* 3:1-44.

Feinerman, E. and K.C. Knapp. 1983. Benefits from Groundwater Management:Magnitude, Sensitivity, and Distribution. *American Journal of Agricultural* Economics 65: 704-710.

Fisher, F.M. 1994. The Harvard Middle East Water Project: Model Overview and Results So Far. Harvard University.

Isaac, J., O. Youssef, M. Ja'fari, I. Shawwa, J.R. Deshazo, and R. Newell. 1994. Water Supply and Demand in Palestine: 1990 Baseline Estimates and Projections for 2000, 2010, and 2020. Prepared for the Harvard Middle East Water Project, Harvard University.

Maler, K.-G. 1990. International Environmental Problems. *Oxford Review of Economic Policy* 6: 80-108.

Markusen, J.R. Cooperative Control of International Pollution and Common Property Resources. *Quarterly Journal of Economics* 89: 618-632.

Nash, J.F. 1953. Two-Person Cooperative Games. *Econometrica* 21: 128-140.

Netanyahu, S. 1988. Bilateral Cooperation on Transboundary Water Resources: The Case of the Israeli-Palestinian Mountain Aquifer. Ph.D. Dissertation. Department of Agricultural and Resource Economics. University of Maryland. College Park.

Netanyahu, S., R.E. Just, and J.K. Horowitz. 1998. "Bargaining Over Shared Aquifers: The Case of Israel and the Palestinians." In *Conflict and Cooperation on Trans-Boundary Water Resources*, edited by R. E. Just and S. Netanyahu. Kluwer Academic Publishers, Boston.

III

INTERNATIONAL EXPERIENCE IN CROSS-BOUNDARY MANAGEMENT AND ALLOCATION OF WATER RESOURCES

Chapter 9

From Rights to Needs

Water Allocations in International Treaties

Aaron T. Wolf
Department of Geosciences, Oregon State University, U.S.A.

At the heart of most international water conflicts is the question of "equitable" allocations, criteria for which are vague and often contradictory. However, application of an equitable water-sharing agreement along the volatile waterways of the globe is a prerequisite to hydropolitical stability. This paper explores the question of equity measures for water-sharing agreements in the context of global hydropolitics, describing the practice of water resources allocations as exemplified in the Transboundary Freshwater Dispute Database – a computerized database of 145 treaties relating to international water resources. Forty-nine of these treaties delineate water allocations.

What is noticeable in reading through the *practice* of water conflict resolution, as documented in these 49 treaties, is the almost total absence of the *theory*, particularly the extreme principles of absolute sovereignty or absolute riverine integrity. Many of the treaties simply divide water equally between riparians, some divide the *benefits* derived from the waters equally – not at all the same thing. Most favor existing uses, and/or guarantees to down-stream riparians; the upstream riparian is favored only rarely. One interesting pattern which emerges is that while many international water negotiations begin with differing legal interpretations of hydrography or chronology, they often shift rather to a needs-based criteria for water allocations, as measured by some mutually agreeable parameter such as irrigable land or population. Mostly, one is struck by the creativity of the negotiators in addressing specific language to each very specific local setting and concerns. In fact, each local setting is so geographically diverse, whether hydrologically, politically or culturally, that one wonders at the apparent futility of a search for a generalized code which would address every situation. We conclude that international efforts might shift from attempts at defining generalized principles to encouraging treaty negotiations for each specific transboundary basin.

1. INTRODUCTION[1]

As global populations continue to grow exponentially, and as environmental change threatens the quantity and quality of natural resources, the ability for nations to peacefully resolve conflicts over internationally distributed water resources will increasingly be at the heart of stable and secure international relations. There are more than 200 international rivers, covering more than one half of the total land surface of the globe, and untold numbers of shared aquifers. Water has been a cause of political tensions between Arabs and Israelis; Indians and Bangladeshis; Americans and Mexicans; and all ten riparian states of the Nile River. Water is the only scarce resource for which there is no substitute, over which there is poorly-developed international law, and the need for which is overwhelming, constant and immediate.

These resource conflicts will gain in frequency and intensity as water resources become relatively more scarce and their use within nations can no longer be insulated from impacting on one's neighbors. It has been suggested that more conscious attention to the art and science of negotiation, mediation and arbitration can provide useful insights for resolving these conflicts without recourse to the limited solutions possible in international courts of law or, worse, the devastating possibility of armed conflict.

The central issue at the heart of the international water quantity disputes is the fact that there are no internationally accepted criteria for allocating shared water resources. The questions considered, although usually dealt with within the realms of law or economics, are inherently geographical (Karan, 1961): Can one generalize a code of conduct for locations

[1] This paper is a summary of a larger work, "Criteria for Equitable Allocations: The Heart of International Water Conflict." Funding for this research was provided by the US Institute of Peace, Grant #174-95S. I am tremendously grateful to the Institute for its assistance, as I am to Mae Statius Muller and Mieke Hendriks, my hosts and guides at the International Court of Justice in The Hague during the summer of 1996. I owe a particular debt of gratitude to Jesse Hamner, my research assistant at the University of Alabama, for his conscientious work on our treaty collection. Mention should also be made of the tremendous strides the UN Food and Agriculture Organization has made in collecting and cataloguing water-related treaties – much of this study could not have been accomplished without their collections.

(watersheds) which are by nature hydrologically, politically and culturally unique? How does one develop guidelines for allocating a vital resource which is mobile, which fluctuates in time and in space, and which ignores political boundaries?

This paper describes some criteria for water-sharing which have evolved over time within legal and economic frameworks, and their strengths and weaknesses. The allocation criteria of water-sharing treaties which have actually been used in transboundary water treaties are then examined and compared with these theoretical measures of equity.

2. CRITERIA FOR WATER ALLOCATIONS – PRACTICE

2.1 Transboundary Freshwater Dispute Database

The UN Food and Agriculture Organization has identified more than 3,600 treaties relating to international water resources dating between 805 and 1984, the majority of which deal with some aspect of navigation (UN FAO 1978; 1984). Since 1814, approximately 300 treaties have been negotiated which deal with non-navigational issues of water management, flood control or hydropower projects, or allocations for consumptive or non-consumptive uses in international basins. Restricting ourselves to those signed in this century which deal with water *per se*, excluding those which deal with boundaries or fishing rights, we have collected the full text of 145 treaties in a Transboundary Freshwater Dispute Database, in conjunction with projects funded by the World Bank and the US Institute of Peace. Negotiating notes or published descriptions of many treaty negotiations are also being collected. Jesse Hamner, has developed a systematic computer compilation of these treaties, which are catalogued by basin, countries involved, date signed, treaty topic, allocations measure, conflict resolution mechanisms and non-water linkages.

Very little systematic work has been done on the body of international water treaties as a whole, although authors have often used treaty examples to make a point about specific conflicts, areas of cooperation, or larger issues of water law (see for example Vlachos, 1990; Eaton & Eaton, 1994; Housen-Couriel, 1994; Dellapenna, 1995; and Kliot, 1995). In one of the most thorough exceptions, Wescoat (1996) assesses historic trends of water treaties dating from 1648-1948 in a global perspective.

This work summarizes those treaties from the Transboundary Freshwater Dispute Database which describe specific allocations between two or more nations, excluding those which establish basin authorities or describe specific flood control or hydroelectricity projects *if* specific allocations are not described.[2] For example, the 1957 accord which establishes the Mekong Committee is excluded, but a 1975 Declaration of Principles among the same riparians, which describes principles for water allocations, is included. We also limit our study to those treaties negotiated in this century. Only a few treaties dated before 1900 include specific allocations, and an inordinate number of those are colonial in nature and approach, which teach us little about interests between sovereign states.

Of our collection of 145 treaties, 49 describe allocations for consumptive or non-consumptive uses. These treaties with water allocations generally come about in conjunction with boundary waters agreements, river development agreements, and/or single-project agreements. Our treaties are divided into those categories and summarized in Table 1.

2.2 Water Conflicts and their Resolution: a Synopsis of Experience

What is noticeable in reading through the *practice* of water conflict resolution, as documented in these 49 treaties, is the almost total absence of the *theory*, particularly the extreme principles of absolute sovereignty or absolute riverine integrity. Neither of these principles is encoded in a single one of the documents surveyed here. Nine treaties do not address the issue at all, simply basing their allocations 50-50 between two riparians. In fact, each local setting is so diverse, both hydrologically and politically, that one is struck by the apparent futility of a search for a generalized code which would address every situation. Yet one is also struck by the creativity of the negotiators in addressing specific codes to each very specific situation. Some divide waters equally between riparians; some divide the *benefits* derived from the waters equally – not at all the same thing. Most favor existing uses, and/or guarantees to down-stream riparians; the upstream riparian is favored only rarely. But each has sections which address the specific setting and concerns of local geography. The trends found in our reading of these treaties are described in the sections which follow.

[2] We also, regretfully, exclude those without English translations available – about ten of which could be applicable to this study. Since a vast majority of treaties are deposited with the United Nations for inclusion in the UN Treaty Series, which generally includes an English version, this exclusion does not overly hamper our study. We recognize, though, that access to these treaties would make it more complete.

2.2.1 From Rights to Needs

Many of the negotiations surveyed begin with parties basing their initial positions in terms of rights. Up stream riparians often invoke some variation of the Harmon Doctrine, claiming that water rights originate where the water falls. India claimed absolute sovereignty in the early phases of negotiations over the Indus Waters Treaty, as did France in the Lac Lanoux case, and Palestine over the West Bank aquifer. Downstream riparians often claim absolute river integrity, claiming rights to an undisturbed system or, if on an exotic stream, prior appropriation based on their history of use. Spain insisted on absolute sovereignty regarding the Lac Lanoux project, while Egypt claimed prior appropriations against first Sudan, then Ethiopia on the Nile.

In almost all of the disputes which have been resolved, however, particularly on arid or exotic streams, the paradigms used for negotiations have not been "rights-based" at all – neither on relative hydrography nor specifically on chronology of use, but rather "needs-based." "Needs" are defined by irrigable land, population, or the requirements of a specific project. In agreements between Egypt and Sudan signed in 1929 and in 1959, for example, allocations were arrived at on the basis of local needs, primarily of agriculture. Egypt argued for a greater share of the Nile because of its larger population and extensive irrigation works. In 1959, Sudan and Egypt then divided future water from development equally between the two. Current allocations of 55.5 BCM/yr. for Egypt and 18.5 BCM/yr. for Sudan reflect these relative needs (Waterbury, 1979).[3]

Likewise along the Jordan River, the only water agreement for that basin ever negotiated (although not ratified) until very recently, the Johnston Accord, emphasized the needs rather than the inherent rights of each of the riparians. Johnston's approach, based on a report performed under the direction of the Tennessee Valley Authority, was to estimate, without regard to political boundaries, the water needs for all irrigable land within the Jordan Valley basin which could be irrigated by gravity flow (Main, 1953). National allocations were then based on these in-basin agricultural needs, with the understanding that each country could then use the water as it wished, including to divert it out-of-basin. This was not only an acceptable formula to the parties at the time, but it allowed for a break-through in negotiations when a land survey of Jordan concluded that its future water

[3] It should be pointed out that not everyone's needs were considered in the Nile Agreements, which included only two of the nine riparian states – Egypt and Sudan, both minor contributors to the river's flow. The notable exception to the treaty, and the one which might argue most adamantly for greater sovereignty, is Ethiopia, which contributes between 75-85% of the Nile's flow.

needs were lower than previously thought. Years later, Israel and Palestine came back to needs in the Interim Agreement of 1995, where Israel first recognized Palestinian water rights on the West Bank – a formula for agriculture and per capita consumption determined future Palestinian water needs at 70-80 MCM/yr. and Israel agreed to provide 28.6 MCM/yr. towards those needs.

Needs are the most prevalent criteria for allocations along arid or exotic streams outside of the Middle East as well. Allocations of the Rio Grande/Rio Bravo and the Colorado between Mexico and the USA are based on Mexican irrigation requirements; Bangladeshi requirements determined the allocations of the Ganges, and Indus negotiations deferred to Pakistani projects.

One might speculate as to why negotiations move from rights-based to needs-based criteria for allocation. The first reason may have something to do with the psychology of negotiations. Rothman (1995), among others, points out that negotiations ideally move along three stages: the adversarial stage, where each side defines its positions, or rights; the reflexive stage, where the needs of each side bringing them to their positions is addressed; and finally, to the integrative stage, where negotiators brainstorm together to address each side's underlying interests. The negotiations here seem to follow this pattern from rights to needs and, occasionally, to interests. Where each negotiator may initially see him- or herself as Egyptian or Israeli or Indian, where the rights of one's own country are paramount, over time one must empathize to some degree to notice that even one's enemy, be he or she Sudanese, Palestinian, or Pakistani, requires the same amount of water for the same use with the same methods as oneself.

The second reason for the shift from rights to needs may simply be that rights are not quantifiable and needs are. We have seen the vague guidance that the ILC draft rules provide for allocations – a series of occasionally conflicting parameters which are to be considered as a whole. If two nations insist on their respective rights of upstream versus down, for example, there is no spectrum along which to bargain; no common frame of reference. One can much more readily determine a needs-based criterion – irrigable land or population, for example – and quantify each nation's needs. Even with differing interpretations, once both sides feel comfortable that their minimum quantitative needs are being met, talks eventually turn to straightforward bargaining over numbers along a common spectrum.

Because of its relative success, needs-based allocations have been advocated in recent disputes as well, notably in and around the Jordan River watershed where riparian disputes exist not only along the river itself, but also over several shared groundwater aquifers. Gleick (1996) defines basic human needs, regardless of climate, as 50 liters per capita per day for personal use alone (18.25 m^3/yr.) and, in earlier work (Gleick, 1994) suggests 75 m^3/yr. as appropriate minimum levels per capita for the Middle East. Shuval (1992) also argues for a minimum baseline allocation between Israel, West Bank Palestinians and Jordan based on a per capita allotment of 100 m^3/yr. for domestic and industrial use plus 25 m^3/yr. for agriculture. He adds 65% of urban uses for recycled wastewater, and advocates a series of water import schemes and desalination plants to provide the difference between regional supply and future demand.

Wolf (1993) likewise advocates a needs-based approach, but considers new sources such as recycled wastewater as separate issues. He plans for total urban needs of 100 m^3/yr. per person, and extrapolates to the point in the future where *all* of the basin's 2,500 MCM/yr. has to be allocated first to these needs, in other words when the regional population reaches 25 million, expected in the early part of the next century.

2.2.2 Relative Hydrography Versus Chronology of Use

Generalized legal principles focus on some version of upstream versus downstream relations, whether defined in the extreme as absolute sovereignty versus absolute riverine integrity or versus prior appropriation, or more moderately as equitable use versus the obligation not to cause harm. In practice, the only situation in which there is still any ambiguity is along humid, under-developed rivers. Along arid or exotic streams, where some aspect of consumptive use is involved, there is very little debate – prior uses are *always* protected (with only one exception, described below) and, in general, downstream needs are favored.

2.2.2.1 Absolute Principles

The negotiations which led to the disavowal of the legal principles of both absolute sovereignty and absolute riverain integrity was the Lac Lanoux case of 1957, which found, in short, that "...the upstream State has a right of initiative...provided it takes into consideration in a reasonable manner the interest of the downstream State" (cited in MacChesney, 1959, 170).

The only situations in which absolute rights are codified in treaties are relating to some tributaries of international waterways in conjunction with broader boundary waters accords, always in a quid pro quo arrangement. Such is the case in only three of our case studies. Mexico and the USA each retain absolute sovereignty to some internal tributaries of the Rio Grande/Rio Bravo, for example. In a 1950 boundary waters agreement of five tributaries of the Isar which flow from Austria to Hungary, one is allowed to flow freely to Hungary, two can be developed entirely by Austria, and two can be developed by Austria provided it allows minimum flows during winter months. Interestingly in this case, and perhaps adding incentive to a particularly creative agreement, Austria is upstream riparian on these tributaries to the Isar, then becomes a downstream riparian to Bavaria (Germany) after the Isar flow into the Danube, which bends back into Austria. In contrast, a 1925 accord on the streams which form the boundaries between Finland and Norway allocates each state half the boundary streams, but absolute sovereignty to each state over all the tributaries to those streams in which both banks are within one country.

2.2.2.2 Prior Uses

In contrast to the extreme rarity with which absolute principles are codified, prior uses are protected in every treaty in which they are mentioned (except one, described below), notably in every single boundary waters accord in our collection.

The entire focus of some treaties is on protecting existing uses. All of the six existing treaties regarding the Nile, for example, are about protecting Egyptian uses in early years, later those of Egypt and Sudan. More often, a clause is included in a broader treaty, whether the focus is boundary demarcations, boundary waters or water resources development, which protects existing uses. Peru continues to supply water to Ecuadorian villages, for example, as part of their 1944 boundary demarcation. The boundary water accords between the USA and Canada, and between the USA and Mexico, all have prior use clauses included. A 1969 accord between Portugal, for Angola, and South Africa, for Southwest Africa, which describes an elaborate river development project, includes "humanitarian" allocations for human and animal requirements in Southwest Africa.

The supremacy of prior uses would not necessarily be surprising in those cases along arid or exotic streams, where investment in irrigation infrastructure has long relied on the knowledge of a stable supply, even on humid region rivers, and even as water is divided proportionally, prior uses are generally protected. The boundary agreement between Russia and China along the Horgos River divides the water equally, but protects the uses of existing canals and one Chinese outpost. The three boundary waters accords between Austria, Hungary and Czechoslovakia all allocate each two signatories half the natural flow of shared rivers, "without prejudice to acquired (or existing) rights."

The only treaty in which existing uses were relinquished is the 1995 Israel/Palestine accord on West Bank and Gaza aquifers. Israel began tapping into these aquifers as long ago as 1955; before the accord they made up as much as 40% of Israel's renewable freshwater supply (Wolf, 1995). Because the West Bank aquifers naturally flow to Israel, and because they had been using the water longer, Israelis had been claiming prior rights in peace negotiations. By recognizing and quantifying Palestinian needs, and by agreeing to provide 28.6 MCM/yr. towards those needs, the 1995 accord represents the only case in which prior rights are explicitly relinquished.

Again, we might speculate on the inherent supremacy of prior uses. First, we have noted the shift in thinking from rights to needs – existing water use is a pretty clear expression of "needs." Second, treaties with clauses for water allocations generally come about in conjunction with a boundary delineation, a division of boundary waters, or an agreement over future river development. In each of these cases, those using the water are important constituents of those party to the negotiations. In the former two case regarding boundary waters, negotiations would probably be carried in the political arena where the support of those living within a watershed would be vital to an accord's success. In the case of river development, the technocrats who negotiate these treaties, usually from water agencies, are generally extremely aware of the needs of those in a basin. In all cases, existing uses represent existing constituents, in contrast to hypothetical future users or future generations – groups whose influence is particularly difficult to garner.

2.2.2.3 Upstream/downstream Relations

Rights inherent in an upstream or downstream position are not explicitly claimed in any of the treaties in our collection. This should not be understood to suggest that the upstream/downstream relationship is ignored; only that when it is addressed, it is done so implicitly.

In general, the downstream riparian is favored, or at least its allocations are protected, along arid and exotic streams. This is not to say that the down stream riparian receives more water, since this is not always the case – Mexico receives less water on both the Colorado and the Rio Grande/Rio Bravo than the USA – only that it is the allocations of the downstream riparian which are generally delineated and protected. Mexico, Egypt, Bangladesh and Pakistan all have their needs defined and given precedence in their respective treaties. This precedence probably comes about as a consequence of two earlier observations – that rights give way to needs and that prior uses are generally protected. Since there is more, and generally older, irrigated agriculture downstream on an arid or exotic stream, and since agricultural practices predate more recent hydroelectric needs – the sites for which are in the headwater uplands – the downstream riparian would have greater claim whether measured by needs or by prior uses of a stream system.

The only treaties in which upstream allocations are delineated (except for the internal tributaries granted absolute sovereignty noted above) are on boundary waters agreements in humid regions. The 1956 boundary waters accord between Austria and Hungary grants the upstream state up to one third of the water of any of the covered river systems. (This is an interesting exception, for which I have no explanation – similar treaties between Austria and Czechoslovakia, and between Czechoslovakia and Hungary, have no such provision). Three other humid boundary water agreements simply divide the waters equally – Austria/Hungary, Czechoslovakia/Hungary and Finland/Norway. In the only treaty which explicitly favors the upstream riparian, the 1925 accord on the Gash between Italy, for Eritrea, and the United Kingdom, for Sudan, not only grants upstream Eritrea all of the low flow and half of the moderate flow of the stream, Sudan also agreed to pay Eritrea a share of what was received for agricultural cultivation in the Gash Delta.

2.2.2.4 Prioritizing Use

The Helsinki Rules list eleven hydrographic and socio-political factors which ought to be taken into account as a whole in water allocations; the ILC Draft Rules list seven, but does suggest that the "requirements of vital human needs" be given "special regard." Neither the Helsinki nor the ILC parameters have been explicitly used in any treaty to derive allocations. The Helsinki Rules *are* listed, verbatim, only in the 1975 Mekong Agreement – and the criteria that a benefit-cost ratio for each proposed project be performed is added – but no allocations are derived.

Four treaties do differentiate between types of use (other than existing uses, described above), but they use many fewer criteria and each list is prioritized. After listing the criteria from the Helsinki Rules, for example, the Mekong Agreement gives domestic and urban uses a preference. The two sets of boundary waters agreements between the USA and Canada, and the USA and Mexico prioritize differently, probably due to the amount of water available along each border region: the former prioritizes by domestic and sanitary, navigation, and power and irrigation; the latter gives descending weight to domestic, agriculture, electric power, other industry, navigation, fishing and other beneficial uses. The 1960 Indus Waters Treaty lists its order of priority as domestic, non-consumptive, agriculture and hydro-power. Notably absent in all of these lists are any instream or other environmental requirements.[4]

[4] This may be changing: at a 1997 meeting on international waters of Latin America, a representative of the Global Environmental Facility suggested that watershed needs start with the environmental needs at the delta and work backwards.

2.2.3 Economic Criteria: Beneficial Uses and "Baskets" of Benefits

2.2.3.1 Beneficial Uses

Some economists have suggested that water, like any scarce resource, should be allocated to its most efficient use, and an entire literature has developed describing water market allocations.[5] In practice, economic criteria have influenced water allocations only in the exception.

The one topic most affected by economic criteria is when principles of "beneficial" uses are specifically defined, notably in treaties describing hydropower or river development projects. Of the 28 treaties in these two categories, five allocate water equally. Two of the 28 refer not to equal allocations, but to equal allocations of benefits – not at all the same thing. The boundary waters agreement between the USA and Canada, for example, allocates water according to equal benefits, usually defined by hydropower generation. This results in the odd arrangement that power may be exported out of basin for gain, but the water itself may not. In the 1964 treaty on the Columbia, an arrangement was worked out where the USA paid Canada for the benefits of flood control and Canada was granted rights to divert water between the Columbia and Kootenai for hydropower. Likewise, the 1975 Mekong accord defines "equality of right" not as equal shares of water, but as equal rights to use water on the basis of each riparian's economic and social needs. The relative nature of "beneficial" uses is exhibited in a 1950 agreement on the Niagara, which provides a greater flow over the famous falls during "show times" of summer daylight hours, when tourist dollars are worth more per cubic meter than the alternate use in hydropower generation.

While compensation for lost power generation or flooded land is fairly common, appearing in ten of the 28 development treaties, compensation for water itself is not – only four of all 49 treaties have such provisions. In the first such accord, a 1910 agreement on Aden groundwater, Great Britain agreed to pay the Sultan of the Abdali 3,000 rupees a month if the proposed wells went unmolested; otherwise the price dropped to 15 rupees per 100,000 gallons. In a 1926 accord on the Cunene River, no charge was made for water diverted for subsistence, but South Africa would pay unspecified fees to Portugal if the water were used for "purposes of gain." South Africa not only paid much of the development costs of the Lesotho Highlands

[5] See for example Goslin (1977); Krutilla (1969); LeMarquand (1976; 1977).have questioned Some studies question the equity and justice associated with market allocations. See, for example, Margat (1989); London & Miley (1990); Tsur & Easter, in Dinar & Loehman, eds. (1995); and Frohlich & Oppenheimer in Dinar and Loehman, eds. (1995).

project, but it pays Lesotho outright for water delivered. In a slight twist, Great Britain agreed in 1926 to pay upstream Eritrea a share of its cultivation in the Gash delta – 20% of any sales over £50,000. Payments were discontinued when Great Britain took control of Eritrea in WWII.

The treaty with the most economic influence is the 1995 groundwater agreement between Israel and Palestine. While no payments are made outright for water, provisions are included to consider water markets in the future, and the two sides agree not to subsidize marketed water – moves long encouraged by economists to promote efficient use.[6]

2.2.3.2 "Baskets" of Benefits

In most of these treaties, water issues are dealt with alone, separate from any other political or resource issues between countries – water *qua* water. By separating the two realms of "high" and "low" politics, or by ignoring other resources which might be included in an agreement, some have argued, the process is either likely to fail, as in the case of the 1955 Johnston accords on the Jordan, or more often to achieve a sub-optimum development arrangement, as is currently the case on the Indus agreement, signed in 1960. Increasingly, however, linkages are being made between water and politics, between water and other resources. These multi-resource linkages may offer more opportunities for creative solutions to be generated, allowing for greater economic efficiency through a "basket" of benefits. Some resources which have been included in water negotiations include:

Financial resources. An offer of financial incentives is occasionally able to circumvent impasses in negotiations. World Bank financing helped resolve the Indus dispute, while UN-led investments help achieve the Mekong Agreement. Cooperation-inducing financing has not always come from outside of the region. Thailand helped finance a project in Laos, as did India in Pakistan, in conjunction with their respective watershed agreements. A provision of the Nile Waters Treaty has Egypt paying Sudan outright for water to which they both agreed Sudan had rights, but that it was not able to use.

Energy resources. One increasingly common linkage being made is that between water and energy resources. As noted above, in conjunction with the Mekong Agreement, Thailand helped fund a hydroelectric project in Laos in exchange for a proportion of the power to be generated. In the particularly elaborate 1986 Lesotho Highlands Treaty, South Africa agreed to help finance a hydroelectric/water diversion facility in Lesotho – South Africa acquired rights to drinking water for Johannesburg, and Lesotho

[6] Water subsidies within each party's territory are not covered by the agreement and will probably continue.

receives all of the power generated. Similar arrangements have been suggested in China on the Mekong, Nepal on the Ganges, and between Syria and Jordan on the Yarmuk.

Political linkages. Political capital, like investment capital, might likewise be linked to water negotiations, although no treaty to date includes such provisions. This linkage might be done implicitly, as for example the parallel but interrelated political and resource tracks of the Middle East peace talks, or explicitly, as talks between Turkish acquiescence on water issues have been linked in a quid pro quo with Syrian ties to Kurdish nationalists.

Data. As water management models become more sophisticated, water data is increasingly vital to management agencies. As such, data itself can be used as a form of negotiating capital. Data-sharing can lead to breakthroughs in negotiations – an engineering study allowed circumvention of an impasse in the Johnston negotiations when it was found that Jordan's water needs were not as extensive as had been thought, allowing for more room in the bargaining mix. In contrast, the lack of agreed-to criteria for data in negotiations on the Ganges has hampered progress over the years.

Data issues, when management effectively, can also allow a framework for developing patterns of cooperation in absence of more contentious issues, particularly water allocations. For one, data gathering can be delegated to a trusted third party or, better, to a joint fact-finding body made up of representatives from the riparian states. Perhaps the best example of this internationally is on the Mekong, where the Mekong Committee's first five-year plan consisted almost entirely of data-gathering projects, effectively both precluding data disputes in the future, and allowing the riparians to get used to cooperation and trust.

Water-related "baskets." Some of the most complete "baskets" were negotiated between India and Nepal, in 1959 on the Bagmati and the Gandak, and in 1966 on the Kosi (all tributaries of the Ganges). These two treaties include provisions for a variety of water related projects, including irrigation/hydropower, navigation, fishing, related transportation, and even aforestation – India plants trees in Nepal to contain downstream sedimentation. These treaties are good examples of how broader "baskets" can allow for more creative solutions.

2.2.4 The Unique Local Setting

While most of the debate in the legal realm has been over trying to accommodate as many concerns as possible in an attempt to find generalized principles for all of the world's international water, riparians of these basins have in the meantime been negotiating agreements which focus on specifically local concerns and conditions. Further distinguishing the generalized world of theory from the specific one of practice, while many of these treaties incorporate particularly local issues, they often include a clause which explicitly disavows the treaty as setting an international precedent. The 1950 accord on Austria/Bavaria boundary waters is typical: "Notwithstanding this agreement," it reads, each State maintains its "respective position regarding the legal principles of international waters." The most-recent agreement in our collection, the 1996 Ganges Agreement, includes the similar provision that the parties are "desirous of finding a fair and just solution without...establishing any general principles of law or precedent."

The uniqueness of each basin, whether hydrological, political or cultural, stands out in the creativity of many of the treaties. The 1969 accord on the Cunene River allows for "humanitarian" diversions solely for human and animal requirements in Southwest Africa as part of a larger project for hydropower. Water loans are made from Sudan to Egypt (1959), and from the USA to Mexico (1966). Jordan stores water in an Israeli lake while Israel leases Jordanian land and wells (1994), and India plants trees in Nepal to protect its own water (1966). In a 1964 agreement, Iraq "gives" water to Kuwait, "in brotherhood," without compensation. In contrast, a 1957 agreement between Iran and the USSR has a clause which allows for cooperation in identifying corpses found in their shared rivers.

The changes of local needs over time are seen in the boundary waters between Canada and the USA. Even as the boundary waters agreements of 1910 were modified in 1941 to allow for greater hydropower generation in both Canada and the United States along the Niagara to bolster the war effort, the two states nevertheless reaffirmed that protecting the "scenic beauty of this great heritage of the two countries" is their primary obligation. A 1950 revision continued to allow hydropower generation, but allows a greater minimum flow over the famous falls during summer daylight hours, when tourism is at its peak.

Cultural geography can overwhelm the capacity of generalized law as well. In 1997 discussions among the riparians of the Euphrates basin, Syrians objected strenuously to proposals for water pricing. This led to a temporary impasse until it was explained by an outside observer that some Islamic interpretation forbids charging money for water itself; the term was modified to "tariff," to represent costs only for storage, treatment and delivery, and discussions were able to proceed.

In what will no doubt become a classic modification of the tenets of international law, Israelis and Jordanians invented legal terminology to suit particularly local requirements in their 1994 peace treaty. In negotiations leading up to the treaty, Israelis, arguing that the entire region was running out of water, insisted on discussing only water "allocations," that is, the future needs of each riparian. Jordanians, in contrast, refused to discuss the future until past grievances had been addressed – they would not negotiate "allocations" until the historic question of water "rights" had been resolved.

There is little room to bargain between the past and the future, between "rights" and "allocations." Negotiations reached an impasse until one of the mediators suggested the term "rightful allocations" to describe simultaneously historic claims and future goals for cooperative projects – this new term is now immortalized in the water-related clauses of the Israel-Jordan Treaty of Peace.

3. CONCLUSIONS

The major barrier to water's role as an agent of peaceful relations is the lack of a widely accepted measure for equitably dividing shared water resources. This paper explored existing methods for delineating water allocations in theory, as manifested in the generalized realm of international water rights law and the efficiency-based context of economic theory, and in practice, as exhibited in the 49 treaties of the Transboundary Freshwater Dispute Resolution Database which specify water allocations. In general, we found surprisingly little relationship between the worlds of theory and practice.

In describing the current state of international water law, most recently exhibited in the ILC Draft Rules, we found a history of attempts at generalizing code for the 200-plus international waterways of the world. Although the document has important components to fostering peaceful relations, it falls far short in the critical topic of water allocations. The document advises "reasonable and equitable" use, and offers a series of considerations which ought to be taken into account, but no specific guidelines for quantifying each country's share. Furthermore, the document institutionalizes an inherent conflict between the "rights-based" positions of the upstream riparian – the principle of equitable use, a more-subtle manifestation of absolute sovereignty – and the downstream riparian – the obligation not to cause significant harm, a refined protection of the right of prior appropriation. Little room for bargaining is left between this rights-based opposition between hydrography and chronology.

This paper described the practice of transboundary water allocations as exemplified in 49 treaties which actually delineate transboundary water resources. In our reading of these treaties, we found an almost total absence of theory, whether legal or economic. Rather than follow these generalized principles, each treaty showed sometimes exquisite sensitivity to the unique setting and needs of each basin.

The trends we found generally included:

1. A shift in positions often occurs during negotiations from "rights-based" criteria, whether hydrography or chronology, in favor of "needs-based" values, based on irrigable land or population, for example. We speculated that this shift may be based on the psychology of negotiations, or simply because needs are easier to quantify than rights.
2. In the inherent disputes between upstream and downstream riparian and existing and future uses, we found that the needs of the down stream riparian are more often delineated – upstream needs are mentioned only in boundary waters accords in humid regions – and that existing uses, when mentioned, are *always* protected. We also found that specific uses are occasionally prioritized, although instream and environmental requirements are ignored in these priorities.
3. Economic benefits have not been explicitly used in allocating water, although economic principles have helped guide definitions of "beneficial" uses and have suggested "baskets" of benefits, including both water and non-water resources, for positive-sum solutions.
4. The uniqueness of each basin is repeatedly suggested, both implicitly and explicitly, in the treaty texts. The generalized guidelines offered for allocations in theory, whether based on legal or economic equity, simply cannot capture the geographic uniqueness of each of the world's international waterways, whether hydrological, political, or cultural aspects.

This assessment of the critical issue of allocations is the first result from what we hope will be continued systematic study of the 145 treaties we have collected in our Transboundary Freshwater Dispute Resolution Database. In future study, we hope to assess the relationship between the substance of the treaties and other geographic variables, particularly climate, power relationships, types of government, and changes over time. We would also like to assess mechanisms for conflict resolution for their relative effectiveness.[7]

Our conclusions should not be taken to suggest that the tremendous effort over the last three decades of the ILC should be dismissed – the ILC Draft Rules have embodied such critical concepts as notification of possible adverse effects, protection of eco-systems, and emergency situations.

[7] A version of the one-page summaries is available on disk from the author on request. Eventually, we hope to digitize the full-text of the treaties and to make them available on-line. Any comments or suggestions for future work are welcome.

However, by institutionalizing the inherent conflict between "reasonable and equitable use" and "the obligation not to cause harm," and by not prioritizing principles of sharing, the work does not make great strides in delineating the allocation of transboundary waters – an issue that is at the heart of most international water conflicts. Rather, by coming to such contradictory and nebulous definitions, the ILC may indirectly have found the geographic perspective which Gilbert White has been arguing for at least 40 years – that "if there is any conclusion that springs from a comparative study of river systems, it is that no two rivers are the same" (White, 1957, 160).

It may be that allocations ought best be left to the negotiation process between the riparians of each basin, and that the efforts of the United Nations might therefore shift from defining generalized principles to encouraging treaty negotiations for each transboundary basin – there are "only" 200 plus transboundary watersheds. Despite the inherent difficulties, treaties are not only the best representation of local needs and settings, but they also carry the highest priority in international law. By encouraging local negotiations, global political issues could also be better avoided. Why should China's concerns over sovereignty interfere with Belgium, France and the Netherlands developing cooperative integrated management over the Schelde? And in turn, why should the Schelde be the model for the Euphrates, where the direction for international management seems to be toward each riparian being responsible for an agreed-to quantity and quality crossing each respective boundary at agreed-to times?

As Wescoat (1992, 329) has argued in his review of the ILC rules, "a searching examination of past agreements might have underscored the importance of historical and geographical perspectives on international water problems." We think it has.

REFERENCES

Dellapenna, J. (1995). Building International Water Management Institutions: The Role of Treaties and Other Legal Arrangements. In: J.A., Allan & Chibli Mallat (eds.), *Water in the Middle East: Legal, Political, and Commercial Implications*. Tauris Academic Studies, London, New York, pp. 55-89.

Dinar, A. & Loehman, E. (eds.) (1995). *Water Quantity/Quality Management and Conflict Resolution*. Preager Publishers, Westport, CT.

Eaton, D. & Eaton, J. (1994). Joint Management of Aquifers between the Jordan River Basin and the Mediterranean Sea by Israelis and Palestinians: An International Perspective. In: E. Feitelson & M. Haddad (eds.), *Proceedings of Joint Management of Shared Aquifers: First Workshop*. Jerusalem, June 27-29, pp. 131-152.

Gleick, P. (1994). Water, War, and Peace in the Middle East. *Environment*, 36(3).

------------- (1996). Basic Water Requirements for Human Activities: Meeting Basic Needs. *Water International*, 21(2):83-92.

Goslin, I.V. (1977). International River Compacts: Impact on Colorado. In: *Water Needs for the Future -- Political, Economic, Legal, and Technological Issues in a National and International Framework.* Westview Press, Boulder.

Housen-Couriel, D. (1994). Some Examples of Cooperation in the Management and Use of International Water Resources. Hebrew University of Jerusalem, Truman Research Institute for the Advancement of Peace, March.

Karan, P. (1961). Dividing the Water: A Problem in Political Geography. *The Professional Geographer,* 13(1):6-10.

Kliot, N. (1995). Building a Legal Regime for the Jordan-Yarmouk River System: Lessons from Other International Rivers. In: *The Peaceful Management of Transboundary Resources.*

Krutilla, J.V. (1969). *The Columbia River Treaty - The Economics of an International River Basin Development.* Published for the Resources for the Future by the John Hopkins Press. Baltimore, MD.

LeMarquand, D. (1976). Politics of International River Basin Cooperation and Management. *Natural Resource Journal,* 16: 883-901.

---------------- (1977). *International Rivers: The Politics of Cooperation.* Westwater Research Center, University of British Columbia, Vancouver, British Columbia.

----------------- (1993). The International Joint Commission and Changing Canada-United States Boundary Relations. *Natural Resources Journal,* 33(1):59-92.

London, J.B. & Harry, W.M. Jr. (1990). The Interbasin Transfer of Water: An Issue of Efficiency and Equity. *Water International,* 15:231-235.

MacChesney, B. (1959). Judicial Decisions: Lake Lanoux Case. *American Journal of International Law,* 53:156-171.

Main, C.T. (1953). *The Unified Development of the Water Resources of the Jordan Valley Region.* Tennessee Valley Authority, Knoxville.

Margat, J. (1989). The Sharing of Common Water Resources in the European Community (EEC). *Water International,* 14:59-61.

Rothman, J. (1995). Pre-Negotiation in Water Disputes: Where Culture is Core. *Cultural Survival Quarterly,* 19(3):19-22.

Shuval, H. (1992). Approaches to Resolving the Water Conflicts between Israel and her Neighbors -- A Regional Water-for-Peace Plan. *Water International,* 17(3):133-143.

United Nations Food and Agriculture Organization (1978). *Systematic Index of International Water Resources Treaties, Declarations, Acts and Cases, by Basin: Volume I.* Legislative Study, 15.

United Nations Food and Agriculture Organization(1984). *Systematic Index of International Water Resources Treaties, Declarations, Acts and Cases, by Basin: Volume II.* Legislative Study, 34.

Vlachos, E. (1990). Prologue. *Water International,* 15(4):185-188.

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

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 Historical-Geographic Perspective, 1648-1948. *Colorado Journal of International Environmental Law and Policy,* 7 (1):39-74.

White, G. (1957). A Perspective of River Basin Development. *Journal of Law and Contemporary Problems,* 22:186.

Wolf, A. (1993). Guidelines for a Water-for-Peace Plan for the Jordan River Watershed. *Natural Resources Journal*, 33(3).

---------- (1995). *Hydropolitics along the Jordan River: Scarce Water and its Impact on the Arab-Israeli Conflict*. United Nations University Press, Tokyo.

Table 1. International Treaties which Delineate Water Allocations

BOUNDARY WATERS AGREEMENTS				
Main/ Sub-Basin (s)	**Parties/Date of Treaty**	**Title of Treaty**	**Method for Water Allocations[1]**	**Comments[1]**
Boundary waters between Canada and USA	Great Britain (for Canada), USA 1/11/1910	Treaty between Great Britain and the United States relating to boundary waters and boundary questions	Existing uses protected; equal shares of benefits (not necessarily of water). Order of precedence for uses: domestic and sanitary; navigation; power and irrigation.	Niagara: No diversion above Falls; 20,000 cfs to USA and 36,000 cfs to Canada for hydropower. St. Mary and Milk: Both rivers treated as single unit, with overall equal apportionment to each party; Canada retains prior rights to minimum 500 cfs on St. Mary during irrigation season, USA does likewise on Milk.
Boundary waters between Mexico and USA/Colorado, Tijuana, Rio Grande (Rio Bravo)	Mexico, USA 5/21/1906 2/3/1944	Utilization of waters of Colorado and Tijuana Rivers and of the Rio Grande (Rio Bravo)	Full rights to some tributaries, partial rights (by thirds) to others, half rights to main stem of boundary rivers. Minimum flows guaranteed to cross-boundary streams. Uses prioritized by: domestic, agriculture, electric power, other industry, navigation, fishing, other beneficial uses.	Rio Grande: 1906 treaty assures Mexico 60,000 acre-feet/yr, mostly in summer, according to set schedule. 1944 treaty allocates full rights to some tributaries, partial rights (by thirds) to others, half rights to main stem. Any shortages due to drought can be made up in following cycle. Colorado: Mexico guaranteed minimum flow of 1,500,000 acre-feet/yr. Tijuana: Commission agrees to study "equitable distribution." Allocations "are not to be construed as a recognition of any claims to said waters."
Colorado	Mexico, USA 8/24/1966	Exchange of notes constituting an agreement concerning the loan of waters of the Colorado River for irrigation of lands in the Mexicali Valley	USA "loans" water for irrigation to Mexico during one dry year in exchange for value of lost power generation.	USA provides 40,535 acre-feet above 1944 Treaty allocations during September and December 1966 (after an especially dry year), but retains an equal amount the following year (or over three years if low flow). Mexico pays market value for lost power generation at Hoover and Glen Canyon dams. Treaty explicitly mentions that no precedent is being set.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 1

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Colorado	Mexico, USA 9/30/1973	Mexico-US Agreement on the permanent and definitive solution to the salinity of the Colorado River (Minute #242)	Reaffirms 1944 agreement for 1,500,000 acre-feet/yr to flow to Mexico, but describes salinity and quality of flow. Also restricts some groundwater pumping of shared aquifers.	
Boundary waters between Austria and Czechoslovakia/ Danube	Austria, Czechoslovakia 12/7/67	Treaty between the Republic of Austria and the Czechoslovak Socialist Republic concerning the regulation of water management questions relating to frontier waters	"Existing water rights in respect of frontier waters and the obligations connected therewith shall remain unaffected"; all others to be worked out within States or through Commission.	
Boundary waters between Austria and Hungary	Austria, Hungary 4/9/1956	Treaty between the Hungarian People's Republic and the Republic of Austria concerning the regulation of water economy questions in the frontier region	Rights to use of 1/2 of natural (not enhanced by artificial means) flow to each party from rivers which flow along the boundary, "without prejudice to acquired rights;" upstream state of watercourses which intersect boundary may not decrease flow by more than 1/3; no development without joint approval.	

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 2

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Boundary waters between Czechoslovakia and Hungary/Danube, Tisza	Czechoslovakia, Hungary 4/16/1954	Agreement between the Czechoslovak Republic and the Hungarian People's Republic concerning the settlement of technical and economic questions relating to frontier watercourses	Each State has rights to half the natural (excluding artificially increased) discharge, "without prejudice to acquired rights," of frontier watercourses; no development which might affect discharge or the bed.	
Boundary waters between Iran and Iraq/Tigris	Iran, Iraq 12/26/1975	Agreement between Iran and Iraq concerning the use of frontier watercourses	Equal parts.	Flows of the Bnava Suta, Qurahtu and Gangir rivers are divided equally. Flows of the Alvend, Kanjan Cham, Tib and Duverij are divided based on a 1914 commission report on the Ottoman/Iranian border "and in accordance with custom."
Euphrates (?)	Iraq, Kuwait 2/11/1964	Agreement between Iraq and Kuwait concerning the supply of Kuwait with fresh water	Iraq agrees to supply Kuwait with 120 million imperial gallons per day without compensation, and to discuss additional needs if necessary.	Water source is unspecified in the agreement.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 3

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Ganges	Bangladesh, India 11/5/1977 12/12/1996	Treaty between the Government of the Republic of India and the Government of the People's Republic of Bangladesh on sharing of the Ganga/Ganges waters at Farakka	Schedule is established for dry months – January 1– May 31 which allocates the flow at Farakka: flow of 70,000 cusecs or less – 50% to India, 50% to Bangladesh; 70,000-75,000 cusecs – 35,000 cusecs to Bangladesh, rest to India; 75,000 cusecs or more – 40,000 cusecs to India, rest to Bangladesh.	1977 agreement was only to last for five years. Short-term agreements reached in 1982 and 1985; the latter lapsed in 1988. A final agreement was reached December 1996.
Gash	Italy (Eritrea) and United Kingdom (Sudan) 6/12/1925 4/8/1951	Notes exchanged between the United Kingdom and Italy respecting the regulation of the utilization of the waters of the River Gash; and 1951 amending letters	Eritrea can divert all water from a flow up to 5 m3/sec, about half the flow above 5 m3/sec, and a maximum of 17 m3/sec, or a total of 65 MCM/yr. The rest flows to Sudan.	Sudan paid Eritrea a share of what was received for cultivation in the Gash Delta – 20% of any sales over £50,000 (payments discontinued with British control of Eritrea). One of few agreements which explicitly favors upstream riparian.
Ili/Horgos	China, Russia 6/12/1915	Protocol between China and Russia for the delimitation of the frontier along the River Horgos	Upper reaches: Prior rights for Chinese outpost; lower reaches: prior rights for existing canals, rest to be shared equally.	China "binds itself" to withdraw only the water necessary for one outpost in upper reaches (within Chinese territory), otherwise, water will go to existing canals with remainder to be shared equally.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 4

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Pasvik (Patsjoki)/ Pasvik (Patsjoki), Jakobselv (Vuoremajoki)	Finland, Norway 2/14/1925	Convention between the Kingdom of Norway and the Republic of Finland concerning the waters of the Pasvik (Patsjoki) and the Jakobselv (Vuoremajoki)	Equal shares of shared boundary waters, absolute sovereignty over tributaries where both banks are within single territory.	Jakobselv (Vuoremajoki) and parts of Pasvik (Patsjoki) form boundary – the waters from these are divided equally. Absolute rights for tributaries of the Pasvik (Patsjoki) which have both banks in one state are retained by that state.
Rhine/Lake Constance	Austria, Germany, Switzerland 4/30/1966	Agreement regulating the withdrawal of water from Lake Constance	Requires notification and agreement for withdrawals over 750 l/sec within the catchment area, or 1,500 l/sec outside.	Must notify of withdrawals and "afford one another good time to express their views," and to submit to arbitration if disagreement. "Withdrawals...shall not be deemed to justify any claim to the provision of water in a specific volume or of a specific quality."
Roya	Italy, France 10/14/1972	Franco-Italian convention concerning the supply of water to the Commune of Menton	Italy allows 400 l/sec withdrawal from alluvial aquifer for French town; Italian town can tap into delivery pipeline for 100 l/sec.	Italian government grants 70-year concession to Menton to be governed by Italian law on water-related issues. Menton deposits 10 million lires for security against concession.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 5

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
West Bank and Gaza Aquifers	Israel, Palestine 9/28/1995	Israeli-Palestinian Interim Agreement	Population and consumption patterns – Israel recognizes Palestinian water rights, and agrees to provide 28.6 MCM/yr additional water towards future Palestinian needs of 70-80 MCM/yr.	Final allocations and rights to be determined in final status negotiations. Interim accord marks first time prior rights relinquished in an agreement, first joint management of aquifer systems, and first treaty which allows for future market mechanism, provided water is not subsidized.
Zarumilla	Ecuador, Peru 5/22/1944	Declaration and exchange of notes concerning the termination of the process of demarcation of the Peruvian-Ecuadorian frontier	Prior rights for Ecuadorian villages.	"Peru undertakes...to guarantee the supply of water necessary for the life of the Ecuadorian villages on the right bank of the so-called old bed of the river Zarumilla..." in conjunction with boundary delineation.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 6

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Araks, Atrak	Iran, USSR 8/11/1957	Agreement between Iran and the Soviet Union for the joint utilisation of the frontier parts of the rivers Aras and Atrak for irrigation and power.	50% of all potential water and power resources on the shared portions of the two rivers.	Provides for "separate and independent division and transmission of water and power in each party's territory," along with joint data-gathering. Also, each party has rights to potential even "...if the activities of one of the parties...are slower than those of the other."
Boundary waters between Canada and USA/Columbia, Kootenai	Canada, USA 9/16/1964	Treaty relating to cooperative development of the water resources of the Columbia River Basin (with annexes)	Equal share of benefits – cooperative management for flood control and hydropower. Water may not be diverted out-of-basin (except for some benefits specified in treaty), but power may (for compensation).	Equal share of benefits from power generation. USA pays Canada for benefits of flood control (payment can be in cash or in electric power) and, in 1964 Exchange of Notes, agrees to pay US$254,000,000 for entitlement. Canada granted diversions from Kootenai to Columbia and from Columbia to Kootenai, provided minimum flows are maintained.
Cunene	Portugal (Angola), South Africa (Southwest Africa) 7/2/1926	Agreement between the Government of the Union of South Africa and the Government of the Republic of Portugal regulating the use of the water of the Cunene River	Up to half of flood water may be diverted to Southwest Africa from above dam.	Dam to be constructed in Portuguese territory with shared cost. No charge for diversion if for subsistence, but payment would be made to Portuguese government if water used for "purposes of gain."

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 7

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Cunene	Portugal (Angola), South Africa (Southwest Africa) 1/21/1969	Agreement between the Government 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	Diversion solely for water for human and animal requirements in Southwest Africa and initial irrigation in Ovamboland, limited to 1/2 of flow or 6 m3/s.	"Humanitarian" part of larger project for hydropower. South Africa pays for water diversion and compensation to Portugal for land flooded as a result of dam (also royalties for hydropower generated).
Douro	Portugal, Spain 8/11/1927	Convention between Spain and Portugal to regulate the hydro-electric development of the international section of the River Douro	Roughly equal sections of the international stretch of the Douro are allocated to each for development. No diversions permitted, except "for reasons of public health," and only with joint agreement.	Separate, but equal and coordinated development.
Ganges/Bagmati, Gandak	India, Nepal 12/4/1959	Agreement between His Majesty's government of Nepal and the government of India on the Gandak irrigation and power project	Diversion for project – irrigation and power generation – are laid out in a monthly schedule of water requirements, with about 60% to Nepal (5,760-16,060 cusecs) and 40% to India (3,690-14,600 cusecs). Nepal retains rights to irrigate with any water above these project requirements.	Broad "basket" of benefits to each side: land acquisition, power generation, capital resources (primarily from India), irrigation water, and transportation facilities.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 8

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Ganges/Kosi	India, Nepal 12/19/1966	Amended agreement between His Majesty's Government of Nepal and the Government of India concerning the Kosi project	Nepal retains right to divert upstream water, "as may be required from time to time." India has right to regulate balance.	Broad "basket" of benefits, including irrigation/ hydropower project, navigation, fishing, and aforestation (India plants trees in Nepal to contain sedimentation).
Indus	India, Pakistan 5/4/1948	Inter-dominion agreement between the Government of India and the Government of Pakistan, on the canal water dispute between East and West Punjab	Rights are not determined, but India agrees, "without prejudice to its legal rights," to reduce flows of tributaries at a rate which would allow Pakistan to develop alternative sources.	India was to reduce flow from upper Indus basin rivers progressively, to allow Pakistan to "develop areas where water is scarce and which were under-developed in relation to Parts of West Punjab." Pakistan agreed to pay for some water sources.
Indus	India, Pakistan, World Bank 9/19/1960	The Indus waters treaty	River divided geographically: three eastern tributaries to India, three western tributaries to Pakistan.	Considerations were made for some withdrawals in other state's tributaries, in order of priority: domestic, non-consumptive, agriculture, hydro-power. Agreement was phased in and India paid for some Pakistani works deemed "replacement."

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 9

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Jordan/Yarmuk	Jordan, Syria 6/4/1953	Agreement between the Republic of Syria and the Hashemite Kingdom of Jordan concerning the utilization of the Yarmuk waters	Dam would be built to guarantee 10 m3/sec. minimum flow to Jordan, about 7/8 of natural flow of river. Syria relinquishes rights to tributaries between dam and 250m contour, receives 75% of hydropower.	Jordan was to cover 95% of costs, and provide 80% of workforce; Syria the remainder. Dam was never built, although plans were said to have been revived in August 1996.
Jordan	Israel, Jordan, Lebanon, Syria Finalized 1/1/1956, never ratified	Johnston Accord	Allocations of Jordan based on survey of irrigable land within basin: Israel – 31%; Jordan – 56%; Lebanon – 3%; Syria – 10%.	Allocations were based on irrigable land within basin; then each could do what it wished with water. Each tributary had one state without designated flow, to accommodate fluctuating supply. Accord was never ratified for political reasons.
Jordan/Yarmuk, shared aquifers	Israel, Jordan 10/26/1994	Treaty of peace between the State of Israel and the Hashemite Kingdom of Jordan	Allocations of Yarmuk and Jordan based on Johnston accord; agreed in conjunction with joint development projects. Water from shared aquifers allocated on basis of prior use.	"Rightful allocations" divide waters on the basis of historic rights plus future projects. Creative management: land and water historically used by Israel leased from Jordan; in absence of storage facility, Yarmuk water "loaned" to Israel in summer, returned to Jordan from Jordan River during winter.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 10

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Mekong/ Lower Mekong	Cambodia, Laos, Thailand, Vietnam 1/31/1975	Joint declaration of principles for utilization of the waters of the lower Mekong basin	Allocations are based, verbatim, on eleven parameters of 1966 Helsinki Rules definition of "reasonable and equitable shares" plus addition of benefit-cost ratio of each project.	"Equality of right" does not mean equal shares of water, but equal right to use water on basis of economic and social needs. Domestic and urban uses should have a preference; existing uses are protected. All parties must agree to any out-of-basin transfers. Groundwater with hydrologic connection to main stream is covered by agreement. Agreement based on 1957 establishment of Mekong Committee – renewed in 1995.
Nile/Atbara Nile/Semliki, Isango	Great Britain, Italy – 1891, 1925 Great Britain, Ethiopia – 1902 Great Britain, Congo – 1906	Series of protocols, agreements, and exchanges of notes	"Prior hydraulic rights" – Great Britain made agreements with upstream riparians to allow Nile tributaries to flow uninterrupted to Sudan and Egypt. Water for "subsistence" of local populations may be used, and existing uses are protected.	Agreements required any upstream development be "in consultation" with Great Britain. 1925 exchange of notes offers British support for Italian concession for railway in Eritrea, Ethiopia, and Somaliland, and recognition of "exclusive character of Italian economic influence" in area to be covered by railway, in exchange for Great Britain gaining concession to build barrage at Lake Tana and, recognizing the "prior hydraulic rights of Egypt and the Sudan," an agreement by Italy not to modify the flow.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 11

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Nile	Egypt, United Kingdom 5/7/1929	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 (Nile Waters Agreement)	Prior rights – restricts amount Sudan may use in order to guarantee to Egypt the water needed for existing agriculture.	Entirely protects existing, downstream uses – no irrigation or power works are to be built on the river which would reduce the quantity of water arriving in Egypt, modify the date of its arrival, or lower its level. If Egypt were to develop projects in Sudan to enhance flow, agreement would have to be reached beforehand with local authorities, although Egypt would retain direct control of such works.
Nile	Egypt, Sudan 11/8/1959	Agreement between the Government of the United Arab Republic and the Government of Sudan	Prior rights ("present acquired rights") for natural flow, plus benefits of Aswan Dam divided, based on population, on a ratio of 14.5 to Egypt, 7.5 to Sudan. Water from future projects, and the costs bome, would be divide equally.	If benefits of projects are greater than expected, they are to be divided equally. Egypt paid 15 million Egyptian pounds to Sudan for compensation for flooding and relocation from Aswan Dam; Sudan was to loan 1.5 BCM/yr to Egypt until 1977. Both states agreed to develop joint position before negotiating with any other riparian.
Orange/ Senqu	Lesotho, South Africa 11/7/1986	Treaty on the Lesotho Highlands water project between the Government of the Kingdom of Lesotho and the Government of the Republic of South Africa	Lesotho agrees to provide increasing water delivery to South Africa, from 57 MCM/yr in 1995 until 2,208 MCM/yr after 2020. Lesotho receives hydropower and capital payment from project.	A boycott of international aid for apartheid South Africa required that the project be financed, and managed, in sections. The water transfer component was entirely financed by South Africa, which would also make payments for the water which would be delivered. The hydropower and development components were undertaken by Lesotho, which received international aid from a variety of donor agencies, particularly the World Bank.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont. 12

Main/ Sub-Basin (s)	**Parties/Date of Treaty**	**Title of Treaty**	**Method for Water Allocations**[1]	**Comments**[1]
Aden groundwater	Great Britain, Sultan of Abdali (Aden) 4/11/1910	Terms of a convention regarding the water supply of Aden between Great Britain and the Sultan of the Abdali	Great Britain buys groundwater from Sultan of the Abdali.	Sultan gives Great Britain land in perpetuity and guarantees safety of headworks. Great Britain agrees to pay 3,000 rupees/month if works unmolested; otherwise 15 rupees/100,000 gallons. Early groundwater agreement.
Ebro/Lake Lanoux, Font-Vive, Carol	France, Spain 7/12/1958 (revised 1/27/1970)	Agreement between the Government of the French Republic and the Spanish Government relating to Lake Lanoux	France diverts water out-of-basin, then tunnels same volume back before Carol reaches boundary; guarantees minimum 20 MCM flow timed for Spanish irrigation.	French hydropower project which moves water out-of-basin, then returns through tunnel before boundary. Arbitration for this project led to an important international precedent when a Tribunal ruled in 1957 that "territorial sovereignty...must bend before all international obligations," effectively negating the water rights doctrine of "absolute sovereignty," while admonishing downstream state from the right to veto "reasonable" upstream development, negating the "natural flow" principle.
Indus/Sirhind Canal	Great Britain, Patiala, Jind, Nabha 8/12/1903	Final working agreement relative to the Sirhind canal between Great Britain and Patiala, Jind and Nabha	Available supply, and development costs, divided by percentage: Patiala – 83.6; Nabha – 8.8; Jind – 7.6. British villages receive water sufficient to irrigate the same proportion of its lands as of other villages nearby.	If the flow allocations cannot be met, the engineer may reduce flows proportionally, or may deliver full proportion to one, then shut off entirely while the others receive their full allotments.

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

cont.13

Main/ Sub-Basin (s)	Parties/Date of Treaty	Title of Treaty	Method for Water Allocations[1]	Comments[1]
Näätämo/ Näätämo, Gandvik	Finland, Norway 4/25/1951	Agreement between the Governments of Finland and Norway on the transfer from the course of the Näämo (Neiden) River to the course of the Gandvik River.	Water diverted between basins for power generation in Norway, which agrees to compensate Finland for lost water power.	Fish habitat and timber transport are also described.
Niagara	Canada, USA 5/20/1941; 10/27/1941	Exchange of notes between the Government of the United States and the Government of Canada constituting an arrangement concerning temporary diversion for power purposes of additional waters of the Niagara river above the Falls	5,000 cfs additional diversion to the USA and 3,000 cfs to Canada agreed to for hydropower generation during war effort; raised an additional 7,500 cfs to USA and 6,000 cfs to Canada in addendum.	Despite war effort, protecting the "scenic beauty of this great heritage of the two countries" is described as the primary obligation of the two countries.
Niagara	Canada, USA 2/27/1950	Treaty between the United States of America and Canada relating to the uses of the waters of the Niagara River	Equal amount of water for power generation, and equal share of cost, to each country. Minimum flow of river delineated	Benefits of tourism versus hydropower: 100,000 cfs minimum during "show times" at Falls – summer daylight hours; otherwise 50,000 cfs. "Primary obligation to preserve and enhance scenic beauty..."

[1] All units are reported as in original documents. One gallon = 3.61 liters; one acre-foot = 1,233 cubic meters; one cfs (cusecs) = 0.0283 cubic meters/second (cumecs).

Chapter 10

Institutional Cooperation on Groundwater Issues

Dutch experiences

Carel de Villeneuve

Ministry of Transport, Public Works and Water Management, the Netherlands

1. INTRODUCTION

In the Netherlands water is not seen as a commodity. In contrast to normal products, or scarce resources intended for consumption like oil, coal and gas, it is a permanently present in different shapes, describing ever again the hydrological cycle: it evaporates from the sea into clouds; it precipitates upon earth in the form of rain, snow or hail; it is assembled in groundwater or surface water; and, eventually, it flows back into sea. If human beings use water, they do not really consume it; they take it out of the system, but eventually it gets back into the environment in the shape of wastewater. Roughly speaking, it stays in the same drainage area and is continuously being reused there. Water is a renewable, but also a finite resource, essential for all living beings, humans, fauna and flora alike.

Therefore I seriously question what we mean when speaking about "water property rights"! The only private right we might lay a claim on is an interest, a share in water withdrawal at a given place, and the use made of it will have to comply with the standards of good housekeeping. Such a share should rather be defined in percents than by an exact amount, because the water flow is not fixed. The same is the case for water quality: water pollution, caused by human activities, diminishes the possibilities of water use. Our primary care should be to sustain our water reserves instead of squandering them first and seeking solutions elsewhere later.

This chapter is structured as follows: first I present an analysis of the groundwater problems we are confronted with in the Netherlands; next, I present the lessons we have drawn from those problems; then, how these lessons have influenced our institutional groundwater policy; and finally, I outline the way we are working together with our neighbours in this context.

2. GROUNDWATER PROBLEMS IN THE NETHERLANDS

We can distinguish two categories of problems with groundwater: *quality problems* and *quantity problems*. Often, the two categories are interlaced, influencing each other so that a negative spiral is generated.

2.1 Quality Problems

The *quality problems* are largely due to overuse of pesticides and nitrates. Pesticides are used in order to further crop resistance, and have therefore been applied in the Netherlands in large quantities. Unhappily, the advantage of pesticides is at the same time their disadvantage: their persistency allows them to accumulate in the soil, the groundwater and ultimately surface water, thus threatening drinking water and forming a toxic time-bomb for ecosystems.

Nitrates are used for fertilising the soil and thereby furthering crop growth. As long as they are entirely taken in by the crops they are meant to fertilise, there would be no problem. But intensive livestock-breeding, which has taken huge proportions in the Netherlands, has become the enemy of its own success: it has resulted in an enormous excess of manure which often is being spread out by the farmers over the fields if only to get rid of it. This results in the soil, and eventually the groundwater, getting saturated, the impact of which is equally detrimental to public health and the environment: drinking water standards are no longer attained, and surface water becomes eutrophic, stimulating the growth of oxygen-consuming algae that suppress the original ecosystem.

Other groundwater quality problems occur as well, such as leachate from dumping sites, or leaks from corroded tanks and pipelines.

2.2 Quantity Problems

The *quantity* problem is still more disturbing. The Netherlands, with its humid climate, its polders and four international rivers joining into a delta, are a country with potentially considerable water resources. But the rivers are contaminated; it is therefore costly to produce drinking water from them. Surface water is only used for drinking water purposes in the western part of the country, where the groundwater is saline due to sea water intrusion; it is taken from the rivers Rhine and Meuse and either purified and stored in the Lake IJssel or in large drinking-water-basins, or it is infiltrated into the dunes, where a natural purification process takes place. The remaining two-thirds of the Netherlands' drinking water consumption consists of groundwater.

Besides, groundwater is being exploited for other uses. Not only through regular withdrawal, as is the case with drainage, livestock drenching and industrial extraction; but also by means of infrastructural interventions, such as normalisation of streams and artificial lowering of surface water levels.

Normalisation of streams has been applied throughout the country during the last half-century, in order to either facilitate surface water discharge and shipping, or readjust and rationalise agricultural partitioning; however, with less obstacles in its way, the residence time of water in the rivers was considerably shortened, causing the surface water level and the communicating groundwater tables to sink.

Obviously, artificial lowering of surface water levels leads to the same effect. This has often been done in order to render fields better exploitable and more accessible to agricultural equipment.

Large construction works in urban and industrial areas can also have their effects on the groundwater level, reducing the subsoil's sponge capacity. And finally, we should mention here the considerable water level lowering impact of open brown coal mining in Germany near its border with the Netherlands.

Just as is the case with quality problems, these quantity problems affect drinking water as well as the environment. Overall groundwater withdrawals tend to exceed the annual replenishment. Thus, the annual groundwater stocks available for drinking water purposes diminish. Besides, problems arise in nature and forestry areas, where the roots of trees and plants are no longer able to reach the decreasing groundwater level, bringing destruction to valuable ecosystems and to wood production. The negative impact of such developments on tourism should not be underestimated either, as tourism is a growing and promising factor in the economy.

2.3 Interference of Quality and Quantity Problems

Worse still is that the quality- and quantity-related problems interact, and that this interaction has a mutually reinforcing, spiral-like impact. Lowering groundwater table may lead to a diminished pressure from the reduced fresh groundwater stocks against brackish groundwater, and eventually facilitate salt water intrusion, rendering groundwater unsuitable for drinking water purposes. Furthermore, where groundwater is already polluted, level lowering will increase the concentration of pollutants in it. If we just continue doing business as usual, we might on the long run be confronted with the mere availability of very little, highly polluted water, with a very high degree of salinity. By then, it would be too late: no industry, no agriculture and no tourism are interested in investing in moon landscapes, and the land loses its economic attractiveness.

If I have well understood the problems facing Palestinians and Israelis, quite a few parallels can be drawn. And, happily, in both cases, public awareness has considerably increased that somehow action has to be taken. But how?

3. FUNDAMENTAL LESSONS

The problems sketched made us draw the following conclusions:

1. *clean freshwater is a limited resource.* If we go on with abstracting more groundwater than is annually replenished, the stocks will gradually get exhausted. This will be detrimental to future generations, possibly even already for ourselves. Therefore, a sustainable freshwater policy is to be formulated *per drainage basin*; existing detrimental uses will have to be made subject to review; and new potentially detrimental activities will have to be made subject to some kind of impact statement. As is the case with other scarce resources, pricing may be a useful instrument here;
2. *clean freshwater is a basic need for the population.* Life without a minimum of fresh water for drinking and washing purposes is not possible, and water management policy must take this into account, by assigning the very first priority to these needs;
3. *different other interests are involved with freshwater.* Once basic human needs have been provided for, drinking water production, agriculture, industry, tourism, all have their own interests to defend when it comes to dividing the remaining surpluses. Of course, all interest groups will tend to stress their own importance, but when confronted with each other, with researchers and with policy makers, and given a share of responsibility, their representatives will see that sustainability is serving their own purpose as well, and that they will have to content themselves with sharing the remaining freshwater surpluses;
4. *quality and quantity factors are closely interrelated.* Generally speaking, sustainable water quality and sustainable water quantity are interdependent and, if well co-ordinated, will mutually reinforce each other;
5. Finally, *groundwater and surface water are interconnected*, as long as we are not talking about fossil or otherwise isolated groundwater sources. Groundwater overdraft therefore may have its effect on neighbouring

surface water levels; surface water level lowering may affect contiguous groundwater tables. Moreover, it should be carefully considered which use is to be assigned to which freshwater source. As groundwater generally represents a higher quality, it should be assigned in the first place to uses requiring water of a higher quality, such as drinking water and related industrial processes such as the production of beverages. Uses such as irrigation, water cooling, and other industrial processes, should content themselves, if necessary, with surface water.

6. *Mere technical supply-side solutions are insufficient.* When confronted with scarcity of resources that are essential for survival, demand must be influenced rather than supply. And this requires psychological elements to be taken into account as well.

4. THE NETHERLANDS GROUNDWATER MANAGEMENT STRUCTURE

The Netherlands have incorporated these policy considerations into their policies; they are largely shared by the European Commission, which in 1996 has issued an action programme on groundwater. However, we have not yet translated all of those policies into effective groundwater management structures. Even then, I can mention the following characteristics of the Netherlands' groundwater management:

- The formulation of quantitative groundwater policy is legally entrusted to the provinces by our Groundwater Act. The provinces have legislative, planning and licensing powers. We are actually considering the possibility to give provinces the power to delegate the practical application of these policies to our waterboards. These are elected authorities under control of the provinces and exclusively charged with surface water management and protection against floods, and financed by taxes they impose upon their own electorate, among whom the agricultural sector, industry and the urban centres are strongly represented. Delegation of powers to the waterboards would not only integrate groundwater and surface water policy application, but would also bring government action in groundwater matters closer to the public and the related interest groups.
- Quantitative groundwater planning is an integrated part of water policy planning at national level, where water management strategy is formulated, as well as at provincial level, in provincial water management plans. This planning structure is legally provided for in both our Water Management Act and our Groundwater Act.

- Qualitative groundwater policy and planning are integrated into environmental policy and planning; strategy is fixed at national level, management and implementation at provincial level.
- At national level, integration of qualitative groundwater policy into the other water policy fields takes place through the Minister for Water Management co-signing the Environment Policy Plan, and the Environment Minister co-signing the Water Management Policy Plan. The provinces take care of integration of their water and environment management plans.
- The Netherlands' National Organisation for Applied Scientific Research TNO in Delft has a separate Institute of Applied Geoscience, which functions as the central organisation in the country for acquiring, managing and disseminating information and for applied research on groundwater. Here, the fields of groundwater quantity and groundwater quality are scientifically brought together, to be subsequently translated into policy terms by the National Institute for Inland Water Management and Wastewater Treatment for quantity, and by the National Institute for Health and the Environment as far as quality is concerned.
- The Netherlands' government has introduced a levy on the use of groundwater for drinking water purposes by the consumer, as an incentive for economising on water.
- As the condition of our groundwater is not (or not yet?) critical, we have not fixed quantities for basic human needs.

5. TRANSBOUNDARY ASPECTS

What remains is the international component, to which I turn now. Indeed, water policies are to be formulated as much as possible per drainage basin. Together with our neighbours, we have created river Commissions for our four transboundary river systems (Rhine, Meuse, Scheldt and Ems) and for the Northeast Atlantic; in the case of the Rhine and the Atlantic, these structures are functioning already since several decades and with clear results. River catchment areas do not always coincide with groundwater systems, and especially deeper layers of groundwater. Even then, it appears to be possible to somehow integrate the two - at least according to our experience; and this experience is corroborated by the European Commission's proposal for a "Directive establishing a framework for a Community action in the field of water policy", which opts for a general river basin-oriented approach for water management in Europe, and assigns groundwater layers to the nearest or most appropriate River basin districts. Here I must add that the shallow aquifers along our border are largely of local importance. I will briefly dwell upon our relations with Belgium, to our south, and upon those with Germany, to our east.

5.1 Relations with Belgium

Belgium is a federal state, consisting of two large regions: Flanders, the north-western part of the country, and Wallonia, in the south-east; and of the Brussels agglomeration. Each Region has its own parliament, its own government and its own administration, and has constitutional powers to conclude international conventions, under supervision of the federal government. The Netherlands share by far the largest part of their southern boundary with Flanders; only in the extreme south-east of the country do we share a border of some 10 km with Wallonia. In Belgium, the Regions are competent for groundwater-related matters; the federal state has no power to intervene.

Groundwater matters are discussed with Belgium in the context of regular informal contacts ad high administrative level. At first, discussions were canalised by means of the Benelux Economic Union. This Union, which created a customs union between Belgium, Luxembourg and the Netherlands immediately after World War II, also, in 1979, convened a Standing Working Group on Groundwater. The Benelux Union, which has a relatively small permanent secretariat in Brussels, takes particular care of relations between local and regional authorities.

The Benelux Working Group on Groundwater uses to convene twice a year, usually together with a Belgian/Netherlands-Commission dealing with transboundary non-navigational watercourses; the delegations to both fora were largely the same. Since 1997, due to the Belgian federalisation, both fora were taken out of the Benelux structure and merged into the so-called "Netherlands-Flemish Integrated Water Management Consultations", while a separate, new consultation body between the Netherlands and Wallonia was set up. The Netherlands-Flemish consultations are chaired by the Director-General for the Environment of the Flanders administration and the Water Director Affairs of the Netherlands Directorate-General for Public Works and Water Management; both administrations also provide a secretary. Members are, on the Flemish side, representatives of the central administration's services for the environment, public works, and mining; of regional companies in the environmental and drinking water fields; and of the concerned provincial administrations. On the Netherlands' side, the Ministries competent for Water Management and for the Environment are represented, as well as the administrations of the three southern provinces.

Decisions of the Benelux requiring the parties to notify to each other any project menacing to appreciably affect their groundwater and installing a body for dealing with damage compensation issues remain valid. Moreover, in 1993, it was decided that drainage-area-committees were to be set up, dealing with groundwater and surface water, quality and quantity problems in an integrated way. All local and regional competent authorities are being represented in these committees. As far as groundwater is concerned, they are charged with:

- implementing international agreements;
- co-ordinating policy objectives;
- exchanging information on projects on both sides of the border;
- drawing up surveys of groundwater abstraction in their area;
- drawing up transboundary management programmes;
- initiating and participating in integrated water management projects;
- preparing common projects open for EC subventions;
- drawing up a yearly report and a yearly action programme.

The delegations must have the same size, but they may be assisted by external experts. The committees may create sub-committees, and even joint sub-committees for studying groundwater movements in the deeper layers, where two or more drainage basin committees are concerned.

In 1994, four committees were installed alongside the border between Flanders and the Netherlands. All of them are meeting twice a day, and they either have issued or are in an advanced stage of introducing their "management vision papers". Under the Wallonian-Netherlands consultations, a fifth committee was installed in 1997. The whole system will eventually be connected to the International Meuse and Scheldt River Commissions.

Even if these bilateral fora have no legislative or executive powers, the system works. It brings together all authorities competent in the groundwater field, at local as well as legislative level; it makes the responsible people work together, understand each other, and recognise where and how win/win-solutions can be attained. We are rather reluctant to give direct executive or legislative powers to international commissions; thereby, groundwater policy-making would no longer be subject to parliamentary control, and would be isolated from other, related policy fields such as environmental policy, physical planning, land use, nature conservation, agriculture policy and tourism, and integration of these policies would be made considerably more difficult.

5.2 Relations with Germany

As concerns Germany, another federal country where the Länder are in charge of groundwater policy, I can be brief. Up till recently, contacts over groundwater matters have been incidental. I already mentioned the brown coal mining case; because of the groundwater being pumped out of the German mining sites and diverted to neighbouring brooks, the groundwater table downstream in the Netherlands will be lowered, and soil subsidence risks are generated. At first, the Land Nordrhein-Westphalia refused to grant a request by the concerned Dutch province to establish an environmental impact statement on the consequences on Netherlands' territory, but after an intervention on national scale, it revised its opinion, and is now co-operating with our province.

No bilateral commissions or working groups exist with competence in groundwater affairs, but lately, some groundwater matters have been raised within two subcommittees of our Bilateral Commission for Transboundary Waters. No one raised objections against this procedure, and this example may well be followed by other subcommittees.

Chapter 11

Centralized vs. Decentralized Approaches to Groundwater Management and Allocation in the Context of Overdevelopment

A Comparison with Respect of Criteria of Sustainable Use: Transferability, Efficiency, Equity

Gregory A. Thomas
Natural Heritage Institute, San Francisco, California, U.S.A.

1. INTRODUCTION

This paper seeks to derive from groundwater management regimes that have evolved in the western United States some lessons that may be useful in devising allocation and management systems in other settings also characterized by unsustainable levels of demand. For groundwater as for other amenities, allocative rules become necessary when the consequences of one person's consumption choices decrease the access or increase the costs for another consumer. That is the case where high extraction levels are associated with falling water tables, for instance, with the shared aquifers on which the Israeli and Palestinians depend.

Because the western United States reached this point where groundwater became "an economic good" somewhat earlier than other regions (in the 1930s in California), it has had several decades to experiment with an array of property rights concepts and management institutions. While time does not permit a rigorous or exhaustive comparison of the advantages and disadvantages of these approaches, some more casual observations are presented herein with respect to certain performance criteria that would be expected to be of universal pertinence to the design of resource management institutions, i.e.: *sustainability* (do the rules prevent or discourage present consumption at the expense of future use?), *transferability* (do the rules foster relatively free market transactions that can allocate the resource according to highest economic uses?), *efficiency* (do the rules maximize benefits relative to costs?), and *equity* (are the differentials in the distribution of groundwater supplies generally viewed as fair and defensible?).

2. APPROPRIATIVE AND CORRELATIVE RIGHTS

In general, in the western United States (and rather uniformly throughout the world), groundwater is regarded as belonging in the first instance to the state or the people at large. For instance, in California, the Water Code provides:

"All water within the State is the property of the people of the State, but the right to the use of water may be acquired by appropriation in the manner provided by law" (Water Code §102).

And, a standard water law treatise states that "[a]n appropriative water right is real property that can attain the status of fee simple... The right is taxable, transferrable with or without the land, and constitutionally protected at both the state and federal levels."

Individual property interests in groundwater are acquired basically through the rule of capture, and as an incident of the ownership of the overlying land. But the amount and rate of extraction is governed by the correlative rights of other users with certain preferences being recognized. Correlative rights means that any individual pumper's right to extract water is limited to the rate and amount that will not harm any other pumper drawing from the same groundwater basin. In theory, that usually means that the right to extract is limited to the safe yield (the long-term recharge rate) divided by the number of pumpers using the resource. In practice, the matter is much more complicated by issues having to do with the depth and spacing of individual wells. The rules are enforced, as other encroachments on real property rights, through demonstrations of actual injury in a court of law. The enforcement barrier is quite high in that the proof depends on hydrogeologic interconnections that are expensive to ascertain and demonstrate. Considerable impairments of rights will be tolerated before an aggrieved party will find it worthwhile to pursue a remedy.

That is one reason why the actual allocation of the resource will often be governed more by the preference rules than by the correlative use rule. The preference rules fall into a hierarchy which will vary from one jurisdiction to the next. Colorado, for instance, is a state that administers its groundwater with an unusual degree of hydrologic reality. Unlike most other western jurisdictions, Colorado law recognizes that surface and groundwater are not discrete resources but are often intimately connected. Thus, its allocative rules distinguish between groundwater that is tributary to surface water and groundwater that is non-tributary. Tributary groundwater is subject to the same allocation rules as the surface flows, namely the doctrine of prior appropriation. Under this doctrine, the user preference goes to the earliest user to physically control the water and put it to a "beneficial use" (providing that use is maintained thereafter and not abandoned). Beneficial uses include virtually any use that provides social, economic, environmental or recreational benefits.

California preference rules basically work as follows: Overlying landowners have the first and best right to pump their groundwater, but this right is limited to the amount of water that is put to "reasonable use" for some beneficial purpose. With respect to each other, overlying owners have correlative rights and share proportionately in water supply reductions in the event of shortages. Where the groundwater basin had been "adjudicated," the court "equitably apportions" the available groundwater among the overlying landowners. Groundwater recharge that is surplus to current reasonable uses on all of the overlying lands may be appropriated for use elsewhere. Here, temporal priority prevails such that the appropriator who is first-in-time is first-in-right. Reductions in water use are imposed in reverse order of seniority. Those who import water for groundwater recharge, as in a conjunctive use program, enjoy a right to abstract that imported water in preference to other users, either for use on or beyond the overlying lands, subject, however, to usual limitation that injury to other groundwater users must be avoided. A final complication is the doctrine of "prescription", which essentially confers a property right in groundwater upon a user who has openly pumped the water for a period of five years or more and has developed a reliance on its availability, irrespective of whether that pumping was legal and pursuant to right. Thus, established uses ripen into enforceable rights over time. The principal limitation on the prescriptive right is that it does not attach in cases where the water has been pumped to the detriment of a public agency such as a municipality or an agricultural water district.[1]

[1] Unlike California, most states, particularly those with centralized permit systems, have rejected this principle of acquisition due to their need "to estimate with some certainty the availability of unappropriated water; the possible existence of prescriptive rights make it difficult to do this" (Tarlock, p. 5-99-5-100). In California, "for prescriptive rights to be effective enough to oust an overlying owner or an appropriator, they must infringe upon these rights in the traditional, open notorious, and hostile manner for the requisite term [five years]. This means that as soon as a lowering of the common water table is observed, the pumpers are put on notice that an overdraft is occurring and they should initiate legal

3. MANAGEMENT BY LOCAL WATER DISTRICTS

Local water management entities in the western United States take many forms. The forms described in this paper are the California Water Districts, which are governed by the irrigators whom they serve with voting power weighted according to acreage, and the California Irrigation Districts, which are governed by popular franchise within their service areas. These districts are quasi-municipal corporations, chartered by the legislature and are considered agencies and instrumentalities of state government for purposes of many statutes which empower and impose duties on state agencies, including notably the California Environmental Quality Act which requires public agencies to assess the environmental consequences of their actions before undertaking them. These districts, in the main, deliver surface water supplies under contracts with either the U.S. Bureau of Reclamation's Central Valley Project or the State of California's State Water Project. Water from these projects is delivered to a total of about 60 active water agencies responsible for various forms of water distribution and management. These projects are operated in a coordinated fashion. Together, they comprise the largest irrigation water development project in the world, delivering an annual average of some 10 million acre feet (equivalent to 14 thousand million cubic meters) of water. These districts are featured not because they manage or deliver groundwater in California – with rare exception they do not – but because their form and structure are well developed and easily adaptable to groundwater development and allocation. They represent, in any event, the quintessential example of a local water management entity in the United States, organized, governed and financed by the farmers whom they serve.

In general, districts are organized as public corporations, and are empowered to levy taxes and obtain private property through eminent domain when required for legitimate district purposes (Frederick & Hanson, 1982). They are responsible for contracting with State and Federal water supply agencies, and may also be responsible for securing water rights. Districts range from small organizations of farmers with each district resident of voting age given voting rights, to limited corporate owners with vast tracts of land and voting rights granted on the basis of property ownership.

For example, the Central California Irrigation District contains over 1800 different farmers with equal representation (dependent upon resident status).

steps to protect their interests" (E. Robert, Beck, p. 211). It should be noted that as of 1980, prescriptive rights cannot be acquired against the state of California itself (Tarlock, p. 5-100).

In contrast, in 1979 the Westlands Water District was reportedly controlled by only four or five large owners, and in the Tulare Lake Basin Water Storage District a single corporation had dominant control of all elections and management decisions (DWR, 1979).[2]

4. CENTRALIZED GROUNDWATER MANAGEMENT THROUGH STATE-WIDE PERMIT SYSTEMS

Regimes that administered groundwater in a centralized manner issue permits defining rates and timing of extractions and generally setting certain metering and reporting requirements. The regimes vary, however, with respect to the management objectives and criteria employed. For example, Arizona's permit system is designed principally to stabilize groundwater levels in response to a legacy of overdrafting. Thus, it principally governs (and reduces) already existing groundwater pumping under a rule of reasonable use. In other jurisdictions, such as Colorado or New Mexico, the principal purpose is to systematize and prioritize future appropriations of groundwater as an adjunct of the surface water permit system, which is also governed by the doctrine of prior appropriation.

Under the Arizona model (management of groundwater overdrafts), the state is divided into management areas corresponding with groundwater sub-basins, each with its own director. Additional management areas can be created by the central authority or through initiative by local interests. The management criteria are expressed as a timetable for achieving safe-yield, which is defined as a long-term balance between annual withdrawals and natural and artificial groundwater recharge. The director of each management area promulgates management plans, after public hearings, which require the director to impose increasingly stringent mandatory conservation measures on all groundwater users within the area until the safe yield goal is met. In the event that management plans do not prove sufficient to meet the conservation goals, the director is empowered to purchase at fair

[2] Many of the larger water district landholdings have been gradually divested during the past five years in response to acreage limitations for receipt of low cost federal water set in the 1982 Reclamation Reform Act. However, several investigations have found that many apparent divestments are simply paper reorganizations which continue to be operated collectively as single large farms (GAO, 1989; NRDC, 1989; Villarejo & Redmond, 1988). New legislation has been introduced in the U.S. Senate to close the loopholes which have permitted acreage limitations to be exceeded (Bradley, S.2658 and S.2659, 18 May 1990).

market value (and retire) groundwater rights used for irrigation. The purchases are financed out of a tax on groundwater pumping that is levied on all persons withdrawing water within a management area. Domestic wells below a given threshold are exempt from the management program and the fee, except that they, like other wells, are required to register.

The approach in other western jurisdictions, such as New Mexico and Colorado, is to delineate basins which have "reasonably ascertainable" boundaries, and then issue permits for new appropriations within these basins based upon findings that previous users (of either groundwater or surface water) will not be injured. Notice of the application for a permit is published in local newspapers and existing rights-holders have the opportunity to file protests. In the event of a protest, the applicant has the burden of demonstrating to the centralized permit authority that the requested groundwater use will not unreasonably interfere with the existing water rights. That proof can require complex and expensive hydrogeologic evidence.

Although centralized water management regimes differ in terms of objectives and permit criteria, the basic feature common to all such systems is that the state agency operating the regime is granted sufficient political power to implement and enforce its allocation decisions (Smith, 833). The responsible state agency is given the power not only to issue permits and establish criteria, but also to resolve conflicting claims, bring suit against violators, condemn property, and purchase and import water from outside the district. Such powers are not merely implied, but rather are granted expressly in the enabling legislation.

Where authority is centralized, safeguards are sometimes needed to ensure that the responsible agency does not fall prey to interested parties to improperly interfering with either the fact-finding or decisionmaking processes. These rules usually focus on avoiding employee conflicts of interest, requiring open hearings, and punishing persons (both inside and outside the agency) who violate these conduct provisions (World Bank Paper, 1981, #458, 133).

The United States' experience with centralized water management regimes indicates that such regimes have fairly predictable advantages and disadvantages. The advantage of the centralized approach is that it allows decisions to move beyond immediate local interests to address those of the public at large, future generations and the environment. The most significant disadvantage of the centralized model is the administrative and bureaucratic apparatus necessary to operate such a regime. A centralized water allocation system requires a professional staff of trained experts (in areas such as economics, law and hydrogeology) as well as an understaff to retrieve and compile facts (Lee, 1990, p. 607). Without such human resources, the responsible agency will be unable to make informed decisions. In choosing a groundwater management model, a state must determine whether it can provide the funding and personnel necessary to effectively implement a centralized regime.

5. FACTORS FOR COMPARATIVE EVALUATION

5.1 SUSTAINABLE USE

Groundwater basins can be managed either as a renewable resource, where extractions are balanced with recharge over time, or as an exhaustible resource that it is eventually depleted. The western states have occasionally decided that it was necessary to mine certain basins for short term stability and growth. This is not a wise policy in the long term, particularly in the absence of some assurance that the groundwater source will be replaced by new, stable surface supplies.

In evaluating the degree to which management approaches along the decentralized-to-centralized continuum foster sustainable use of groundwater, three interrelated considerations come into play: (1) How successful is the approach in avoiding overdrafting of the aquifer(s)? (2) How well does the approach generate the information on the use of the resource that is critical to sustainable management decisions? (3) How well does it foster the conjunctive management of groundwater and surface resources? Each of these will be explained briefly.

Overdrafting of groundwater basins is generally considered the measure of unsustainable use of the resource and is the probable result of unrestricted or unmanaged usage. It results wherever withdrawals exceed natural or artificial recharge over the long term. Short-term variations in water table levels are expected as a result of natural fluctuations in precipitation from year to year and become purposeful when the aquifer is utilized as a storage structure in a conjunctive use modality. Thus, the most effective system may involve depleting the basin below optimal levels in dry years and recharging it above the optimal level in wet years. Active recharge occurs when water is imported to maintain groundwater storage; it is passive when recharge is accomplished through the ordinary percolation of surface waters, such as from tributary groundwater. Managing a basin to preserve it over time may mean that growth will be more limited, but it ensures that there will not be an abrupt disruption of supply in the long term. Basin preservation also avoids effects associated with groundwater mining such as land subsidence, loss of wetlands, and salinity intrusion.

Long-term sustainable management of a groundwater basin requires that some entity – the pumpers themselves, courts, regulatory bodies, local management districts or permitting authorities – make decisions on an ongoing basin regarding timing, volume and location of groundwater extractions. These decisions can be made only or best if based on information regarding pumping rates, recharge rates, surface-groundwater interactions, basin size and boundaries, hydrostatic pressures, potential sources of contamination, etc.

Often what is regarded as a water scarcity crisis is in reality a water management crisis. One management innovation that can alleviate scarcity and promote supply reliability is conjunctive management of surface and ground waters. Conjunctive use is simply the coordinated management of ground and surface waters to even out the interannual variations in precipitation and thereby provide a more reliable water supply. Basically, underground basins are used to store water generated in years of above average runoff for use in years of below average runoff, just as a surface reservoir is utilized. Indeed, surface storage is usually a necessary part of a conjunctive management program since the water must be stored during the periods of heavy runoff for "spreading" or percolation into the groundwater basin during drier periods when the soil is not already saturated. During wet years, all users rely primarily on surface supplies and store the excess underground. In drier years, the stored groundwater is pumped to supplement the inadequate surface supplies. Thus, groundwater is actively recharged and the sustainable use or safe yield rates are substantially augmented.

Conjunctive use must be understood as a purposeful strategy of coordinated use of developed surface and groundwater. This is to be contrasted with the common scenario of excessive groundwater mining eventually creating a political mandate for large-scale surface water development to "bail out" the groundwater users. These types of projects are generally so expensive that the groundwater users cannot afford to use this substitute water supply unless the costs are heavily subsidized, as was the case with virtually all of the reclamation projects during the past 90 years in the United States. These projects are usually further subsidized through very large and uncompensated costs to the aquatic and riparian ecosystems. The extent of these costs is nowhere more graphic than in the Pacific region of the United States where the salmon fishing industry is on the brink of collapse as virtually every anadromous fish stock has been declared to be on the brink of extinction. The most important cause of the declines in these populations is irrigation water dams and delivery projects that were made necessary by historic patterns of unsustainable use of groundwater in the western states. The economic and environmental costs of this bailout scenario are much higher than the costs of a well-managed, sustainable, conjunctive use program.

5.1.1 Decentralization

As long as groundwater is plentiful, a decentralized system can work satisfactorily because there is little need to manage or allocate it. However, where groundwater is scarce, the decentralized system may result in significant overdraft of groundwater basins and related problems such as salinity intrusion and land subsidence. These problems are often very serious because overlying owners fail to become sufficiently concerned about them until the basin has reached a critical state (de Lambert, 1984, p. 373).

Unless rights are defined and limited through agreement or adjudication, a decentralized system does little to prevent overdraft or encourage conservation. Water users have little incentive to voluntarily undertake such measures because they have little assurance that their efforts will benefit the basin as opposed to other water users. While overlying owners must use groundwater reasonably and avoid harm to other overlying owners, the "reasonableness" standard tolerates substantial inefficiencies and it is usually difficult to judge when use begins to harm other owners in the absence of clearly defined rights and well developed information concerning extractions from the basin. Because of the costly and difficult hydrologic proofs required to demonstrate the fact and extent of injury, the threshold of injury is rather high before remedies can be sought. The preference rules help to some extent. Water exporters (those using groundwater off the overlying land) may be relatively easy to curtail because they enjoy the lowest priority. Water importers are protected because an importer of recharge water has first call on its extraction.

A prerequisite to management and control of groundwater is the ability to measure groundwater pumping at particular wells. Yet in a decentralized system, it is essentially impossible for one landowner to force another to monitor and report groundwater use. The individual water users within a decentralized system are also unlikely to have the means or the interest necessary to obtain sophisticated information concerning the characteristics of the groundwater basin. Thus, where water is sufficiently scarce, water users in decentralized systems may seek adjudication of their rights as a means of developing the information necessary to effective management of the groundwater basin.

In a number of areas in California, judicial solutions have been fairly successful in restoring the basins. In a water rights adjudication, a court establishes a physical solution to the overdraft problem by obtaining information about the groundwater in the basin, defining and limiting the water rights of all of the users of the groundwater basin, and setting up a "watermaster" to administer the judgment. The court retains jurisdiction to amend the judgment in the future if additional issues arise that the watermaster cannot address.

The watermaster can be a person or a committee of persons who are expert in water issues and possibly representative of different water use interests in the basin. The most effective basin adjudications are those where the watermaster has broad, flexible powers to administer the judgment and address situations as they arise. Watermasters generally have the power to require pumpers to file periodic reports. levy a pump tax, replenish water in an aquifer, import water for spreading and replenishment of aquifers and control storage within the basin (Murphy, 1984, p.34; Mallery, 1983, p. 1294). The watermasters do not usually work in isolation; they must coordinate with a number of state and local agencies to address issues of water supply and demand for the basin users. With sufficient powers and flexibility, watermasters have been successful in eliminating overdraft problems in groundwater basins by limiting demand and obtaining supplemental surface supplies with fees paid by the groundwater users.

Nevertheless, it should be noted that a court does not examine water problems comprehensively, but confines itself to the rights of the parties before it. It does not consider the interests of other right holders, the general public or the state in the management of the scarce resource. Moreover, by the time local water users are forced to seek a judicial remedy, the court may be loathe to reduce extractions because the local economies may have come to depend upon more water than safe yield will allow. When a management structure has been created through negotiation or adjudication, however, compliance with management measures is quite good. The court generally retains jurisdiction to address any serious problems that cannot be handled by the watermaster.

Because critical overdraft of groundwater basins is likely in a decentralized system, water users are often forced to seek ways to increase surface water supplies both as replacement water and to prevent land subsidence and salinity intrusion. Importing surface water is often quite expensive and becomes less feasible as available sources are tapped out. Conjunctive use arrangements, which may avoid the groundwater mining and surface water bailout cycle, are unlikely to emerge in a decentralized system due to the lack of sufficient information and motivation. Individual water users will usually be unable to arrange for the recharge of groundwater in that conjunctive use programs can be very costly and no single owner has any guarantee that he will benefit from the recharge of the groundwater basin in a system of undefined rights.

If water rights have been adjudicated, conjunctive management may be more feasible because extractions can be controlled. However, in an adjudicated basin, water users are less likely to rely on surface water as the watermasters generally attempt to limit the demand of all water users so as to gradually restore the basin. Watermasters seeking surface water to augment groundwater supplies generally lack jurisdiction to order or facilitate interbasin transfers that may be necessary to implement a conjunctive use program (de Lambert, 1984, p. 384).

5.1.2 Local District

Management by local districts may be a less expensive and time-consuming alternative to adjudication. Local districts can control groundwater pumping by their members in several ways. Where the district supplies surface water, it can price that supply at a rate below the cost of lifting groundwater at a sustainable rate. It can also use surface supplies to replenish the groundwater. This is the technique of the Arvin Edison Water Storage District in Kern County California, for instance. The local district can also own or operate the wells on behalf of the members. Or, the local district can be vested with the power to orchestrate the pumping and recharge of groundwater by its members.

Where a local district management structure has been established by the water users, compliance with conservation requirements and other management measures tends to be quite high. In California, parties have demonstrated such a strong record of voluntary compliance with these management programs that sanctions and enforcement measures have been unnecessary (Blomquist, 1992, p. 302). This is explained in part by the fact that the management programs are perceived as legitimate and fair because the districts are created and governed by the water users themselves (Blomquist, 1992, p. 347). Individual water users also tend to believe that they are benefiting from basin management and feel confident that they are sharing the costs and burdens equitably (Id. 302, 347). This sense is supported by the close contact between the district and the users and the readily available monitoring information concerning the problems of the groundwater source.

This harmony is a tenuous one, however. In California, the landowners have resisted direct control by the districts of groundwater use. In theory, local districts generally have the finances and the legal authority to develop comprehensive information concerning pumping rates and locations and the hydrogeologic characteristics of the basins they are managing. They can, for instance, require groundwater pumpers within the district to meter their pumps and report extractions to the district. They can also, in theory, impose limitations on groundwater pumping to assure sustainable yield, for instance, as a condition on the eligibility of the landowner to receive surface water deliveries. As a practical matter, however, this has not happened in California. The landowners regard their groundwater as private property and have been extremely resistant to any outside control or even monitoring. This xenophobia extends even to the water districts that supply their surface water. Since California Water Districts are controlled wholly by their member-farmers, and even the Irrigation Districts are dominated by farm interests, the districts have not sought to place any direct restrictions on groundwater use and often do not even know who is pumping how much water or when. Since the right to receive a specified share of the district supplied surface water is a contract right, the districts have not been able to place groundwater management preconditions on the provision of surface water.

This managerial impotence is, however, an artifact of the way in which the California districts are established and governed, and not a necessary attribute of the district management model.[3] Districts could certainly be formed under an arrangement where eligibility to receive water from the district was contingent upon the farmer/landowner agreeing to reasonable controls on the extraction of groundwater. Indeed, NHI is currently defining a conjunctive use program for California in which the right to receive recharge water (above current entitlement), would depend upon a contractual agreement permitting the district to orchestrate both the recharge and discharge of the supplemental water.

There are also several notable cases of groundwater management districts in Southern California achieving a high level of success in imposing monitoring and reporting requirements on groundwater pumpers. However, these are districts with relatively few member-pumpers, and most of these

[3] In 1977, the Governor of California created a Commission to review California water rights law. Based on this review, the Commission recommended the formation of local management units in areas where groundwater was not already managed through adjudication or local districts. The Commission further recommended that these units should have powers similar to those exercised by many existing districts and court-appointed watermasters. Finally, the Commission recommended that a central state agency should have authority to evaluate and approve local management programs and to seek judicial relief through the attorney general in the event local programs failed to meet broad, state-management objectives (Smith, 1984a, p. 241). These recommendations suggest that the system best able to promote sustainable use may be one that uses elements of both the local district and the central agency approach.

are municipalities where long-term reliability of supply is a very high priority. This information reported is quite detailed and accurate because the districts work closely with the water users (Blomquist, 1992, p. 344). The primary deficiency may be a lack of information on the hydraulic interconnections among basins and districts.

The primary limitation on the ability of local districts to effect sustainable use of groundwater is that district boundaries often reflect political considerations rather than the hydrogeologic boundaries of the groundwater basins on which they draw. The result, of course, is that individual districts act like individual landowners drawing from a common resource. The incentive is to capture as much as possible before the neighboring district does so. While this can be controlled through contractual arrangements among districts, it is more readily controlled through a groundwater permit system administered by an authority superior to the individual districts.

Another weakness of local districts in terms of promoting sustainable use is that they are more easily pressured by the water users they serve to avoid limiting extractions. An important element of the management systems adopted by most local districts to date has been use of a supplemental surface water supply, particularly in agriculturally-dominated basins. The most extreme example of this is the Orange County Water District which has made no attempt to limit demands on groundwater but rather has purchased whatever additional surface water supplies are necessary to recharge the groundwater basin. This program has been successful to date because additional surface water has been available for purchase. However, this approach is not advisable in the long run in that it merely transfers water management problems from one media to another. If surface supplies are not available or become more limited in future, some districts will have to revise their management strategies (Mallery, 1983, p. 1292).

In California, local districts generally have the power to establish a conjunctive use system. The problem is that the boundaries of the local districts may not coincide with those of the groundwater basin, making it difficult for them to operate an efficient basinwide conjunctive use program. This problem might be addressed as an initial matter by setting up districts with boundaries that correspond to groundwater basins. Local agencies that already exist may enter into contractual arrangements to jointly manage a basinwide conjunctive use program. However, the transaction costs involved in joint management of a basin between assorted local districts may be high, and the success of such joint management arrangements has not yet been tested seriously. A better solution might be to create an overarching state agency with the power to organize and mandate conjunctive management by local districts (see Krieger & Banks, 1962, p. 75).

5.1.3 Centralization

As a general proposition, groundwater is more likely to be used sustainably under a more centralized management structure. Groundwater permit systems are structured specifically to assure sustainable use of the resource over the long term. Analysts contend that a centralized state management system is better able to protect groundwater basins because the state is less constrained by contractual and fiscal considerations than are the local water districts. The remoteness of a central agency from the demands of particular areas or water users also makes a central agency better able to resist short term pressures to exploit basins and allows the agency to take into account the broader water situation of interrelated basins and the state as a whole. A central agency can also construct large projects more easily and import water more efficiently to overdrafted regions (Mallery, 1983, p. 1293).

In a centralized system, voluntary compliance is less likely because water users are more remote from the management structure. This means that they are less likely to be convinced that the system is responsive to their interests, that they are benefiting from it, or that others will fairly share the sacrifices. A central agency must rely more heavily on enforcement and sanctions to ensure compliance. However, the agency may be slow to discover violations because it is more difficult for a remote central agency to monitor activities closely. To increase effectiveness, a central agency might seek assistance from local agencies and/or institute citizen suit provisions designed to encourage citizens to become enforcement watchdogs.

A centralized agency may have the power and the finances necessary to develop general information on basins and pumping, but it is less likely to be motivated and able to develop extensive and comprehensive information on every basin within its jurisdiction. Large systems have more difficulty collecting, acting upon and communicating information, especially about complex problems, and they are more vulnerable to information losses (Blomquist, 1992, pp. 344, 350). On the other hand, a central agency may be more motivated to investigate the relationships between basins and the impacts of pumping practices across different areas.

A centralized agency should be well situated to manage a conjunctive use program, taking into account long-term management opportunities. Unlike local districts, a centralized agency is not constrained by boundary problems. All groundwater basins are within its jurisdiction. Moreover, if surface waters are already regulated by a centralized agency, some argue that it makes most sense for the same agency to manage groundwater since these are interrelated resources (Mallery, 1983, p. 1307). On the other hand, setting up and managing a conjunctive use program for all of the basins in a state might be a burdensome undertaking for a single agency, leading to unnecessary delays and poor responsiveness to changes in circumstances. Providing for input from local agencies might alleviate these problems, but would probably not eliminate them.

Centrally administered water management is best suited to foster conjunctive management of surface and groundwater with respect to all of the considerations described in this paper. Where use of water is defined by permits, the rights and obligations are prescribed and can, as necessary, be adjusted. The use of water for groundwater recharge can be accorded an appropriate preference in the issuance of surface water permits. Basins for storage can be designated and used without restricting the benefits to the overlying landowners. And, the state authority can take steps to either eliminate the hydrogeologic uncertainties associated with basin boundaries and their hydrologic inter-connections, or provide mechanisms for spreading the costs and risks associated with the residual uncertainties. A centralized authority can, for instance, assess a pumping tax on all groundwater extractions and use the funds to generate recharge water (by, for instance, financing water conservation improvements, retiring marginal irrigated lands, or creating surface storage reservoirs).

For the same reasons that a central agency is well situated to promote sustainable use, it is likely to avoid reliance on surface water bailouts. A central agency is not subject to such immediate pressures from particular water users to deplete groundwater supplies, and must consider the effects of surface water importation on the areas from which the water was taken as well as the area to which it is supplied. Thus, a central agency is much less inclined to turn to surface supplies as a remedy for overdraft except insofar as they can be used to set up an effective conjunctive use program.

5.2 Transferability

This section examines the degree to which the rights created in the groundwater resources under the various management approaches fosters or inhibits the transfer of groundwater from the person or entity that pumps it to the broader array of users, generally remote from the land holding on which the well is located. Thus, we take maximal transferability to be a virtue in achieving the greatest beneficial use from the groundwater resource. It also notable that a developed water market tends to place a relatively high value on groundwater that reflects its relative scarcity. This creates financial incentives to use the resource efficiently compared to the situation where water users may not be placing an appropriate value on the water they use because they either receive it for free, pay a subsidized rate for it, or use more than they need. If wasteful users could sell quantities of excess water, they would realize that wasted water is wasted money (Gregory, 1992, p. 249). Similarly, water users may decide that the value of selling their water is higher than their intended use of the water. The sale of this water is efficient in that it transfers the water to a use with greater economic value.

There are some threshold issues to consider in setting up a market-oriented approach to distribution of water. Although a market system should ensure that water is used most efficiently for the highest valued uses, the transfer to efficient, highly valued uses may be politically problematic. For example, rural communities where prosperity has depended on the availability of large supplies of low-cost water might be faced with a declining economic base. This result may be equitable and logical from a market standpoint, but it may be disruptive to the extent that it causes serious social change (Murphy, 1988, p. 43). If such changes are politically unacceptable, a market system is probably still recommended, but protections or subsidies of some sort may be necessary for certain groups who will not be able to afford the new water prices.

In order for a groundwater transfer system to function properly, rights to groundwater must be well defined and enforced. Indefinite rights have little appeal to potential purchasers. Another important requirement for a successful groundwater transfer system is a method of preventing unreasonable impairment of the rights of others who may be affected by the transfer. In the absence of formal limits on the effects a third party must endure, the market commodity is not as well defined as it can be (Emel, 1987, p. 654). It is interesting to note here that the worst cases of overdevelopment in the United States have occurred in states using the "reasonable" impairment approach as opposed to formal rules setting forth more specific limits on third party impacts (Emel, 1987, p. 671, n. 60).

5.2.1 Decentralization

Unless rights are clearly defined through adjudication or agreement, a transfer system is unlikely to be successful under a completely decentralized groundwater rights system. Water users in such a system know only that they have the right to reasonable use of the basin without specific quantification of how much use is reasonable. Moreover, water users in a completely decentralized system are unlikely to have the means to evaluate the effects of transfers on third parties. Finally, in a system such as the one in California, transfers to non-overlying owners are prohibited unless there is "surplus" water in the basin (i.e., water not needed by other overlying owners). These conditions greatly inhibit a water market.

Once rights in a basin have been determined through adjudication, a transfer system becomes more feasible, although courts in the United States have been somewhat leery of water "speculation." The watermaster or other administrative body can gather the data and apply the models necessary to evaluate the hydrologic responses of proposed pumping scheme changes. Presumably, an overlying owner could even transfer his right to a non-overlying water user as long as this transfer did not impermissible impair the rights of other water users. However, when basins are locally managed transfers out of the basin are likely to be discouraged or prohibited, limiting the effectiveness of the overall market transfer system.

Some analysts assert that a decentralized, privately run water market would threaten both environmental quality and the rights of nonurban constituencies by ignoring the noneconomic values of water. The transfer of water under a decentralized system may redistribute water to those most able to purchase it without necessarily taking into account communal values, traditional cultural patterns and other factors that may not be represented in the water market. In other words, there may be tradeoffs between efficiency and equity.

It may be possible to avoid these problems in a decentralized water market system by establishing public interest provisions regarding water rights transfers in water codes or constitutional provisions. This may be done by placing the burden of proof upon the applicant for a water transfer to demonstrate that the transfer is in the public interest or that other factors outweigh public interest concerns (Cummings & Nercissiantz, 1992, p. 750-1).

5.2.2 Local District

The operation of a transfer system under the management of local districts should be quite similar to systems administered by local watermasters or other locally appointed authorities. The rights of water users in a local district should be known and easily transferable within the basin. The local district generally has powers which enable it to set up a transfer system to reduce the transaction costs involved in the functioning of the market. For example, the district may set up a "common pool," gather information identifying interested buyers and sellers and assist in the recording and oversight of the transaction. Local districts also have the information necessary to assess the impacts of particular transfers on the basin and third parties and the power to prevent unreasonable impacts or infringement on the public interest.

The primary shortcoming of the local district system, like the adjudicated system, is that it may tend to interfere with transfers outside the basin. Local districts represent the interests of local water users who benefit from return flow and recharge when water is used on lands overlying the basin. Local districts are likely to protect these interests unless prevented from doing so by state laws or a state agency with oversight powers in this area.

5.2.3 Centralization

A centralized agency is least likely to place protectionist restrictions upon a market transfer system because it is charged with responsibility for state rather than local water management. A centralized agency may also have greater financial resources enabling it to assist with transfers of large amounts of water which otherwise might be prohibitively cumbersome and costly. Additionally, a state-wide agency faces fewer legal obstacles than a more limited regional agency. A regional transfer decision could be challenged on the grounds that the regional agency lacks authority to manage resources outside its limited jurisdiction. A similar state-wide agency transfer, however, would be immune from such a challenge. Its jurisdiction, by its very geographic nature, is more far-reaching and thus less susceptible to attack.

On the other hand, a centralized agency might be less able to efficiently assist with local transfers within particular basins throughout the state. The agency would be removed from the context of local communities, and therefore less aware of the specific needs and dynamics of the parties involved in the proposed transfer. This could result in a knowledge gap and a subsequent lack of responsiveness. Thus, while the centralized agency possesses the legal power to make water transfers less cumbersome, it may lack the regional sensitivity to make such transfers beneficial and responsive.

5.3 Adminitstrative Efficiency

This factor has two aspects. One is the simplicity, predictability, affordability and enforceability of the management and allocation decisions. The ideal is a system that can be understood and used by any potential beneficiary, regardless of sophistication, at minimal transaction costs (i.e., without lawyers and hydrologists, if possible), where the decisions are transparent and reliable without the necessity of intervention by courts, and where the decisions will be enforced without elaborate administrative or judicial processes.

The second aspect concerns how accurately the administrative decisions reflect the physical realities. A groundwater management program is not administratively efficient if it complicates surface water administration or environmental management decisions because it fails to appreciate the interconnections. When surface and groundwaters are interdependent, a management program recognizing this relationship may achieve optimum beneficial use and conservation of both sources. Similarly, when groundwater basins are interdependent, a management program must take this into account for optimum use and protection of the water. Finally, good management should account for the relationship of pumping in one area of a basin on pumping in other areas of the basin.

5.3.1 Decentralization

The decentralized system is the simplest from an administrative standpoint and the one that relies most heavily on the judiciary to resolve the problems that arise. Where water is plentiful, the simplicity of this system is attractive because disputes should be rare and the savings in time and money spent on administration substantial. However, where water is scarce, the merits of this system are questionable.

Heavy reliance on the judiciary is problematic for a number of reasons. First, parties are not often spurred to action until basin overdraft becomes a serious problem. By that time, equitably reducing allocations by adjudication is very difficult because economic damage is likely to be substantial. Second, the great number of necessary parties makes consensus difficult to obtain and causes the litigation to be lengthy, complex and expensive. When the number of water users in a basin is large, it may be virtually impossible to join them all. Interested parties may also be excluded by oversight or objection and, therefore, may not be bound by the judgment or stipulation. Third, the rules of court may not be well-suited to groundwater adjudications. Overdraft presents the possibility of immediate and irreparable harm, yet the complexity of groundwater litigation makes adjudication lengthy, cumbersome and expensive. Fourth, adjudication is limited and local in nature. A judgement cannot decide issues that the parties to a case do not raise, and may not reflect sufficient concern for overall management of state resources (de Lambert, 1984, pp. 389-90). Finally, reliance on the judiciary may be problematic in a state where the judiciary is politicized or lacking in objectivity.

Nevertheless, parties willing to endure the time, expense and limitations of litigation have adjudicated basin rights and set up effective management systems in California. These management systems are fairly simple from an administrative standpoint and inexpensive to administer once the litigation is completed because voluntary compliance levels are high and the watermaster or administrative committee is close to the water users. The court retains jurisdiction to address issues if necessary.

When rights are litigated, the court hearing the case must perform a fairly comprehensive investigation of the hydrogeology of the basin at issue in order make a rights determination that will lead to sustainable basin management. However, a court will not usually investigate the interrelationship of a litigated basin with other basins or the general water situation in the state. Thus, management in an adjudicated basin may take into account hydrogeologic realities within a basin, but not much beyond this.

In a decentralized system such as that in California, percolating groundwater is not generally recognized as being interconnected with surface water. Surface water and groundwater are not even managed under the same legal system. Nor is there much information or awareness of the relationship between groundwater basins or even the effects of pumping within a single basin. An overlying landowner may withdraw percolating groundwater without regard to, and usually without knowledge of, how this affects surface water users and other basin users. If there is a notable connection and impact, a dispute may arise, and a court will attempt to devise a physical solution.

5.3.2 Local District

The administrative complexity of a local district system is similar to that of a system where a water master or other authority oversees an agreement reached through negotiation or adjudication. A certain level of bureaucracy is necessary to the function of any such institution, but local districts are smaller and less bureaucratic than a large centralized agency. Most significantly, the local districts are governed by a board representative of the members to which they deliver water and therefore immediately responsive to their needs and preferences. They can also adapt their programs to address geological, hydrological and political differences in their basin.

In California, local districts may be administratively more complex than they need to be because they have developed on an ad hoc basis and because they have been tailored specifically to mesh with the different water management or supply institutions already in place is their areas. However, they have functioned fairly successfully and economically, perhaps because they are managed by their customers. Water users have a significant incentive to set up water districts that are not wasteful or inefficient because they bear the costs of operation (Blomquist, 1992, p. 343). They may also be less reluctant to pay management costs and more willing to comply with restrictions imposed by a local district or adjudicated system that they have established. In fact, at least one analyst asserts that the overlapping, polycentric systems developed in California reflect efficient functional specialization rather than wasteful duplication and chaos (Blomquist, 1992, p. 341).

A local district system does not rely on the judiciary for the basic rights determination and information gathering needed in a decentralized system. The local districts have the power to undertake these tasks themselves, although parties may still demand recourse to the courts in some cases. Recourse to the courts is also necessary to resolve disputes between local districts unless a central agency is empowered to resolve such disputes in an overseeing role.

Like a court, a local district generally limits its investigation of hydrogeology realities to the basin for which it has responsibility. A district may investigate interrelationships with other basins to the extent that use in those basins is negatively impacting its own basin, but otherwise it has little interest in such information.

5.3.3 Centralization

A centralized system is likely to be highly complex from an administrative standpoint for many reasons including the fact that the task of administering a management program for all groundwater basins in the state would be enormous. It is also well known that central agencies with broad powers tend toward bureaucracy and conservativism, resulting in general delay and resistance to taking action or changing policy. Further, studies show that central agencies tend to develop their own agendas, distinct from the mission entrusted to them, based on a desire to survive and expand as an institution. (Anderson, p. 158; Ostrom, 1971, pp. 36-37). The expenses involved in running a central agency almost always escalate over time as the agency follows a natural course of expansion and specialization.

These tendencies are problematic where dynamic and innovative management is needed, and are perhaps the most important reason to resist complete centralization of a groundwater management system. On the other hand, some centralized control is beneficial because a central agency is generally more balanced in terms of its consideration of local and statewide interests and provides broader long-range planning. A centralized system is also least reliant on the judiciary, given the power of a central agency to resolve many conflicts that would otherwise be taken to court. Ultimately, however, a central agency must rely on the judiciary for the enforcement of its orders if they are disputed.

A central agency is much more likely to take an interest in investigating basin relationships and general interaction between different water supplies throughout the state because it is responsible for statewide management. Moreover, a central agency should have better resources to undertake such investigations. With respect to individual basins, however, a central agency may be less interested in generating the detailed information on hydrogeologic realities that is of such concern to local districts.

Many states with centralized water management regimes have attempted to bring their laws into conformity with the hydrogeologic "realities" discussed above. Foremost among such attempts is the integration of surface water and groundwater management. Many sources of groundwater are fed directly or indirectly by surface waters. Thus a diversion or reduction of surface water will have an impact on the level or flow of groundwater and vice versa. Despite this close interrelationship, most states subject surface water and groundwater to independent, and often irreconcilable, management schemes (Gregory, 1992, p. 257). Colorado is among the first states to address this concern.

Colorado recently enacted legislation which distinguishes between "tributary" groundwater (fed by surface water) and "nontributary" groundwater (not fed by surface water). Under the Colorado approach, tributary groundwater is governed by the same rules as surface water, while nontributary groundwater retains its distinct management rules. Such an approach is enlightened for two reasons. First, by bringing the law into conformity with existing natural systems, the law will no longer struggle to force square pegs into round holes. Allocation decisions, for groundwater and surface water alike, will more accurately reflect scientific realities. Second, by integrating the two allocation and agency apparatuses, the state will improve administrative efficiency.

The best way to obtain the benefits of centralized control while minimizing the problems of bureaucracy may be to create a system that relies principally upon local districts for day-to-day management but places certain limited powers in the hands of an overseeing central agency. These powers would be focused on the goals of reducing conflict between basins and promoting a comprehensive, statewide solution to groundwater management uninhibited by the parochial perspective of the districts. This type of mixed system is particularly appropriate where population and water supplies differ greatly from one area to another.

Another approach with more concentrated decision-making authority at the state level is a system such as the one established in Arizona. In Arizona, the state Department of Water Resources administers all state water laws except those directly relating to water quality. Active Management Areas (AMAs) are established for different areas following hydrological rather than political boundaries. Each AMA has an area director appointed by the director of water resources and a five-member Groundwater Users Advisory Council appointed by the governor.

5.4 Efficiency to Use

This factor is concerned with the extent to which the management approach allocates the use of groundwater in a manner that leads to greatest overall social benefit. There are two aspects to this factor. The first is the policing and elimination of wasteful applications of water. Before waste can be policed, it must be defined. Waste is generally considered to be a failure to put water to a reasonable beneficial use. However, whether a use is considered reasonable and beneficial may vary from area to area and time to time depending upon the scarcity of water and other physical circumstances and social customs.

Overapplication of irrigation water, beyond the amounts minimally needed for crop evapotranspiration and salt leaching (where applicable) may be wasted, for instance, unless the excess percolates to usable groundwater. One should not assume, however, that all such incidental groundwater recharge is beneficial. Timing and location are critical issues. Recharge should take place during relatively wet years, not during years of scarcity. Thus, inefficient irrigation practices, in effect, exacerbate shortages during droughts and deprive some users of a share. Also, it is important that recharge be confined to areas where the water can be recovered economically and without impairment of quality. Thus, over application of irrigation water is inefficient when it occurs in areas where the depth to groundwater is long, where perched groundwater contributes to drainage problems, where salts and other minerals tend to leach into the groundwater, or where chemicals in the soil are likely to contaminate the recharge water.

The second factor of concern is the ability of the management system to allocate scarce groundwater supplies to the most valuable and valued uses. Markets will tend to do this with respect to relative economic value, where water transfers are relatively unfettered. Promoting water use efficiency is one of the primary purposes for adopting a water market system. But economic efficiency is not the only touchstone. Often, questions of social equity and non-economic values such as recreation, aesthetics and biological diversity need to be taken into account. These are dealt with to some extent in the next section.

5.4.1 Decentralization

As noted at the beginning of this paper, decentralized systems allocate groundwater according to the doctrines of prior appropriation and reasonable use. Appropriative rights allocate groundwater according to priority in time, not priority in value of use. The underlying philosophy is that economic development is best promoted by putting water to work early, even if not particularly well. Thus, as long as the use is regarded as "beneficial," the law does not ask how beneficial. Moreover, non-use of a portion of the right leads to its loss. "Use it or lose it" is the rubric. This philosophy is a prescription for inefficient use of groundwater, and the examples of wasteful use abound in the jurisdictions that employ it.

The doctrine of reasonable use implies a certain limitation on the types of uses that will be recognized. In a jurisdiction such as California, both the courts and the water administration authority have the power to curtail wasteful uses of groundwater. However, that power has rarely been exercised because the legal test of what constitutes waste is not very demanding. For example, in California, the standard of reasonableness has historically been judged by the prevailing practices in the community. Thus, if irrigation practices are rather uniformly wasteful, as many observers have concluded, the courts are unlikely to impose sanctions on any particular irrigator. In a 1935 case, carriage losses of over 50% of the water delivered by one water district was judged not to be unreasonable. The modern conception of reasonable use is likely to be more demanding in that prevailing practices are no longer the sole consideration and the general water conservation ethic has increased considerably. Still, the threshold of unreasonableness is likely to remain fairly high and either administrative of judicial interventions to curtail wasteful practices will probably not be frequent enough to inspire substantial changes in water use techniques. Individual users are unlikely to have sufficient information to identify those who are committing waste or sufficient motivation to prosecute wasteful water users in the absence of information demonstrating a serious and direct affect on their own water consumption. This situation may change once users in a decentralized system have adjudicated or negotiated their rights and developed information in the process concerning water use in the basin.

Local water users in a completely decentralized system rarely take voluntary action to apportion insufficient groundwater supplies or enjoin pumping causing overdraft. Because groundwater is a common pool resource, the costs to an individual user of additional withdrawals are spread among all users of the basin. Users have little incentive to conserve because their efforts will not necessarily go towards preservation of the basin but may instead go toward increasing the supply of other users. In fact, users may be deterred from conserving if there is any chance that they will lose a portion of their water right in a future proceeding defining rights based upon past use. This kind of decentralized system eventually leads to the situation known as the "tragedy of the commons" unless the structure of decision making arrangements can be modified to enable persons to act jointly in relation to the common resource (Ostrom, 1971, p. 16).

Under a basin management structure set up through negotiation or adjudication, there is more incentive to conserve because the rights of all users are defined and limited so that saved water benefits the overall basin rather than other individual users. Conservation is encouraged by the need to meet limits on demand and by a desire to reduce the fees usually charged for pumping.

5.4.2 Local District

Local districts, like watermasters, should be well situated to police waste in that they are most likely to develop good, detailed information concerning the water use in their basin. However, local districts have historically been reluctant to police water users for waste by their members who elect the district directors. This is now changing in California as a result of two developments. The first is simply the growing scarcity of water supplies available to the districts as a result of reallocations of a portion of the developed water to environmental restoration purposes. When water is scarce, the district members themselves have a lower tolerance for wasteful use, and this is reflected in the willingness of the district managers to reform water rates to induce conservation or otherwise assist their growers. Second, districts that receive federally supplied water are now required to develop and submit water conservation plans for approval by the U.S. Bureau of Reclamation. These plans are likely to cast the districts into a much more proactive role in improving water management practices on the farms. Good performance by the districts is all the more likely in an environment in which the renewal of the contracts for the federal water may, in part, depend upon it.

Districts are well situated to stimulate and assist farmers in adopting efficient water management practices. The local districts act in many respects like a public utility and, as such can provide an array of incentives and assistance to the customers to cause them to save water. This saved water is a source of incremental supply to the district/utility, and worth paying for at a level that reflects the marginal costs of alternative supplies. Some ways in which districts can promote more efficient water use include (1) progressive (or tiered) water rate designs which discourage excessive water use by charging at higher rates for consumption beyond the minimum amounts necessary for particular crops; (2) repurchasing water from willing farmers at rates equivalent to the "avoided cost" of alternative supplies, thereby creating an internal water market that makes it financially attractive to save water; or (3) directly investing in water conservation techniques or technologies on the customer's farm in exchange for a share of the water that is saved. All of these devices are the subject of experiments being conducted by California water districts today.

5.4.3 Centralization

In contrast, a more remote central agency will have more difficulty obtaining information about the wasteful practices of individual water users, but less ambivalence about sanctioning users for waste that is discovered. It is critical that the central agency devise a system by which it can effectively monitor and enforce its allocation program. One method for accomplishing these goals is to employ a large staff of information gatherers and enforcement personnel. There are many difficulties with adopting such a system. First, the administrative costs of maintaining such a staff are significant. Second, there is no incentive for local interests to cooperate with the agency information gatherers.

A second approach to monitoring and enforcement has been adopted by Arizona. Arizona requires all persons withdrawing water to maintain detailed records, and to submit annual reports to the state. In addition to imposing fines on parties who fail to maintain such records and submit timely reports, Arizona also makes these reports readily available to the public. By subjecting water users to the scrutiny of their fellow water users, Arizona provides private parties with strong incentives for both compliance and enforcement.

Along with the monitoring and enforcement systems discussed above, many states have also provided incentives for the more efficient use of water. Arizona, for instance, has established a program by which farmers are paid to retire their agricultural lands (Smith, 1984b, p. 861). This reduces the demand for irrigation water and thus benefits water conservation. Additionally, Arizona has also set minimum standards for casings, pipes, fittings, wells and valves. These incentives and minimum standards are particularly attractive in that they impose a fairly minimal administrative burden on the state.

5.5 Equity

Equitable distribution of an essential and common resource such as water is an objective that tends to temper and counterbalance, in some respects, the economic efficiency objective. A system that allocates the resource according to the ability to pay (as economic efficiency, considered alone, might require) would place the resource beyond the reach of the poorest strata of society for whom it is no less critical for both domestic and food production. A system that makes water available to all for essential needs at affordable prices may be preferred to a system that is maximally efficient in an economic sense.

In addition to the issue of universal access, equity also implies enfranchisement in the processes of deciding on the development and distribution of the resource. The premise is that in some fundamental sense tile water is a common property resource that belongs to all of the people, and all should therefore have a voice in its disposition. In this section, therefore, we look at both equitable access and equitable participation in decision-making.

Finally, we include environmental assessment and protection as another equity concern on the premise that environmental quality, like the water resource itself is an asset held in common which should not be compromised to benefit the few. Thus, we regard a groundwater management regime that is regardful of environmental values and seeks to prevent damage as superior to one that does not. Environmental amenities associated with groundwater development would include effects on wetlands and vernal springs and on riparian habitats, and the disposal of drainage water, contaminated by materials leached from soils, which can be generated due to the overapplication of irrigation water.

Some systems have evolved based on the idea that it is equitable to protect the interests of the water users who were first in time. This type of system was popular on the Western frontier of the United States because it originally served to promote economic development, fair allocation and stability of water rights. However, as frontier conditions disappeared, water management objectives and their interrelationships changed (Grant, 1987, p. 73). Critics of the priority system note its failure to promote the most productive use of water and its harshness in barring new uses of water and in shutting down junior appropriators completely during shortage to fully satisfy the demands of senior appropriators.

Another system that might be considered equitable is one based on the idea that there should be equality of access to water by all potential users, with pro rata sharing in times of shortage. The group of water users might be limited geographically or by requiring ownership of land overlying the water source but not by seniority of water use.

As reflected above, questions of equity are not resolved simply by choosing a framework for water management. For example, in an "equal access" system, is it equitable to limit access based on a water user's ownership of land overlying the water or location within the general watershed? Should water rich areas be required to share their wealth with less fortunate areas? Are some uses valued more highly than others by society and should these uses be protected in the event that a water market transfer system will not do so? Different systems of groundwater management may be more or less appropriate depending upon how a particular society answers these questions.

5.5.1 Decentralization

In theory, the benefits of groundwater access are equally available to all overlying owners in a decentralized, correlative rights system. However, the consequence of progressive overdraft is to increase the cost of pumping groundwater, with the greatest effects being caused nearest the apex of the "cone of depression," causing those with the shallower wells, or those least able to absorb the increasing (power) costs of lifting the groundwater to be shed from the system until the point is reached where the remaining usage equals the recharge rate. The increased costs of pumping are shared by all users regardless of their contribution to the depletion of the resource. In effect, the resource is allocated according to ability to pay the increasing costs of pumping, with those least able to pay, including poor domestic water users, being deprived of their share. Many would consider this kind of effect to be inequitable.

This is not unlike the distributional effects of any market except that, in the case of groundwater, the cost escalations are preventable through more active management of the resource. Groundwater basins can be managed to ensure that they are not depleted in ways that cause those least able to pay to lose access to the supply.

When water users in a decentralized system decide to adjudicate their rights, the court attempts to fashion a physical solution that will comport with notions of equity. A court will generally look at past use in an effort to determine the vested rights of the water users to the basin. Water users are then assigned rights based on their past use, diminished by the amount necessary to operate the basin in a sustainable manner. However, the very process of adjudication may be inequitable in that it can eliminate many small water producers who cannot pay the costs of defending their right to a few acre-feet or less of groundwater (Blomquist, 1992, p. 314).

Nevertheless, water users with relatively limited finances who are able to participate in the adjudication will be better protected in future because the improved management of the basin will enable them to use it more economically.

In a decentralized system without identified rights, the water users of the basin do not generally make allocation decisions as a group because they are not united under a management structure. The management goals of such a system in California are to ensure that water is put to beneficial use, that users do not unduly infringe on the rights of others in the basin, and that only surplus water is applied on non-overlying lands. However, water users do not generally make conscious management decisions in pursuit of these goals in the absence of litigation bringing particular issues to their attention.

When rights are adjudicated or negotiated, water users in California have often chosen their own watermaster or administrative committee and have created a management structure giving them guarantees of representation (see Blomquist, 1992, p. 212). As noted previously, such participation can have important consequences in terms of the level of voluntary compliance.

In a decentralized, correlative rights system, there is essentially no management structure in place to provide for the needs of the environment. Nor is there an incentive for individuals, to take steps to protect the environment because of the "tragedy of the commons" pressures inherent in the system. When a court adjudicates rights in a basin, it may provide some indirect protection of the environment to the extent that it imposes a physical solution that involves basin restoration. However, the court's goal is to resolve a dispute over the rights of water users. Protection of the environment is not generally a consideration.

5.5.2 Local District

For irrigation water, the local district approach to management in California has differed from that of adjudicated basins in that small producers have not been eliminated from the system. Generally, each farmer's share of the water supply is a *pro rata* amount based upon irrigated acreage. Sometimes the entitlement is established contractually. More often, water shares are specified in the by-laws of the district, which is constituted as a quasi-municipal corporation. Of course, the right to receive the water is contingent upon payment. Charges generally are comprised of a water service charge, which is based on the quantity of water delivered, and a general assessment based on the number of acres under the ownership or control of the district member. Water rates are established at a level that will defray the actual costs incurred by the district. For domestic water supply, the local districts operate as a public utility, delivering water to all who demand it within the service area at a rate that defrays the costs of water acquisition, management and conveyance. In both cases, a user will be suspended from the system for failure to pay the water charge. It is conceivable, however, that minimal amounts, regarded as essential for subsistence purposes, could be provided at reduced costs or even without charge under a rate schedule that recouped the revenue loss through higher rates for marginal consumption. Indeed, tiered rates of this sort are a highly effective water conservation tool in the agricultural sector, as discussed in a previous section.

As with adjudicated basins, water users are usually closely involved in establishing a local district management structure and ensuring their representation in that structure. It is interesting to note that the basin governance structures constituted by water users in successful California cases have shown a preference for decision making by consensus (Blomquist, 1992, p. 345). These decision making processes have required water users to take into account, and attempt to accommodate, one another's interests in order to reach a desired outcome (Id.). This has encouraged cooperation and promoted compliance.

In the U.S. setting, water districts are generally state agencies for the purposes of the application of environmental protection laws. In California, for instance, this means that water districts are required to assess and mitigate environmental impacts associated with their water development and distribution activities. Preparation of environmental assessments and reports is a common occurrence.

5.5.3 Centralization

A centralized water management system, as discussed above, is particularly well positioned to integrate interests that are not directly involved in immediate regional water allocation disputes. Such interests include economically disadvantaged persons, future generations and the environment. One method by which water regimes have attempted to help the economically disadvantaged is through the adoption of "lifeline" rate schedules. These schedules start with low block rates for small users and work up to high marginal or penalty rates for large users.

Issues of equity can also be addressed by the centralized agency's method for ranking preferred water uses. If an agency adopts a rigid preference hierarchy, in which certain uses will receive the lion's share of water resources, than those preferred interests will also gain the subsequent economic benefit. If, however, the agency adopts a more flexible and equitable preference system, in which smaller and less politically powerful interests are assured a greater share of the water resources, then this will have the opposite effect. Each centralized agency must strike its own balance, but the power and effect of such preference schemes must be considered if equity is to be served.

Lastly, a central agency is also well situated to incorporate environmental considerations into its allocation decisions. To successfully do so, however, requires more than political goodwill. The enabling legislation must include provisions which specifically require the agency to address environmental factors. These environmental objectives could be accomplish through a variety of possible requirements, such as a notice and comment period prior to approval of water management plans, the completion of environmental impact statements, or specific environmental criteria which all water management plans must consider. Requiring central agencies to incorporate environmental considerations helps to protect ecosystems, as well as the water resources necessary to sustain future generations of consumers.

6. CONCLUSIONS

Properly designed and delineated local groundwater management institutions consistently outperform the decentralized model as against the criteria examined in this paper. The local management option also compares favorably with a highly-centralized allocation based on a state-wide permit program, for all criteria except that the more centralized approaches are better able to foster conjunctive use of ground and surface water. The local management option has the strong advantage of being sensitive, adaptable and responsive to local conditions and perceptions of need. It also has the virtue of depending largely upon local rather than state or national initiative to create, finance and govern the management institution and avoids the type of ponderous bureaucracy which has been the bane of too many natural resource management regimes historically.

REFERENCES

Anderson (1983). *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment*. Pacific Institute for Public Policy Research.

Anderson (1989). Some Thoughts on Conjunctive Use of Ground Water in California. *Western State University Law Review*, 16:559.

Blomquist (1992). *Dividing the Waters*. ICS Press, San Francisco.

Cummings & Nercissiantz. (1992). The Use of Water Pricing as a Means for Enhancing Water Use Efficiency in Irrigation: Case Studies in Mexico and the United States. *Natural Resources Journal*, 32:731.

Department of International Economic and Social Affairs and Department of Technical Co-operation for Development, Efficiency and Distributional Equity in the Use and Treatment of Water: Guidelines for Pricing and Regulations. (1980). *Natural Resources/Water Series*, 8, United Nations.

Emel (1987). Groundwater Rights: Definition and Transfer. *Natural Resources Journal*, 27:653.

Frederick & Hanson (1982). Water For Western Agriculture, Resources for the Future. Washington DC.

Grant (1987). The Complexities of Managing Hydrologically Connected Surface Water and Groundwater Under the Appropriation Doctrine. *Land and Water Law Review*, 22:63.

Gregory (1992). Groundwater and Its Future- Competing Interests and Burgeoning Markets. *Stanford Environment Law Journal*, 11:229.

Closing (1988). Imported Groundwater Banking. The Kern Water Bank – A Case Study. *Pacific Law Journal*, 19:1225.

Krieger & Banks (1962). Ground Water Basin Management. *California Law Review*, 50:56.

de Lambert (1984). District Management for California's Groundwater. *Ecology Law Quarterly*, 11:373.

Lee (1990). Managing Water Resources in Latin America. *Natural Resources Journal*, 30:581.

Mallery (1983). Groundwater. A Call for a Comprehensive Management Program. *Pacific Law Journal*, 14:1279.

Murphy (1988). The Potential for Legislative Choice Concerning Groundwater and Aquifers. *Journal of Land Use & Environmental Law*, 4:23.

Ostrom (1971). *Institutional Arrangements for Water Resource Development*. Indiana University.

Smith (1984a). Rafting California Groundwater Law – Past Attempts and Prerequisites to Reform. *California Western Law Review*, 20:223.

Smith (1984b). Centralized Decision making in the Administration of Groundwater Rights: The Experience of Arizona, California and New Mexico and Suggestions for the Future. *Natural Resources Journal*, 24:641.

Smith (1986). Coercion and Groundwater Management. Three Case Studies and a Market Approach. *Environmental Law*, 16:797.

Villarejo & Redmond (1988). Missed Opportunities, Squandered Resources. Why Prosperity Brought By Water Doesn't Trickle Down in the Central Valley. California Institute for Rural Studies.

World Bank, (1981). Staff Working Paper No. 458: Comparative Study of the Management and Organization of Irrigation Projects. Prepared by Anthony Bottrall, Consultant.

Chapter 12

The Evolving International Law of Transnational Aquifers

Joseph W. Dellapenna
Professor of Law, Villanova University, Villanova Pennsylvania
Rapporteur, Water Resources Committee, the International Law Association

Water is an essential resource for human survival. As a Turkish businessman commented, "Countless millions of people have lived without love, but none without water."[1] Water is essential not only for human survival, but also for human thriving. Yet humans and most plants and animals of use to humans can tolerate only a narrow range of impurities in the water they consume. Furthermore, the quantity of water available on the planet remains essentially unchanged and unchangeable. Therefore, usable water has always been a scarce and valuable commodity.

Despite the limited amount of usable water on the planet, there has been a nine-fold increase in *per capita* consumption of water worldwide since 1900, arising from changing technologies and changing personal habits.[2] The

[1] Quoted in Amikam Nachmani, *The Politics of Water in the Middle East: The Current Situation, Imaginary and Practical Solutions*, in WATER AS AN ELEMENT OF COOPERATION AND DEVELOPMENT IN THE MIDDLE EAST 301, 302 (Ali İhsan Bagis ed. 1994) ("WATER AS AN ELEMENT OF COOPERATION").

[2] Robert Clark, Water: The International Crisis (1993); Commission on Sustainable Dev., Comprehensive Assessment of the Fresh Water Resources of the World, UN Doc. No. E/CN.17/1997/9 (1997); Drought Follows the Plow (Michael Glantz ed. 1994); Robert Engelman & Pamela LeRoy, Sustaining Water, Easing Scarcity: A Second Update (1997); Peter Gleick, The World's Water 1998-1999: The Biennial Report on Freshwater Resources (1998); Sandra Postel, Last Oasis: Facing Water Scarcity (1992); Water in Crisis: A Guide to the World's Fresh Water Resources (Peter Gleick ed. 1993); Malin Falkenmark, *Dilemma When Entering the 21st Century—Rapid Change but Lack of a Sense of Urgency*, 1 Water Pol'y 421 (1998); Johan Kuylenstiern, Pierre Najlis, & Gunilla Björklund, *The Comprehensive Assessment of the Freshwater Resources of the World—Policy Options for an Integrated Sustainable Water Future*, 23 Water Int'l 17 (1998).

burgeoning global population further increases demand in societies that fail to adjust their water consumption patterns to current realities.[3] The prospect of global climate change could worsen the situation dramatically.[4]

The management of fresh water generally requires the relocation of its flow in time or in space or both. Water is, however, an ambient resource that that largely ignores human boundaries. Some 264 rivers—the basins of which are home to about 40 percent of the world's population—are shared by more than one nation.[5] The most cordial and cooperative of neighboring states have found it difficult to achieve mutually acceptable arrangements to govern their transboundary surface waters even in relatively humid regions were fresh water is usually found in sufficient abundance to satisfy most or all needs.[6] Units of a single federal union located in a humid region have engaged in long and bitter political and legal struggles over the waters they share.[7] When the region is arid, intense conflict become endemic despite otherwise friendly relations or even membership in a federal union.[8] No

[3] See Joseph Dellapenna, Population and Water in the Middle East: The Challenge and Opportunity for Law, 7 INT'L J. ENVT. & POLLUTION 72 (1997); Pamela LeRoy, Troubled Waters: Population and Water Scarcity, 6 COLO. J. INT'L ENVTL. L. & POL'Y 299 (1995).

[4] *See generally* CONFRONTING CLIMATE CHANGE (Irving Mintzer ed. 1992); INTERNATIONAL LAW AND GLOBAL CLIMATE CHANGE (Robin Churchill & David Freestone eds. 1991); F.A. Bazzaz, *Global Climate Change and Its Consequences for Water Availability in the Arab World*, in WATER IN THE ARAB WORLD: PERSPECTIVES AND PROGNOSES 243 (Peter Rogers & Peter Lydon eds. 1994); Gretta Goldenman, *Adapting to Climate Change: A Study of International Rivers and Their Legal Arrangements*, 17 ECOL. L.Q. 741 (1990); Ernest Smerdon, *Impact of Global Change on Water Resources*, 9 ARIZ. J. INT'L & COMP. L. 155 (1992).

[5] *See* 1 Nurit Kliot, Deborah Shmueli, & Uri Shamir, Institutional Frameworks for the Management of Transboundary Water Resources 1-5 (1997); Aaron Wolf, *Conflict and Cooperation along International Waterways*, 1 Water Pol'y 251, 251-52 (1998).

[6] *See, e.g.*, The Law of International Drainage Basins (Albert Garretson, Robert Hayton, & Cecil Olmstead eds. 1967) ("International Drainage Basins"); The Legal Regime of International Rivers and Lakes (Ralph Zacklin & Lucius Caflisch eds. 1981) ("Legal Regime"); Ludwik Teclaff, The River Basin in History and Law (1967); Albert Utton, *International Waters*, in 5 Waters and Water Rights chs. 49-51 (Robert Beck ed. 1991 ed.).

[7] *See, e.g.*, Wisconsin v. Illinois, 388 U.S. 426 (1967); New Jersey v. New York, 345 U.S. 369 (1953); New Jersey v. New York, 283 U.S. 336 (1931); Wisconsin v. Illinois, 281 U.S. 179 (1930).

[8] *See, e.g.*, Texas v. New Mexico, 482 U.S. 124 (1987); Kansas v. Colorado, 475 U.S. 1079 (1986); Arizona v. California, 373 U.S. 546 (1963); Texas v. New Mexico, 352 U.S. 991 (1957); Nebraska v. Wyoming, 325 U.S. 589 (1945); Colorado v. Kansas, 320 U.S. 383 (1943); Wyoming v. Colorado, 309 U.S. 572 (1940); Nebraska v. Wyoming, 295 U.S. 40 (1935); Arizona v. California, 283 U.S. 423 (1931); Wyoming v. Colorado, 259 U.S. 419 (1922); Kansas v. Colorado, 206 U.S. 46 (1907); ALOYS MICHEL, THE INDUS RIVER: A STUDY OF THE EFFECTS OF PARTITION 483 (1967); Douglas Grant, *Interstate Water Allocation*, in 4 WATERS AND WATER RIGHTS, *supra* note 6, chs. 43-48; Yvon-Claude Accariez, *Le régime juridique de l'Indus*, in LEGAL REGIME, *supra* note 6, at 53; Richard

wonder the English derived the word "rival" from the Latin word *"rivalis"*, meaning persons who live on opposite banks of a river.[9]

Globalization, with consequent tighter integration of legal systems across national boundaries,[10] reaches to water resource issues every bit as much as it has extended to communications, travel, and commerce until today, environmental and resource issues are to national security, often more so than traditional military issues.[11] This leads to increasing pressure to develop truly transnational resource management in general,[12] and transboundary water management in particular.[13] And while a good deal of this is "soft

Baxter, *The Indus Basin*, in INTERNATIONAL DRAINAGE BASINS, *supra* note 6, at 443; M. Bashir Hussain, *The Law of Interstate Rivers in India: Principles of Equitable Apportionment of River Waters*, 17 INDIAN J. INT'L L. 41 (1977); Jerome Lipper, *Equitable Utilization*, in INTERNATIONAL DRAINAGE BASINS, *supra*, at 15; Charles Meyers, *The Colorado Basin*, in INTERNATIONAL DRAINAGE BASINS, *supra*, at 486; R.C. Sharma & Suparna Nag, *On the Question of Fresh Water Management in South Asia*, in THE PEACEFUL MANAGEMENT OF TRANSBOUNDARY WATER RESOURCES 219 (Gerald Blake *et al.* eds. 1995).

9 Stephen Schwebel, Third Report on the Law of Non-Navigational Uses of International Watercourses, UN Doc. A/CN.4/348, [1982] II Y.B. INT'L L. COMM'N 81 n.142.

10 *See, e.g.*, Daniel Elazar, Constitutionalizing Globalization: The Postmodern Revival of Confederal Arrangements (1998); Eleanor Fox, *Globalization and Its Challenges for Law and Society*, 29 Loy. U.-Chi. L.J. 891 (1998).

11 *See, e.g.*, GLOBAL RESOURCES AND INTERNATIONAL CONFLICT 86 (A.H. Westing ed. 1986); Jutta Brunnée & Stephen Toope, *Environmental Security and Freshwater Resources: Ecosystem Regime Building*, 91 AM. J. INT'L L. 26 (1997); Peter Gleick, *Water and Conflict: Fresh Water Resources and International Security*, 18 INT'L SECURITY 79 (1993); Thomas Homer-Dixon, *Environmental Scarcities and Violent Conflict*, 19 INT'L SECURITY 17 (1994); Thomas Homer-Dixon, *On the Threshold: Environmental Change as Causes of Acute Conflict*, 16 INT'L SECURITY 106 (1991); Wolf, *supra* note 5.

12 *See, e.g.*, *Rio Declaration on Environment and Development*, UN Doc. A/CONF.151/5/Rev. 1 (1992) ("*Rio Declaration*"); Michael Carley, Sharing the World: Sustainable Living and Global Equity in the 21st Century (1998); Global Public Goods: International Cooperation in the 21st Century (Inge Kaul, Isabelle Grunberg, & Marc Stern eds. 1999); Erin Clancy, *The Tragedy of the Global Commons*, 5 Ind. Global Legal Studies J. 601 (1998); Rudolf Dolzer, *Global Environmental Issues: The Genuine Area of Globalization*, 7 J. Transnat'l L. & Pol'y 157 (1998); Daniel Farber, *Stretching the Margins: The Geographic Nexus in Environmental Law*, 48 Stan. L. Rev. 1247 (1996); Paul Williams, *Can International Legal Principles Play a Positive Role in Resolving Central and Eastern European Transboundary Environmental Disputes?*, 7 Geo. Int'l Envtl. L. Rev. 421 (1995).

13 *See, e.g.*, J.G. Lammers, Pollution of International Watercourses: The Search for Substantive Rules and Principles of Law (1984); André Nollkaemper, The Legal Regime for Transboundary Water Pollution: Between Discretion and Constraint (1993); Astrid Boos-Hersberger, *Transboundary Water Pollution and State Responsibility: The Sandoz Spill*, 4 Ann. Surv. Int'l & Comp. L. 103 (1997); Harald Fredericksen, *International Community Response to Critical World Water Problems: A Perspective for Policy Makers*, 1 Water Pol'y 139 (1998); Colleen Graffy, *Water Water Everywhere, Nor any Drop to Drink: The Urgency of Transnational Solutions to International Riparian Disputes*, 10 Geo. Int'l

law"—*i.e.*, agreements on principles without any real enforcement mechanism—it does seem to work to a considerable extent nonetheless.[14]

The problems of transboundary aquifers have yet to be faced. Ground water makes up 97 percent of the world's fresh water apart from the polar ice and glaciers.[15] Before 1945, ground water was a strictly local resource; it could not be pumped in large enough volumes to affect other users even short distances away.[16] With the spread of vertical turbine pumps after World War II, and with exponential growth in the demand for water, ground water emerged as a critical transnational resource. The primary water dispute between the Israelis and the Palestinians over shared underground sources, primarily the Mountain Aquifer but also the Gaza Aquifer (which may or may not be part of the Coastal Aquifer located in Israel).[17] Virtually all water

Envtl. L. Rev. 399 (1998); Christopher Kukk & David Deese, *At the Water's Edge: Regional Conflict and Cooperation over Fresh Water*, 1 UCLA J. Int'l L. & For. Aff. 21 (1996).

14 *See, e.g.*, THE EFFECTIVENESS OF INTERNATIONAL ENVIRONMENTAL AGREEMENTS: A SURVEY OF EXISTING LEGAL INSTRUMENTS (Peter Sand ed. 1992); Thomas Bernauer, *The Effectiveness of International Environmental Institutions: How We Might Learn More*, 49 INT'L ORG. 351 (1995); Michele Betsill & Roger Pielke, jr., *Blurring the Boundaries: Domestic and International Politics and Lessons for Climate Change*, 10 INT'L ENVTL. AFF. 147 (1998); Jan Stefan Fritz, *Earthwatch Twenty-Five Years on: Between Science and International Environmental Governance*, 10 INT'L ENVTL. AFF. 173 (1998); Reiner Grundmann, *The Strange Success of the Montreal Protocol: Why Reductionist Accounts Fail*, 10 INT'L ENVTL. AFF. 197 (1998); Arnold Gurtner-Zimmerman, *The Effectiveness of the Rhine Action Program: Methodology and Results of an Evaluation of the Impacts of International Cooperation*, 10 INT'L ENVTL. AFF. 241 (1998); Günther Handl, *Compliance Control Mechanisms and International Environmental Obligations*, 5 TULANE J. INT'L & COMP. L. 29 (1997); Geoffrey Palmer, *New Ways to Make International Environmental Law*, 86 AM. J. INT'L L. 259 (1992); Philippe Sands & Albert Bedecarré, *The Convention on International Trade in Endangered Species: The Role of Public Interest Non-Governmental Organizations in Ensuring the Effective Enforcement of the Ivory Trade Ban*, 17 B.C. ENVTL. AFF. L. REV. 799 (1990); Prosper Weil, *Toward a Relative Normativity in International Law?*, 77 AM. J. INT'L L. 413 (1983); O. Yoshida, *Soft Enforcement of Treaties: The Montreal Protocol's Noncompliance Procedure and the Functions of Internal International Institutions*, 10 COLO. J. INT'L ENVTL. L. & POL'Y 95 (1999); Oran Young, *The Effectiveness of International Environmental Regimes: A Mid-Term Report*, 10 INT'L ENVTL. Aff. 267 (1998).

15 Fred Powledge, Water: The Nature, Uses and Future of Our Most Precious and Abused resource 22-23 (1982).

16 Daniel Hillel, Rivers of Eden: The Struggle for Water and the Quest for Peace in the Middle East 192 (1994).

17 For the Israeli position on the Coastal Aquifer, see, *e.g.*, NURIT KLIOT, WATER RESOURCES AND CONFLICT IN THE MIDDLE EAST 245 (1994). For the Palestinian position, see, *e.g.*, SHARIF ELMUSA, NEGOTIATING WATER: ISRAEL AND THE PALESTINIANS 13, 17 (1996); THE WRAP TASK FORCE, PALESTINIAN WATER RESOURCES 4 (1994) ("WRAP"); Riyad Hassan El-Khoudary, *Water Crisis in the Gaza Strip and Proposed Solutions*, in WATER AS AN

used by the Palestinians comes directly from wells, while two-thirds of the water consumed by the Israelis is drawn from wells.[18] The Jordanians also take the bulk of their water from wells.[19] The transnational aquifers of the region also sustain the flows of the surface sources. Thus management of the aquifers is central to resolving water resource issues in the peace process.[20]

Clear rules establishing the rights of the several national communities sharing the Jordan Valley in the aquifers that cross their boundaries will be essential to a lasting peace among those communities. Adam Roberts, however, reminds us that "there are some hazards in discussing burning political issues in legal terms."[21] Not only are history, politics, engineering,

ELEMENT OF COOPERATION, *supra* note 1, at 363, 364-69. For an Israeli who concedes that the "Israeli" Coastal Aquifer extends into Gaza, see HILLEL, *supra* note 16, at 202-03. *See generally* AARON WOLF, HYDROPOLITICS ALONG THE JORDAN RIVER: SCARCE WATER AND ITS IMPACT ON THE ARAB-ISRAELI CONFLICT 10 (1995).

18 On Israeli consumption patterns, see Meron Benvenisti, 1986 Report: Demographic, Economic, Legal, Social and Political Developments in the West Bank 20 (1986) ("1986 Report"); Shoshana Gabbay, The Environment in Israel 18, 21-27 (1994); Hillel, *supra* note 16, at 40, 165-66, 173, 200-08, 310 n.17, 312 n.8; Subhi Kahhaleh, The Water Problem in Israel and Its Repercussions on the Arab-Israeli Conflict 42-47 (1981); Kliot, *supra* note 17, at 216-17, 232-37, 246; Stephen Lonergan & David Brooks, Watershed: The Role of Fresh Water in the Israeli-Palestinian Conflict 37, 43-44, 85, 107-15, 127-28 (1994); Water in the Middle East: Conflict or Cooperation? 27, 47-48, 64 (Thomas Naff & Ruth Matson eds. 1984) ("Water in the Middle East"); Wolf, *supra* note 20, at 10, 62-65. On Palestinian consumption, see Meron Benvenisti, The West Bank Data Project 12-15 (1984) ("Benvenisti"); Meron Benvenisti, Ziyad abu-Zayed, & Danny Rubinstein, The West Bank Handbook: A Political Lexicon 1, 223-25 (1986) ("Handbook"); Elmusa, *supra* note 17, at 4, 28-29; Fawzi Gharaibeh, The Economies of the West Bank and Gaza Strip 42 (1985); Hillel, *supra* note 16, at 203, 207, 311-12 n.4; David Kahan, Agriculture and Water Resources on the West Bank and Gaza (1967-1987), at 3, 24 (1987); Kliot, *supra* note 17, at 244-47; Lonergan & Brooks, *supra*, at 75, 86, 105-07, 129, 135; Sara Roy, The Gaza Strip Survey 50 (1986); Water in the Middle East, *supra*, at 48-49; Wolf, *supra*, at 10-12, 60; WRAP, *supra* note 17, at 4,18-19; El-Khoudary, *supra* note 17, at 364, 367; Grey, *supra* note 17, at 223.

19 HILLEL, *supra* note 16, at 169-70, 173-74, 191-92; KLIOT, *supra* note 17, at 226, 230; WATER IN THE MIDDLE EAST, *supra* note 18, at 28; WOLF, *supra* note 17, at 1, 12; B. al-Kloub & T.T. al-Shemmeri, *Sustainable Development of Water Resources and Possible Enhancement Technologies and Application of Water Supply in Jordan*, 20 WATER INT'L 106 (1995); Abdul-Karim Sadik & Shawki Barghouti, *The Water Problems of the Arab World: Management of Scarce Resources*, in WATER IN THE ARAB WORLD, *supra* note 4, at 1, 13, 16-17; Hilmi Salem, *A Budget of the Surface and Ground water in Northern Jordan*, in WATER AND PEACE IN THE MIDDLE EAST 135 (Jad Isaac & Hillel Shuval eds. 1994) ("WATER AND PEACE"); Mohammad Shatanawi & Odeh al-Jayousi, *Evaluating Market-Oriented Water Policies in Jordan: A Comparative Study*, 20 WATER INT'L 88, 88-92 (1995).

20 *See generally* WATER IN THE MIDDLE EAST, *supra* note 18, at 22.

21 Adam Roberts, Prolonged Military Occupation: The Israeli Occupied Territories since 1967, 84 AM. J. INT'L L. 44, 45 (1990).

hydrology, and economics important to the allocation and protection of internationally shared water resources, but international law itself is in some ways a problematic discipline. International law is a decentralized and highly informal system, one that can fairly be described as primitive.[22] By the word "primitive," I do not mean that international law is ineffective or unsophisticated; rather, I am suggesting that the international legal system is highly decentralized and institutionally undeveloped. In such as system, law can easily become a language of moralistic reproach or a means of cloaking national interest in apparently neutral normative terms, or even a means of masking the fact of change with legal fictions. Worst of all, international law can appear to vacillate between "pure scholasticism in the face of urgent practical problems, and of facile application of general rules without a deep understanding of situations that are unique."[23]

Although increasingly the focus of disputes between nations, there is still no sizable body of state practice regarding shared ground water.[24] An all too typical example is found in the several treaties dealing with waters shared between the United States and Mexico; despite the growing importance of ground water to the border regions of the two nations, the treaties are silent on ground water—with potentially disastrous economic and ecological results.[25] Among the very few agreements specifically allocating ground water are two from the colonial period in Africa. In those agreements, European powers involved agreed to allow the certain wells at or near a

[22] J.L. Brierly, The Law of Nations 71-78 (Sir Humphrey Waldock ed. 1963); H.L.A. Hart. The Concept of Law 77-96 (1961); Hans Morganthau, Politics among Nations 265 (4th ed. 1967); Hans Kelsen, An Introduction to the Problems of Legal Theory 108-09 (Bonnie Litschewski Paulson & Stanley Paulson trans. 1992); Water in the Middle East, *supra* note 18, at 157-60; Yoram Dinstein, *International Law as a Primitive Legal System,* 19 Int'l L. & Politics 1 (1986). For arguments against this view, see B.S. Chimni, International Law and World Order: A Critique of Contemporary Approaches 47-55 (1993); A.I.L. Campbell, *International Law and Primitive Law,* 8 Oxford J. Leg. Stud. 169 (1988).

[23] Roberts, *supra* note 21, at 45.

[24] Dante Caponera, Principles of Water Law and Administration 252-53 (1992).

[25] See Convention Providing for the Equitable Distribution of the Waters of the Rio Grande for Irrigation Purposes, signed May 21, 1906, Mexico-United States, 34 Stat. 2953 ("Rio Grande Convention"); Treaty Respecting Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, signed Feb. 3, 1944, Mexico-United States, 3 UNTS 313 ("Colorado Treaty"). See generally Niles Hansen, Economic Growth Patterns in the Texas Borderlands, 22 NAT. RESOURCES J. 805 (1982); Mary Keleher, Note, Mexican-United States Shared Ground water: Can It Be Managed?, 1 GEO. INT'L ENVTL. L. REV. 113 (1988); Ann Berkley Rodgers & Albert Utton, The Ixtapa Draft Agreement Relating to the Use of Transboundary Ground waters, 25 NAT. RESOURCES J. 715 (1985); Utton, supra note 6, § 51.04(f)(2).

boundary to be used "in common" by residents on either side of the border as they were accustomed to do before colonization.[26]

Although the rules governing rights in transnational aquifers are not so well developed as are the rules regarding surface water, those rules are now emerging. This chapter examines the law of transnational aquifers in order to describe what the legal rights of the several national communities are and how they might structure an appropriate regime to resolve disputes over those rights. We begin, however, by taking a brief look at how international law generally works. We then turn to the customary law of internationally shared surface waters before returning specifically to the law of transnational ground waters.

1. CUSTOMARY INTERNATIONAL LAW

Until quite recently, international law governed a relatively small and structureless society of states. The United Nations was created in 1945 with only 51 members—Switzerland alone chose to stay out of the United Nations, and a handful of defeated Axis states were excluded. The current membership of the United Nations is approaching 200, with at least two significant states (Switzerland and the Republic of China [Taiwan]) outside the organization. The United Nations and other international organizations certainly count as full players ("legal persons") in the international legal system.[27] Rapidly proliferating non-governmental and other official and semiofficial participants also now play a distinct albeit subordinate role.[28]

[26] *Agreement Fixing the Frontier between Cyrenaica and Egypt*, signed Dec. 6, 1925, Egypt-Italy, art. 6, 133 BRIT. & FOR. STATE PAPERS 976 (1935); *Exchange of Notes with Regard to the Somali Coast*, Feb. 9, 1888, France-United Kingdom, 83 BRIT. & FOR. STATE PAPERS 672 (1897).

[27] *See, e.g.*, Advisory Opinion on Reparations for Injuries Suffered in the Service of the United Nations, 1949 I.C.J. 174. *See generally* PETER BEKKER, THE LEGAL POSITION OF INTERGOVERNMENTAL ORGANIZATIONS: A FUNCTIONAL NECESSITY ANALYSIS OF THEIR LEGAL STATUS AND IMMUNITIES (1994); IAN BROWNLIE, PRINCIPLES OF PUBLIC INTERNATIONAL LAW 63-64, 679-89, 694-98 (4th ed. 1990); RESTATEMENT (THIRD) OF FOREIGN RELATIONS LAW OF THE UNITED STATES § 219 (Louis Henkin, Andreas Lowenfeld, & Detlev Vagts rptrs. 1987) ("RESTATEMENT THIRD"); Henry Schermers, *International Organizations*, in INTERNATIONAL LAW: ACHIEVEMENTS AND PROSPECTS 67 (Mohammed Bedjaoui ed. 1991) ("ACHIEVEMENTS AND PROSPECTS").

[28] AMOS YODER, THE EVOLUTION OF THE UNITED NATIONS SYSTEM 35-36 (2nd ed. 1992); Jack Manno, Advocacy and Diplomacy in the Great Lakes: A Case History of Non-Governmental-Organization Participation in Negotiating the Great Lakes Water Quality Agreement, 1 BUFF. ENVTL. L.J. 1 (1993); Sands & Bedecarré, supra note 14; Dinah Shelton, The Participation of Nongovernmental Organizations in International Judicial Proceedings, 88 AM. J. INT'L L. 611 (1994); A. Dan Tarlock, The Role of

Even natural and artificial persons (people and corporations) are now recognized to some extent as participants in the international legal community.[29]

Changes in the international system have transformed the international legal system from a relatively simple structure into an increasingly diverse and complex community of actors who too often no longer know much about each other. The system also had to accommodate more sharply differentiated cultural traditions than when it was formed after World War II, differences that were further accentuated by the division of the world into ideological camps. This is precisely the setting in which one might expect the participants to welcome more specialized and more formal legal structures.[30] On a regional level this does appear to be happening (for example, the European Union or the North American Free Trade Association).[31] This also happened on a global scale for particular activities (for example, the International Atomic Energy Agency, the International Civil Aviation Organization, and the World Trade Organization).[32] Still, in large measure, the international legal system remains institutionally underdeveloped and decentralized.[33]

The international legal system lacks the superstructure of institutions—executive, legislative, judicial, and administrative—found in modern national legal systems. To conclude from this lack that international law is not really law is to confuse particular institutional arrangements with what law really is and how it really operates. Similar institutions, useful and necessary as they are in large communities, might yet develop in the

Non-Governmental Organizations in the Development of International Environmental Law, 68 CHI.-KENT L. REV. 61 (1982); David Tolbert, Global Climate Change and the Role of International Non-Governmental Organisations, in INTERNATIONAL LAW AND GLOBAL CLIMATE CHANGE, supra note 4, at 95.

29 *See, e.g.*, Danzig Railway Officials (Poland v. Danzig), PCIJ, Series B, no. 15 (1928), *reprinted in* 4 INT'L L. REP. 287. *See generally* BROWNLIE, *supra* note 27, at 67-69, 553-602; RESTATEMENT (THIRD), *supra* note 27, §§ 701-03; IGNAZ SEIDL-HOHENVELDERN, CORPORATIONS IN AND UNDER INTERNATIONAL LAW (1987); MALCOLM SHAW, INTERNATIONAL LAW 178-81 (3rd ed. 1991); Antonio Cassese, *Individuals*, in ACHIEVEMENTS AND PROSPECTS, *supra* note 27, at 113; François Rigaux, *Transnational Corporations*, in ACHIEVEMENTS AND PROSPECTS, *supra*, at 121.

30 Charles de Visscher, Theory and Reality in International Law 161-62 (3rd ed. 1961).

31 Derek Bowett, The Law of International Institutions 199-248 (4th ed. 1982); J.G. Merrills, International Dispute Settlement 207-29 (2nd ed. 1991); Shaw, *supra* note 29, at 127-28, 762-71.

32 BOWETT, *supra* note 31; SHAW, *supra* note 29, at 742-61, 771-82; Manuel Rama-Montaldo, *The Legal Personality and Implied Powers of International Organizations*, 44 BRIT. Y.B. INT'L L. 111 (1970).

33 *See, e.g.*, A.I.L. Campbell, *The Limits of Powers of International Organizations*, 32 INT'L & COMP. L.Q. 523 (1983); Handl, *supra* note 14.

international system. The absence of those institutions simply did not indicate lack of law in pre-industrial societies the world over.[34] The international system's less formal processes similarly are law and those processes must be examined carefully to learn both the system's capabilities and limitations.

Customary international law is more complex and uncertain than formal agreements such as treaties or conventions. Customary international law consists of the practices of states undertaken out of a sense of legal obligation, that is out of a sense that the practice is required by law (*opinio juris sive necessitatus,* often referred to as simply *opinio juris*).[35] If these two elements combine, law results regardless of how long—or how briefly—the practice has continued.[36] As with treaties, the operative theory on which the binding effect of the customary rule depends is that a state has consented to the rule.[37]

34 *See, e.g.,* Michael Barkun, Law without Sanctions (1968); Paul Bohannan, Justice and Judgment among the Tiv (1957); Melvin Chanock, Law, Custom, and Social Order: The Colonial Experience in Malawi and Zambia (1985); Eugen Ehrlich, Grundlegung zür Soziologie des Rechts (3rd ed. 1967); David Engel, Code and Custom in a Thai Provincial Court: The Interaction of Formal and Informal Systems of Justice (1975); M.B. Hooker, Adat Law in Modern Indonesia (1978); Victor Li, Law without Lawyers (1978); Dennis Lloyd, The Idea of Law 201-02 (1966); Sally Falk Moore, Law as Process: An Anthropological Approach (1978); Laura Nader, Harmony Ideology: Justice and Control in a Zapotec Mountain village (1990); Lawrence Rosen, The Anthropology of Justice: Law as Culture in Islam (1989); June Starr, Dispute and Settlement in Rural Turkey: An Ethnography of Law (1978).

35 The North Sea Continental Shelf (Federal Rep. of Germany v. Denmark & Netherlands), 1969 I.C.J. 3, 44; The S.S. Lotus (France v. Turkey), PCIJ, Ser. A, no. 10, at 18, 28 (1927). *See generally* BRIERLY, *supra* note 22, at 52, 59-60; BROWNLIE, *supra* note 27, at 4-11; ANTHONY D'AMATO, THE CONCEPT OF CUSTOM IN INTERNATIONAL LAW 1-10 (1971); G.M. DANILENKO, LAW-MAKING IN THE INTERNATIONAL COMMUNITY 75-77, 81-82 (1993); LOUIS HENKIN, INTERNATIONAL LAW: POLITICS AND VALUES 29-37 (student ed. 1995); HERSCH LAUTERPACHT, THE DEVELOPMENT OF INTERNATIONAL LAW BY THE INTERNATIONAL COURT 368-93 (1958); RESTATEMENT (THIRD), *supra* note 27, § 102(2); SHAW, *supra* note 29, at 60-76; G.I. TUNKIN, THEORY OF INTERNATIONAL LAW 89-203 (William Butler trans. 1974); 1 J.H.W. VERZIJL, INTERNATIONAL LAW IN HISTORICAL PERSPECTIVE 31-47 (1968); KAROL WOLFKE, CUSTOM IN PRESENT INTERNATIONAL LAW 1-51, 58-64, 66-67, 96-98 (2nd rev. ed. 1993); Luigi Condorelli, *Custom,* in ACHIEVEMENTS AND PROSPECTS, *supra* note 27, at 179.

36 The North Sea Continental Shelf (Federal Rep. of Germany v. Denmark & Netherlands), 1969 I.C.J. 3, 43; Asylum (Colombia v. Peru), 1950 I.C.J. 266, 276-77; D'AMATO, *supra* note 35, at 56-58; DANILENKO, *supra* note 35, at 77-81; WOLFKE, *supra* note 35, at 59-60.

37 The S.S. Lotus (France v. Turkey), 1927 PCIJ Ser. A, no. 10, at 18 ("The rules of law binding upon states ... emanates from their own free will."). *See also* WOLFKE, *supra* note 35, at 50, 160-67.

Customary international law (special or general) develops through a process of claim and counterclaim between states.[38] If a state undertakes an action that affects other states, the other states either acquiesce in the action or take steps to oppose it, usually first by employing rhetorical strategies. If the matter is important enough to the objecting state, it eventually will escalate its opposition by imposing a variety of sanctions up to the possibility of military operations. Regardless of whether the state initiating the action or those reacting to it prevail, over a period of time a practice will emerge that describes how states behave and allows one to predict how states will behave. If nothing more were involved, we might not be talking about anything that could properly be termed law. However, beginning with the simplest rhetorical strategies and continuing right through to outright war, states on both sides of a controversy refer to international law as a primary justification of their claims and their practices.[39] References to law connects a customary practice to a sense of legitimacy, and thus constitutes the practice as law in a highly decentralized and institutionally undeveloped system like international law or, for that matter, customary law among subsistence farmers or nomadic tribesmen. This is particularly true if the states involved reach a consensus, often found through the exchange of diplomatic notes or resolutions adopted at the United Nations or other international organizations, about what each state has a legal right to do in the circumstances at hand.

The notion of customary law is sometimes difficult to grasp, particularly for people familiar only with a modern, centralized legal system. Several commentators have trenchantly criticized the very notion that there is customary international law.[40] Diplomats, however, know very well the difference between appeals to law, appeals to morality, and appeals to expedience; they often express these differences at appropriate points in their statements and assertions. Consider the following analogy. Suppose there is a field between two villages, with no road across the field. People initially will wander at will to go from one village to the other. Gradually, most

[38] DE VISSCHER, *supra* note 30; WOLFKE, *supra* note 35, at 56-58; Christine Chinkin & Romana Sadurska, *The Anatomy of International Dispute Resolution*, 7 OHIO ST. J. DISPUTE RESOL. 39, 70-74 (1991); Myres McDougal & Norbert Schlei, *The Hydrogen Bomb Test in Perspective: Lawful Measures for Security*, 64 YALE L.J. 648 (1955).

[39] *See generally* Rosalyn Higgins, The Development of International Law through the Political Organs of the United Nations (1963) ("Higgins, Political Organs"); Rosalyn Higgins, *The Place of International Law in the Settlement of Disputes by the Security Council*, 64 Am. J. Int'l L. 1 (1970). *See also* Hart, *supra* note 22, at 222-225; Werner Levi, Contemporary International Law: A Concise Introduction 21 (2nd ed. 1991).

[40] See, e.g., N.C.H. Dunbar, The Myth of Customary International Law, 8 AUSTRALIAN Y.B. INT'L L. 1 (1983); H.A. Strydom, Customary International Law: The Legacy of the False Prophets, 27 COMP. & INT'L L. S. AFR. 276 (1994).

people will come to follow a particular line. Perhaps this is the shortest route, or perhaps it is the easiest route, or perhaps it is the route most convenient to the heaviest walkers—walkers whose tread wears a path more decisively into the landscape. Eventually, a definite path emerges, and gradually it will become a road. Eventually, everyone will agree that this road is the only right way to travel from village to village even though no one can say precisely when this notion took hold. At that point, they will object to others as trespassers if they choose to use a different path to go from village to village—by which time we have a legal and not merely a factual claim.[41]

Customary international law actually works quite satisfactorily when there are only a few participants in a particular international process (a special custom) or when general customary international law operates without major controversy.[42] A special custom binds only a few states (usually in a particular region) only if those states that can be shown to have actually consented to the custom. A general custom, which is deemed to bind all states, is presumed to bind a state unless the state can show that it has consistently resisted (or objected to) the custom.[43]

In determining what customary international law actually is, diplomats, international tribunals, lawyers, and scholars must examine a wide variety state practices and then find evidence for the reasons behind the practice.[44]

41 1 PITT COBBET, CASES ON INTERNATIONAL LAW 5 (1922). *See also* BROWNLIE, *supra* note 27, at 31-32; D'AMATO, *supra* note 35, at 51, 88; DE VISSCHER, *supra* note 30, at 149; WOLFKE, *supra* note 35, at 52-56, 160-68; Martti Koskennienmi, *The Normative Force of Habit: International Custom and Social Theory*, 1 FINN. Y.B. INT'L L. 77 (1990).

42 *See generally* LOUIS HENKIN, HOW NATIONS BEHAVE: LAW AND FOREIGN POLICY 25-26, 47, 89-98, 320-21 (2nd ed. 1979); Ian Brownlie, *The Reality and Efficacy of International Law*, 52 BRIT. Y.B. INT'L L. 1 (1981).

43 The Right of Passage over Indian Territory (Portugal v. India), 1960 I.C.J. 6, 39-43; U.S. Nationals in Morocco (France v. United States), 1952 I.C.J. 21, 199-200; The Fisheries Case (United Kingdom v. Norway), 1951 I.C.J. 116, 131; The Right of Asylum Case (Colombia v. Peru), 1950 I.C.J. 266, 268-69, 276-78; BROWNLIE, *supra* note 27, at 5-6, 9-11; D'AMATO, *supra* note 35, at 223; DANILENKO, *supra* note 35, at 109-13; RESTATEMENT (THIRD), *supra* note 27, § 102 comments c, d; SHAW, *supra* note 29, at 76-79; WOLFKE, *supra* note 35, at 58-61, 66-67, 86-90, 160-68; Jonathan Charney, *The Persistent Objector Rule and the Development of Customary International Law*, 56 BRIT. Y.B. INT'L L. 1 (1986); David Colson, *How Persistent Must the Persistent Objector Be?*, 81 WASH. L. REV. 957 (1986); Condorelli, *supra* note 35, at 202-07; Lynn Loschin, *The Persistent Objector and Customary Human Rights Law: A Proposed Analytical Framework*, 2 U.C. DAVIS J. INT'L L. & POL'Y 147 (1996); Ted Stein, *The Approach of a Different Drummer: The Principle of the Persistent Objector in International Law*, 26 HARV. INT'L L.J. 457 (1985); Weil, *supra* note 14, at 433-38.

44 *See generally* BRIERLY, *supra* note 22, at 60-62; BROWNLIE, *supra* note 27, at 5, 11, 24; DANILENKO, *supra* note 35, at 82-128; LEVI, *supra* note 41, at 36-38; WOLFKE, *supra* note 35, at 8-29, 67-85, 116-159; Condorelli, *supra* note 35, at 187-92.

Even though decisions by international courts or international arbitrators do not create binding precedents, they are often useful for determining whether a practice has become a rule of customary law.[45] A widespread pattern of treaties or other international agreements can demonstrate that a practice is so widely followed that it has become a rule of customary law binding even on states that are not parties to the treaty.[46] Even an unratified treaty might demonstrate customary international law.[47] Resolutions of international organizations have been taken as strong evidence that states consider a particular rule to be a legal obligation, leaving one only to determine whether state practice actually is consistent with this *opinio juris*.[48] Even

[45] BROWNLIE, *supra* note 27, at 19-24; LAUTERPACHT, *supra* note 35, at 1-25; SHABTAI ROSENNE, THE LAW AND PRACTICE OF THE INTERNATIONAL COURT 611-14, 616-19 (2nd ed. 1985); SHAW, *supra* note 29, at 678-80.

[46] *See, e.g.*, The North Sea Continental Shelf (Federal Rep. of Germany v. Denmark & Netherlands), 1969 I.C.J. 3, 31, 42-43; The Wimbledon (United Kingdom, France, Italy & Japan v. Germany), PCIJ, ser. A, no. 1, at 25; The Panevezys-Saldutiskis Ry. (Estonia v. Lithuania), 1939, ser. A/B, no. 76, at 51-52. *See* BROWNLIE, *supra* note 27, at 3-4, 11-14, 180-81, 201, 214-17, 604; D'AMATO, *supra* note 35, at 103-66; DANILENKO, *supra* note 35, at 156-72; A.D. MCNAIR, THE LAW OF TREATIES 216-18 (2nd ed. 1961); RESTATEMENT (THIRD), *supra* note 27, § 102 comment f; SHAW, *supra* note 29, at 81-82; WOLFKE, *supra* note 35, at 68-72; Jonathan Charney, *International Agreements and the Development of Customary International Law*, 81 WASH. L. REV. 971 (1986); Grigory Tunkin, *Is General International Law Customary Law Only?*, 4 EUR. J. INT'L L. 534 (1993); Weil, *supra* note 14, at 434-35, 438-40.

[47] *See, e.g.*, Delimitation of the Continental Shelf Boundary (Libya v. Malta), 1985 I.C.J. 13, 29-34; The Gulf of Maine (Canada v. United States), 1984 I.C.J. 246, 294-95 (merits); Fisheries Jurisdiction (United Kingdom v. Iceland), 1973 I.C.J. 3, 18; Advisory Opinion on the Status of Namibia, 1971 I.C.J. 16, 47. *See generally* BROWNLIE, *supra* note 27, at 181, 201-02, 217, 232; Ian Sinclair, *The Impact of the Unratified Convention*, in REALISM IN LAW-MAKING 211 (Adriaan Bos & Hugo Siblesz eds. 1986); Louis Sohn, *Unratified Treaties as a Source of Customary International Law*, in REALISM IN LAW-MAKING, *supra*, at 231; Weil, *supra* note 14, at 435-38.

[48] Military & Paramilitary Activities in Nicaragua (Nicaragua v. United States), 1986 I.C.J. 14, 99-100; Advisory Opinion on the Western Sahara, 1975 I.C.J. 12, 31-37; UN GA Res. 3232, 32d Sess., Preamble (Nov. 12, 1974). *See generally* BROWNLIE, *supra* note 27, at 14-15, 30-31, 698-700; HANNA BOKOR-SZEGO, THE ROLE OF THE UNITED NATIONS IN INTERNATIONAL LEGISLATION (1978); BOWETT, *supra* note 31, at 41-51; HIGGINS, POLITICAL ORGANS, *supra* note 41, at 1-10; RESTATEMENT (THIRD), *supra* note 27, §§ 102(3), 103(2)(c); OSCAR SCHACHTER, INTERNATIONAL LAW IN THEORY AND PRACTICE 84-101 (student ed. 1995); F. BLAINE SLOAN, UNITED NATIONS GENERAL ASSEMBLY RESOLUTIONS IN OUR CHANGING WORLD (1991); WOLFKE, *supra* note 35, at 79-84, 100-04; Hiram Chodosh, *Neither Treaty nor Custom: The Emergence of Declarative International Law*, 26 TEX. INT'L L.J. 87 (1991); Ingrid DeLupis, *The Legal Value of Recommendations of International Organizations*, in INTERNATIONAL LAW AND THE INTERNATIONAL LEGAL SYSTEM 47 (W.E. Butler ed. 1987) ("THE INTERNATIONAL LEGAL SYSTEM"); Rosalyn Higgins, *The Role of Resolutions of International Organizations in the*

unilateral acts of states can demonstrate that the particular state embraces a particular customary rule of law.[49]

Mark Janis has described the process of determining customary international law, even when successful, as "inelegant."[50] We often find gaps and ambiguities in the law as found. Treaties and other international agreements only sometimes fill these gaps or clarify these ambiguities. International decision-makers sometimes fill in gaps or clarify ambiguities through recourse to "general principles of law." General principles are a sort of custom derived not from international practice but from the principles of law found in most or all national legal systems in their internal operation.[51] General principles, however, can seldom amount to more than the most general abstractions about justice and judicial economy and are even less likely to fill the many gaps in customary international law with definitive content given the increasingly heterogeneous nature of an international legal

Process of Creating Norms in the International System, in THE INTERNATIONAL LEGAL SYSTEM, *supra*, at 21; Rahmattullah Khan, *The Legal Status of the Resolutions of the United Nations*, 19 INDIAN J. INT'L L. 552 (1979); I.I. Lukashuk, *Recommendations of International Organizations in the International Normative System*, in THE INTERNATIONAL LEGAL SYSTEM, *supra*, at 31; Stephen Schwebel, *United Nations Resolutions, Recent Arbitral Awards and Customary International Law*, in REALISM IN LAW-MAKING, *supra* note 42, at 203; Weil, *supra* note 34, at 416-18. For criticism of this theory, see MARTEN BOS, A METHODOLOGY OF INTERNATIONAL LAW 63 (1984); ANTHONY D'AMATO, INTERNATIONAL LAW: PROCESS AND PROSPECTS 229-32 (1986). Soviet jurist Grigory Tunkin, who strongly rejects the idea that resolutions can create customary international law, concedes that they can influence the formation of customary international law. G.I. Tunkin, *The Role of Resolutions of International Organizations in Creating Norms of International Law*, in THE INTERNATIONAL LEGAL SYSTEM, *supra*, at 5.

49 *See, e.g.*, The Nuclear Tests Case (Australia & New Zealand v. France), 1974 I.C.J. 255, 267-70. *See generally* MARK JANIS, AN INTRODUCTION TO INTERNATIONAL LAW 14, 38-43 (2nd ed. 1993); WOLFKE, *supra* note 35, at 77-78; Krzysztof Skubiszewski, *Unilateral Acts of States*, in ACHIEVEMENTS AND PROSPECTS, *supra* note 27, at 221.

50 JANIS, *supra* note 49, at 52-54. *See also* Condorelli, *supra* note 35, at 181-83.

51 *See generally* BRIERLY, *supra* note 22, at 62-63, 67-68, 366-73; BROWNLIE, *supra* note 27, at 15-19, 153-62; DANILENKO, *supra* note 35, at 173-89; DE VISSCHER, *supra* note 30, at 356-58; JANIS, *supra* note 49, at 54-61; LEVI, *supra* note 41, at 39-44; RESTATEMENT (THIRD), *supra* note 27, § 102(4); ROSENNE, *supra* note 45, at 608-11; CHRISTOPHER ROSSI, EQUITY AND INTERNATIONAL LAW: A LEGAL REALIST APPROACH TO INTERNATIONAL DECISIONMAKING 87-154 (1993); SCHACHTER, *supra* note 48, at 49-61; SHAW, *supra* note 29, at 84-89; TUNKIN, *supra* note 35, at 190-203; WOLFKE, *supra* note 35, at 105-08; Hanna Bokor-Szegö, *General Principles of Law*, in ACHIEVEMENTS AND PROSPECTS, *supra* note 27, at 213; Monique Chemillier-Gendreau, *Equity*, in ACHIEVEMENTS AND PROSPECTS, *supra*, at 271; Christopher Ford, *Judicial Discretion in International Jurisprudence: Article 38(1)(c) and "General Principles of Law,"* 5 DUKE J. COMP. & INT'L L. 35 (1994); R.Y. Jennings, *Equity and Equitable Principles*, 42 ANNUAIRE SUISSE DE DROIT INTERNATIONAL 27 (1986).

community composed of an increasing number of states expressing highly varied legal traditions.[52]

Despite difficulties in determining the precise content of customary international law, the system has been remarkably successful. International life could not exist without a shared norms that are largely self-effectuating in conducting that life.[53] Only by focusing exclusively on the relatively few, albeit highly dramatic, instances in which the international legal system fails can one gain the impression that the system is entirely ineffective.[54] The successful areas of customary law have been codified under UN auspices. In fact, customary rules are open to codification precisely because the rules are so seldom questioned and so generally followed.[55]

The principal organ through which the United Nations initiates the codification is the International Law Commission, a body created by the General Assembly in 1947 to help codify and "progressively develop" customary international law.[56] The Commission is composed of 34 jurists and diplomats chosen to represent a broad range of legal cultures and political ideologies. As a result, consensus often comes after years of debate, a process that lends a high degree of credibility to a resulting codification. The Commission reports its findings to the General Assembly. In fact, the

[52] Chen Tiqiang, The People's Republic of China and Public International Law, 8 DALHOUSIE L.J. 3 (1984); Gennady Danilenko, The Changing Structure of the International Community: Constitutional Implications, 32 HARV. INT'L L.J. 353 (1991); Maurice Flory, Adapting International Law to the Development of the Third World, 26 J. AFRICAN L. 12 (1982); Konrad Gunther, Re-Defining International Law from the Point of View of Decolonisation and Development and African Regionalism, 26 J. AFRICAN L. 49 (1982); Ewell Murphy, jr., The Diminishing World of Western Law, 16 TEX. INT'L L.J. 1 (1981); John Ntambirweki, The Developing Countries in the Evolution of International Law, 14 HASTINGS INT'L & COMP. L. REV. 905 (1991); No-Hyoung Park, The Third World as an International Legal System, 7 B.C. 3RD WORLD L.J. 37 (1987); Suakiart Sathirathai, An Understanding of the Relationship between International Legal Discourse and Third World Countries, 25 HARV. INT'L L.J. 395 (1984); Jeremy Thomas, International Law in Asia: An Initial Review, 13 DALHOUSIE L.J. 883 (1990); Wang Tieya, The Third World and International Law, in SELECTED ARTICLES FROM THE CHINESE YEARBOOK OF INTERNATIONAL LAW 6 (Chinese Soc'y Int'l L. 1983).

[53] MERRILLS, *supra* note 31, at 86-90. *See generally* REGIME THEORY AND INTERNATIONAL RELATIONS (Volker Rittgerger & Peter Mayer eds. 1993).

[54] MORGANTHAU, *supra* note 22, at 283; SCHACHTER, *supra* note 48, at 227-46.

[55] DANILENKO, *supra* note 35, at 130-56; SCHACHTER, *supra* note 48, at 66-81; Condorelli, *supra* note 35, at 192-94.

[56] UN CHARTER, art. 13(1); *Statute of the International Law Commission,* GA Res. 174(II), Nov. 21, 1947. *See generally* BRIERLY, *supra* note 22, at 78-86; IAN SINCLAIR, THE INTERNATIONAL LAW COMMISSION (1987); UN SECRETARIAT, THE WORK OF THE INTERNATIONAL LAW COMMISSION (4th ed. 1988); Condorelli, *supra* note 35, at 194-97; B. Graefrath, *The International Law Commission Tomorrow: Improving Its Organization and Methods of Work,* 85 AM. J. INT'L L. 595 (1991).

rules assembled by the Commission often are accorded "quasi-legal effect" as rules of customary international law even before they take the form of a binding legal document.[57]

Even after a body of customary international law has been codified, parts of it often survive as customary law. Thus, while the law of the sea has been codified in a series of international conventions, much of this law remains customary if only because many states have declined thus far to ratify some or all of these conventions.[58] Another example is the virtual outlawry of chemical weapons despite the inability of the international community to ratify a treaty dealing with more than a small part of that concern.[59]

However created, customary international law empowers international actors by legitimating their claims while limiting the claims they are permitted to make.[60] Customary international law is, however, sometimes ill fitted to perform these functions as it frequently is ill-defined and uncertain.[61] Identifying when a practice has crystallized as customary law

[57] Frederick Kirgis. International Organizations in Their Legal Setting: Documents. Comments. and Questions 250-51 (1977).

[58] Convention on the Law of the Sea. opened for signature. April 30. 1982. UN Doc. A/CONF.62/122 (1982): Convention on the Continental Shelf. opened for signature. April 29. 1958. 499 UNTS 311: Convention on Fishing and Conservation of the Living Resources of the Sea. opened for signature. April 29. 1958. 559 UNTS 285; Convention on the High Seas, opened for signature. April 29, 1958, 450 UNTS 82: Convention on the Territorial Sea and the Contiguous Zone. opened for signature. April 29. 1958. 516 UNTS 205. On the continuing importance of customary law in the law of the sea. see Delimitation of the Continental Shelf Boundary Case (Libya v. Malta), 1985 I.C.J. 13, 29-34: The Gulf of Maine Case (Canada v. United States). 1984 I.C.J. 246, 295 (merits); The North Sea Continental Shelf Case (Federal Rep. of Germany v. Denmark & Netherlands), 1969 I.C.J. 3, 31. See generally R.R. CHURCHILL & A.V. LOWE, THE LAW OF THE SEA 5-19 (2nd ed. 1988); RESTATEMENT (THIRD). supra note 27, §§ 513 comment j. 514 comment a. 515 reporters' note 1. 523 comment b: SHAW. supra note 29, at 337-92: Condorelli, supra note 35, at 184-85. 197-200.

[59] See David Kennedy. The Jurisprudence of Non-Proliferation: Taking International Law Seriously, 2 TRANSNAT'L L. & CONTEMP. PROB. 357. 373-74 (1992): David Koplow, Long Arms and Chemical Arms: Extraterritoriality and the Draft Chemical Weapons Convention. 15 YALE J. INT'L L. 1. 19-20 (1990): Elizabeth Smith. International Regulations of Chemical and Biological Weapons: "Yellow Rain" and Arms Control. 1984 U. ILL. L. REV. 1011. 1048. See generally Julie Dahlitz. The Role of Customary Law in Arms Limitation. in THE INTERNATIONAL LAW OF ARMS CONTROL AND DISARMAMENT 157 (Julie Dahlitz & Detlev Dicke eds. 1991).

[60] Peter Haas. *Do Regimes Matter? Epistemic Communities and Mediterranean Pollution Control,* 43 INT'L ORG. 377. 401-02 (1989). *See generally* REGIME THEORY AND INTERNATIONAL RELATIONS, *supra* note 53.

[61] These are characteristics of all customary law, and not just customary international law. *See, e.g.,* MARC BLOCH. FEUDAL SOCIETY 114 (L.A. Manyon trans. 1961); ERIC HAVELOCK. PREFACE TO PLATO 121-22 (1963); FRITZ KERN, KINGSHIP AND LAW IN THE MIDDLE AGES 179 (S.B. Chrimes trans. 1939).

and the precise content of a customary rule is often difficult, requiring research in obscure sources. Turning as it does on a question of motive, any examination of the primary evidence for a customary rule is often inconclusive. International law therefore depends on the work of the leading scholars of international law (the "most highly qualified publicists") for evidence of what the law is, as opposed to what they think the law should be.[62] That this does not authorize scholars to create law according to their notions of what the law ought to be can be a fine distinction, to say the least.

Even if a norm of customary international law is determined with some certainty, enforcement through claim and counterclaim among states leaves us without a neutral enforcement mechanism. Lack of neutral enforcement always leaves a suspicion that national interest overrides real commitment to law. Without neutral enforcement, international law ultimately has nothing better to offer than the law of the vendetta.[63] Coupling of a recognized mode of expert analysis of customary norms with inadequate institutional development produces a serious imbalance in international law. The "most highly qualified publicists" often devise doctrinal schemes of considerable sophistication but cannot translate those schemes into effective institutional arrangements. That task has fallen to diplomats and politicians with predictably mixed results.

Institution building rarely succeeds through customary processes. A lack of institutions to resolve dispute impartially and to enforce even strongly supported international norms relatively efficiently against individuals who violate them can seriously undermine the effectiveness of international law. The institutional primitiveness of international law has always been felt most seriously during major crises.[64] A fully developed institutional framework

[62] *See, e.g.*, The North Sea Continental Shelf Case (Federal Rep. of Germany v. Denmark & Netherlands), 1969 I.C.J. 3, 33-35. *See generally* BRIERLY, *supra* note 22, at 65-66; BROWNLIE, *supra* note 27, at 24-25; LAUTERPACHT, *supra* note 35, at 23-25; RESTATEMENT (THIRD), *supra* note 27, § 103(2)(d); ROSENNE, *supra* note 45, at 614-16; SCHACHTER, *supra* note 48, at 38-39; SHAW, *supra* note 29, at 91-93; WOLFKE, *supra* note 35, at 76-77; Mustapha Sourang, *Jurisprudence and Teachings*, in ACHIEVEMENTS AND PROSPECTS, *supra* note 27, at 283.

[63] WATER IN THE MIDDLE EAST, *supra* note 18, at 61. *See also* HENKIN, *supra* note 35, at 60-62; Richard Bilder, *Some Limitations of Adjudication as an International Dispute Settlement Technique*, 23 VA. J. INT'L L. 1 (1982); Chinkin & Sadurska, *supra* note 38, at 57-60; Margaret Doxey, *International Sanctions in Theory and Practice*, 15 CASE-W. RES. J. INT'L L. 273 (1983); Rosalyn Higgins, *Legal Responses to the Iranian and Afghan Crises*, 74 AM. J. INT'L L. 248 (1980); Marla Radinsky, *Retaliation: The Genesis of a Law and the Evolution toward International Cooperation: An Application of Game Theory to Modern International Conflicts*, 2 GEO. MASON U. L. REV. 52 (1994).

[64] MORGANTHAU, supra note 22, at 242; Richard Falk, The Adequacy of Contemporary Theories of International Law—Gaps in Legal Thinking, 50 Va. L. Rev. 231 (1964).

then is essential to resolve any serious, long-term problem, including competition over increasingly critical water shortage.[65] To go beyond the limits of custom, states must combine the sophisticated insights of international lawyers with the practical structures of political actors through treaties creating institutions for managing cooperative activities and for resolving conflict before its escalates to injurious levels.

2. BASIC PRINCIPLES OF CUSTOMARY INTERNATIONAL WATER LAW

A rich body of custom regarding internationally shared fresh water has emerged in the last century. Historically, claims and counterclaims relating to internationally shared fresh waters focused on surface waters. The application of the resulting norms to international aquifers is a relatively recent development. This section opens with an analysis of the evolution of the customary norms applicable to surface waters through state practice and the elaboration of those norms through the *Helsinki Rules* of the International Law Association.[66] After looking at the application of these norms to ground water, this section closes by evaluating the effectiveness of the customary law of internationally shared fresh waters.

2.1 State Practice and Opinio Juris

Industrialization brought intensive use and extensive diversion of water from its natural sources. Although customary international law by itself is unable to solve the problem of managing transboundary water resources,[67] the pattern of state claim and counterclaim, and of state behavior to effect

[65] See generally TECLAFF, supra note 6, at 113-203; Joseph Dellapenna, Designing the Legal Structures of Water Management Needed to Accomplish the Israeli-Palestinian Declaration of Principles, 7 PALESTINE Y.B. INT'L L. 63, 98-103 (1994) ("Dellapenna, Legal Structures"); Joseph Dellapenna, Rivers as Legal Structures: The Examples of the Jordan and the Nile, 36 NAT. RESOURCES J. 217, 237-44 (1996) ("Dellapenna, Rivers"); Joseph Dellapenna, The Nile as a Legal and Political Structure, in THE SCARCITY OF WATER 121-34 (Edward Brans et al. eds.) ("Dellapenna, Nile"); Joseph Dellapenna, The Waters of the Jordan Valley: The Potential and Limits of Law, 5 PALESTINE Y.B. INT'L L. 15, 40-45 (1990) ("Dellapenna, Jordan Valley"); Joseph Dellapenna, Treaties as Instruments for Managing Internationally-Shared Water Resources: Restricted Sovereignty vs. Community of Property, 26 CASE-W. RES. J. INT'L & COMP. L. 27, 51-56 (1994) ("Dellapenna, Treaties").

[66] International L. Assoc., The Helsinki Rules on the Uses of the Waters of International Rivers (Rep. of 52nd Conf., Helsinki 1966) ("Helsinki Rules").

[67] Dellapenna, *Legal Structures*, *supra* note 65, at 72-90.

such claims, is highly consistent. The ultimate outcome of disputes, leaving aside strong power imbalances among the states sharing an international watercourse is entirely predictable.[68] Only riparian states—states across which, or along which, a river flows—have a legal right, apart from a treaty, to use the water of a river.[69] Beyond that, the initial claims and counterclaims diverge sharply according to the riparian status of the state making the claim.

An upper riparian state initially claims "absolute territorial sovereignty," asserting a right to do whatever it chooses with the water regardless of its effect on other riparian states.[70] Downstream states, on the other hand, generally open by claiming a right to the "absolute integrity of the watercourse," claiming that upper riparian states can do nothing that affects the quantity or quality of water that flows down the watercourse.[71] Friedrich Berber noted that these claims "are grounded in an individualistic and anarchical conception of international law in which personal and egotistical interests are raised to the level of guiding principles and no solution is offered for the conflicting interests of the upper and lower riparians."[72] The utter incompatibility of the claims assures that neither claim will prevail in the end, although the process of negotiating or otherwise resolving the dispute might require decades. The usual solution is a concept of "restricted sovereignty" that goes by the name "equitable utilization" under which all riparian states are free to use water from a common source so long as they do

[68] *See generally* F.J. Berber, Rivers in International Law (R.K. Batstone trans. 1959); J. Bruhàcs, The Law of Non-Navigational Uses of International Watercourses (1993); Caponera, *supra* note 24; Bonaya Adhi Godana, Africa's Shared Water Resources: Legal and Institutional Aspects of the Nile, Niger, and Senegal River Systems (1985); Tiyanjana Maluwa, *Towards an Internationalisation of the Zambezi River Regime: The Role of International Law in the Common Management of an International Watercourse*, 25 Comp. & Int'l L.J. S. Afr. 20 (1992); Stephen McCaffrey, *Second Report on the Law of Non-Navigational Uses of International Watercourses*, UN Doc. A/CN.4/348, [1986] II Y.B. Int'l L. Comm'n 88, 105-10; Schwebel, *supra* note 9; Utton, *supra* note 6, ch. 49; Sheng Yu, *International Rivers and Lakes*, in Achievements and Prospects, *supra* note 27, at 989.

[69] United Nations Convention on the Law of Non-Navigational Uses of International Watercourses, UN Doc. No. A/51/869 (1997), art. 2(c), 4, reprinted in 36 INT'L LEGAL MAT'LS 700 ("UN Convention").

[70] BERBER, *supra* note 68, at 14-19, 77-78, 108; BRUHÀCS, *supra* note 68, at 41-47; CAPONERA, *supra* note 24, at 212-13; ELMUSA, *supra* note 17, at 37-38 (1996); GODANA, *supra* note 68, at 32-35; H.A. SMITH, THE ECONOMIC USES OF INTERNATIONAL RIVERS 7-8 (1931); Maluwa, *supra* note 68, at 25-26; McCaffrey, *supra* note 68, at 105-10; Utton, *supra* note 6, § 49.02(1); Sheng Yu, *supra* note 68, at 989, 990.

[71] BERBER, *supra* note 68, at 19-22; BRUHÀCS, *supra* note 68, at 43-47; CAPONERA, *supra* note 24, at 213; GODANA, *supra* note 68, at 38-40; Maluwa, *supra* note 68, at 24-25; Utton, *supra* note 6, § 49.02(2); Sheng Yu, *supra* note 68, at 990.

[72] BERBER, *supra* note 68, at 14.

not interfere unreasonably with uses in other riparian states.[73] States that are both upper and lower riparians on the same stream (usually relative to different states) often are the first to assert a theory of restricted sovereignty.

Documenting the process of claim and counterclaim that converts a convenient practice into a customary rule of law is easy for internationally shared waters. The most famous claim of absolute territorial sovereignty was made the United States in 1895. A dispute arose in the 1890s when the Mexican government complained that Americans were wastefully diverting water from the Rio Bravo del Norte (what the Americans call the Rio Grande) to the injury of Mexicans down river. The Mexican government complained that the American practices violated both treaties and customary international law.[74] The American Attorney-General, Judson Harmon, gave the American Secretary of State his legal opinion that international law did not impose any obligation on the United States regarding how it used waters within its sovereign borders.[75] This became known as the Harmon Doctrine.[76] After nearly 12 years of dispute, the two states negotiated an agreement whereby the United States promised to "deliver" (by way of the river) 60,000 acre-feet (74 million cubic meters ["MCM"]) of water annually to the lower reaches of the river for Mexican use.[77] Years later, the US State Department concluded that the United States had never considered the

[73] BERBER, *supra* note 68, at 11-14, 78-79; BRUHÁCS, *supra* note 68, at 45-48; CAPONERA, *supra* note 24, at 213-14; GODANA, *supra* note 68, at 40; Maluwa, *supra* note 68, at 26-30; McCaffrey, *supra* note 68, at 110-33; Utton, *supra* note 6, § 49.02(3); Sheng Yu, *supra* note 68, at 991.

[74] Letter of Minister Matías Romero to Secretary of State Richard Olney, Oct. 21, 1894, in 1894 FOREIGN REL. OF THE U.S. 395.

[75] 21 Op. Att'y Gen. 274, 281-282 (1895), *reprinted in* 1 John Bassett Moore, Digest of International Law 654 (1906). *See generally* Charles Hyde, International Law Chiefly as Interpreted and Applied by the United States 565 (2nd ed. 1945); K. Kriskau, Die Harmon Doktrin—eine These der Vereinigton Staaten zum inernationalen Flussrecht (1966); Jacob Austin, *Canadian-United States Practice and Theory Respecting the International Law of International Rivers: A Study of the History and Influence of the Harmon Doctrine*, 37 Can. B. Rev. 393 (1959); Stephen McCaffrey, *The Harmon Doctrine One Hundred Years Later: Buried, Not Praised*, 36 Nat. Resources J. 726, 733-45 (1996).

[76] *See, e.g.*, Kriskau, *supra* note 75; Austin, *supra* note 75; McCaffrey, *supra* note 75.

[77] *Rio Grande Convention*, *supra* note 25. *See generally* BERBER, *supra* note 68, at 110-11; LUDWIK TECLAFF, WATER LAW IN HISTORICAL PERSPECTIVE 429-33 (1985); McCaffrey, *supra* note 68, at 105-07; McCaffrey, *supra* note 75, at 745-57; Utton, *supra* note 6, § 51.02. The agreement was revised in and the United States agreed to deliver 1,850 MCM of water annually. *Colorado Treaty*, *supra* note 25. *See generally* McCaffrey, *supra* note 68, at 107-08; Utton, *supra* note 6, § 51.03.

Harmon Doctrine to be anything more than special pleading and decisively repudiated the Doctrine.[78]

Note the interplay between treaty and custom. The original Mexican claim relied on both treaty and custom, and Attorney-General Harmon rejected both in similar terms. The dispute was resolved through a series of treaties. The treaties created legal obligations between the two nations but they also demonstrate state practice which, if sufficiently widespread, could amount to an international custom. Did the treaties demonstrate the *opinio juris* necessary to make that customary law? At one time that question was hotly disputed; several leading experts on international law generally or on the law of internationally shared rivers concluded that these treaties could not rise to the level of customary law.[79] Their conclusion was disputed at the time, and a consensus emerged in favor of the conclusion that the consistent pattern of treaties did demonstrate both state practice and the necessary *opinio juris* sufficiently to prove a rule of customary international law.[80] The customary rule of equitable utilization now rests on the now nearly innumerable treaties regarding internationally shared waters.[81]

Establishing that state practice conforms to the general principle that each state's sovereignty over its water resources is restricted by the obligation not to inflict unreasonable injury on another state thus is easy. The treaties generally are so tailored to the particulars of a specific drainage basin, however, that it is impossible to derive a more specific mandate applicable to

78 *Memorandum to the Legal Advisor*, Nov. 23, 1942, reprinted in 3 MARJORIE WHITEMAN, DIGEST OF INTERNATIONAL LAW 950 (1964). *See also* State Dep't. *Legal Aspects of the Use of Systems of International Waters*, Sen. Doc. No. 118, 85th Cong., 2d Sess. 89-91 (1958), reprinted in 3 WHITEMAN, *supra*, at 940. *See generally* McCaffrey, *supra* note 75, at 757-67.

79 BERBER, *supra* note 68, at 149; 1 HYDE, *supra* note 75, at 12.

80 *See, e.g.*, BRUHÁCS, *supra* note 68, at 15, 59-65, 71-73, 156; SAMIR SALIBA, THE JORDAN RIVER DISPUTE 48-62 (1968); TECLAFF, *supra* note 77, at 428-43; Lipper, *supra* note 8, at 33-35; Sheng Yu, *supra* note 68, at 993-96.

81 The treaties are collected in UN Doc. A/5409, (1974) II Y.B. INT'L L. COMM'N 49; and UN Doc. A/CN.4/274, (1974) II Y.B. INT'L L. COMM'N 265. *See also* BERBER, *supra* note 68, at 52-127; REPORT OF THE UN COMMISSION FOR EUROPE, LEGAL ASPECTS OF HYDRO-ELECTRIC DEVELOPMENT OF RIVERS AND LAKES OF COMMON INTEREST, 95-152 UN Doc. E/ECE/136 (1952) ("ECE REPORT"); SMITH, *supra* note 70; TREATIES CONCERNING THE NON-NAVIGATIONAL USES OF INTERNATIONAL WATERCOURSES—EUROPE (FAO Legislative Study no. 50, Stefano Burchi ed. 1993); UNITED NATIONS, LEGISLATIVE TEXTS AND TREATY PROVISIONS CONCERNING THE UTILIZATION OF INTERNATIONAL RIVERS FOR OTHER PURPOSES THAN NAVIGATION, ST/LEG/SER.B/12 (1964) ("LEGISLATIVE TEXTS"); Dellapenna, *Treaties*, *supra* note 65, at 42-47; McCaffrey, *supra* note 68, at 134-38; Schwebel, *supra* note 9, at 76-82, 88-90; Utton, *supra* note 6, § 49.03(a).

the waters of a basin not yet allocated by treaty.[82] Just as Mexico and the United States did, the nations involved often share the water according to historic patterns of use, although some other more or less objective measure of need is sometimes substituted (population, area, arable land, etc.).[83] Other treaties simply assured each state of "equal shares." A few treaties, however, speak in more general terms. A watercourse treaty between Norway and Sweden declares the obligation of each state to prevent "any considerable inconvenience" to persons in the other country.[84] The *Treaty of Peace, Friendship, and Arbitration* between the Dominican Republic and Haiti assures each of the right to make "just and equitable use" of their shared waters.[85] The *General Convention Relating to the Development of Hydraulic Power Affecting More Than One State ("Hydraulic Power Convention")*,[86] a treaty ratified by 17 states, speaks in similarly broad terms of an obligation not to "cause serious prejudice" to another state.

These treaties establish state practice relative to internationally shared waters. Demonstrating that these treaties, along with other indicia of the motives behind the arrangements, amount to the requisite *opinio juris* is not so easy. After all, the treaties were convenient even if no rule of law supported the result—in fact, that must certainly have been the reasoning underlying the earliest of these treaties.[87] Few of the treaties say anything about the customary law that informs their negotiation, interpretation, and application. Some treaties even expressly deny any effect as creating or

[82] BERBER, supra note 68, at 148-59; BRUHÁCS, supra note 68, at 16-17, 60-61; GODANA, supra note 68, at 66; SMITH, supra note 70, at 56; Gamal Moursi Badr, *The Nile Waters Question: Background and Recent Developments*, 15 REVUE ÉGYPTIENNE DE DROIT INTERNATIONAL 1, 20 (1959); Aziza Fahmi, *International River Law for Non-Navigable Rivers with Special Reference to the Nile*, 23 REVUE ÉGYPTIENNE DE DROIT INTERNATIONAL 39, 46-48 (1967); Goldenman, *supra* note 4, at 771; Maluwa, *supra* note 68, at 28-29.

[83] *See generally* SALIBA, *supra* note 80, at 51-54, 57-59; TECLAFF, *supra* note 6, at 157-165; TECLAFF, *supra* note 77, at 429-43.

[84] *Convention on Certain Questions Relating to the Law of Watercourses*, signed May 11, 1929, Norway-Sweden, art. 12(1), 120 LNTS 277.

[85] Signed Feb. 20, 1929, art. 10, 105 LNTS 225. *See also Agreement Concerning the Waterpower of the Pasvik River*, signed Dec. 18, 1957, Norway-USSR, 312 UNTS 274.

[86] Opened for signature, Dec. 9, 1923, 36 LNTS 76. *See also General Convention Regulating Navigable Waterways of International Concern*, opened for signature, Apr. 20, 1921, art. 4, 7 LNTS 35. *See* BERBER, *supra* note 68, at 122-24; BRUHÁCS, *supra* note 68, at 11; CAPONERA, *supra* note 24, at 209-10.

[87] *See* David LeMarquand, *Politics of International River Basin Cooperation and Management*, in WATER IN A DEVELOPING WORLD: THE MANAGEMENT OF A CRITICAL RESOURCE 147 (Albert Utton & Ludwik Teclaff eds. 1978); Ludwik Teclaff, *Fiat or Custom: The Checkered Development of International Water Law*, 31 NAT. RESOURCES J. 45 (1991); Oran Young, *The Politics of International Regime Formation: Managing Natural Resources and the Environment*, 43 INT'L ORG. 349 (1989).

implementing general customary international law. In the *Rio Grande Convention,* the United States indicated that the delivery of water under the treaty was not a recognition of any claim on the part of Mexico to the waters and that the United States did not "in any way concede the establishment of any general principle or precedent by the concluding of this treaty."[88] The United States itself, however, has itself since concluded that there is just such a general customary rule of law, relying in part on this very convention as authority for the proposition.[89] Nonetheless, the United States and Canada included a similar disclaimer in their agreement over the Columbia River Basin just three years later.[90]

A few treaties have expressly acknowledged the existence of an underlying customary rule, albeit generally in vague terms. The *Hydraulic Power Convention* states: "The present Convention in no way affects the right belonging to each state, *within the limits of international law,* to carry out on its own territory any operation for the development of hydraulic power which it may consider desirable."[91] The recent *Mekong Basin Agreement* also committed the signatories to "utilize the waters of the Mekong River system in a reasonable and equitable manner," and similar expressions are found in bilateral treaties.[92] Perhaps most persuasive in this setting is the growing practice of states in a politically, hydrologically, or otherwise dominant position on a river accepting from the start of negotiations that a river or other watercourse is a shared resource over which they cannot claim absolute dominion either in terms of territorial sovereignty or in terms of riparian integrity.[93] While these treaties express a concept of

88 *Rio Grande Convention, supra* note 25, arts. 4, 6. *See also Indus Waters Treaty,* signed Sept. 19, 1960, India-Pakistan, art. 11, 419 UNTS 126.

89 State Dep't. *supra* note 79, at 62-63, 89-91. *See generally* Berber, *supra* note 68, at 110-18; L.M. Bloomfield & G.F. Fitzgerald, Boundary Waters Problems of Canada and the United States: The International Joint Commission, 1912-1958, at 46-47 (1958); Saliba, *supra* note 80, at 51-55; McCaffrey, *supra* note 68, at 106-09.

90 Treaty for the Co-Operative Development of the Columbia River Basin, Jan. 17, 1961, Canada-United States, art. 17(1), 15 U.S.T. 1555.

91 *Hydraulic Power Convention, supra* note 86, art. 1 (emphasis added).

92 Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, signed April 5, 1995, Cambodia-Laos-Thailand-Vietnam, art. 5, reprinted in 34 INT'L LEGAL MAT'LS 864 (1995) ("Mekong Agreement"). See also Agreement on Regulation of Boundary Waters, signed November 20, 1866, Spain-Portugal, Annex 1 (the whole agreement in turn is an annex to the Convention on Boundaries, signed on September 29, 1864, Spain-Portugal, LEGISLATIVE TEXTS, supra note 74, no. 241); Treaty Concerning the Regulation of Water Management of Frontier Waters, signed Dec. 7, 1967, Austria-Czechoslovakia, art. 19(4), 728 UNTS 313.

93 *See, e.g.,* The Lake Lanoux Arbitration (France v. Spain), 24 INT'L L. REP. 101, 111-12 (1957) (France did not assert absolute sovereignty); PAPERS REGARDING A TREATY OF ALLIANCE WITH EGYPT—EGYPT NO. 1, at 31 (U.K. Cmd. 3050, 1928) (the United

equitable utilization, just how this restricts particular uses of water is often not clearly indicated.

Many nations have expressed themselves more clearly in international conferences at which the topic of internationally shared waters has arisen. The Western Hemisphere states recognized that no state has an absolute right either to do as it pleases with waters it shares with other states or to demand that other states do nothing with those waters.[94] Even nations that objected to the resulting *Declaration of Montevideo* did so because it was not comprehensive enough, not because they opposed the principle being expressed.

One also finds evidence of a customary law of internationally shared waters in arbitral and judicial decisions applying that law to particular disputes. These decisions are unanimously in favor of the rule of equitable utilization.[95] The best example remains the statement of the Permanent Court of International Justice (the predecessor to the International Court of Justice) in discussing the authority of the *Permanent Commission of the River Oder:*

> When consideration is given to the manner in which states have regarded the concrete situations arising out of the fact that a single waterway traverses or separates the territory of more than one state, and the possibility of fulfilling the requirements of justice and the considerations of utility which this fact places in relief, it is at once seen that a solution of the problem has been sought not in the idea of a right of passage in favour of upstream states, but in that of a community of interest of riparian states. This community of interest in a navigable river becomes the basis a common legal right, the essential features of which are the perfect equality of all riparian states in the use of the whole course of the river and the exclusion of any preferential privileges of any riparian state in relation to others.[96]

Kingdom did not assert absolute sovereignty on behalf of the Sudan). *See also* LAMMERS, *supra* note 13, at 289-90; [SUDANESE] MINISTRY OF IRR. & HYDRO-ELEC. POWER, NILE WATERS QUESTION 13 (1955); SMITH, *supra* note 68, at 147; McCaffrey, *supra* note 68, at 110-13.

[94] *Declaration on Industrial and Agricultural Use of International Rivers*, Montevideo, Dec. 24, 1933 (7th Int'l Conf. of Am. States), *reprinted in* 28 AM. J. INT'L L. 59 (1934 supp.). *See generally* BERBER, *supra* note 68, at 125-27.

[95] *See* UN Doc. A/5409, (1974) II Y.B. INT'L L. COMM'N 49, 187-99; BRUHÀCS, *supra* note 68, at 12-13; CAPONERA, *supra* note 24, at 192-94; SALIBA, *supra* note 80, at 62-64; Lipper, *supra* note 8, at 28-31; McCaffrey, *supra* note 68, at 113-22; Utton, *supra* note 6, § 49.03(b).

[96] Permanent Commission of the River Oder Case, 1929 P.C.I.J., ser. A, no. 23, at 27. *See also* Jurisdiction of the European Commission for the Danube Case, 1927 P.C.I.J., ser. B,

2.2 The Teachings of the "Most Highly Qualified Publicists"

The "most highly qualified publicists are in general agreement that equitable utilization is the applicable rule of customary international law for internationally shared waters. Equitable utilization rests ultimately on the concept of an international drainage basin as a coherent juridical and managerial unit, a concept widely supported by naturalists, engineers, lawyers, and economists.[97] As noted, decisions of international arbitral and judicial tribunals strongly embrace this conclusion. National courts litigating the rights of states or provinces in a federal union have reached similar conclusions.[98] The German *Reichsgerichtshof* expressed the point in these words:

no. 14, at 61-64; LAMMERS, *supra* note 13, at 507; TECLAFF, *supra* note 77, at 378-99; McCaffrey, *supra* note 68, at 113-14.

97 UNCED Report, *Agenda 21, 2* UN Doc. A/CONF.151/26 at 167-68; BRUHÁCS, *supra* note 68, at 17-19, 24-35; CAPONERA, *supra* note 24, at 185-86; LAMMERS, *supra* note 13, at 18; ADRIAN MCDONALD & DAVID KAY, WATER RESOURCES: ISSUES AND STRATEGIES 190-223, 239-45 (1988); TECLAFF, *supra* note 6; M.S. Basson, C. Triebel, & J.A. van Rooyen, *Analysis of a Multi-Basin Water Resources System: A Case Study of the Vaal River System*, in 4 WATER FOR WORLD DEVELOPMENT 237 (R. Droste & K. Adamowski eds. 1988); Leonard Dworsky & Albert Utton, *Assessing North America's Management of Its Transboundary Waters*, 33 NAT. RESOURCES J. 413 (1993); George Francis, *Ecosystem Management*, 33 NAT. RESOURCES J. 315 (1993); C.B.F. Kuijpers, *Integrated Water Management in the Netherlands: Myth or Practice?*, in WATER FOR SUSTAINABLE DEVELOPMENT IN THE TWENTY-FIRST CENTURY 116 (Asit Biswas, Mohammed Jellali, & Glenn Stout eds. 1993) ("SUSTAINABLE DEVELOPMENT"); Joanne Linnerooth, *The Danube Basin: Negotiating Settlements to Transboundary Environmental Issues*, 30 NAT. RESOURCES J. 629 (1990); Maluwa, *supra* note 68, at 22-23; Tiyanjana Maluwa, *The Legal Aspects of the Niger River under the Niamey Treaties*, 28 NAT. RESOURCES J. 671 (1988); Stephen McCaffrey, *International Organizations and the Holistic Approach to Water Problems*, 31 NAT. RESOURCES J. 139, 143 (1991); C.O. Okidi, *The State and the Management of International Drainage Basins in Africa*, 28 NAT. RESOURCES J. 645 (1988); Miguel Solanes, *Legal and Institutional Aspects of River Basin Development*, 17 WATER INT'L 116 (1992); Xue Hanqin, *Relativity in International Water Law*, 3 COLO. J. INT'L ENVTL. L. & POL'Y 45, 46-48 (1992).

98 The Donauversinkung Case (Württemberg & Prussia vs. Baden), 116 *Entsheidungen des Reichsgerichts in Zivilsachen ("RGZ")* 1 (*Staatsgerichtshof* ["SGH"] 1927), *reprinted in* ANN. DIGEST OF PUB. INT'L L. CASES 128 (Hersch Lauterpacht ed. 1931); *Report of the Rao Commission* 10, 11 (1942), quoted in 3 WHITEMAN, *supra* note 78, at 943; Zurich v. Aargau, 4 *Entcherdungern des Schweizischen Bundesgerichts 34, 37 (1898)*. For the United States, see the cases collected *supra* at notes 7, 8. *See also* Decision of Feb. 13, 1939 (Societé énergie électrique du littoral méditerranéen c. Compagnia imprese elettriche liguri) (Corte de Cassazione) (dispute between a French an an Italian company over rights in a transboundary river), *translated in* ANN. DIGEST PUB. INT'L L. CASES No. 47 (Hersch Lauterpacht ed. 1938-40). *See generally* N.D. GULIATI, DEVELOPMENT OF INTERSTATE

> The exercise of sovereign rights by every state in regard to international rivers traversing its territory is limited by the duty not to injure the interest of other members of the international community. Due consideration must be given to one another by the states through whose territories there flows an international river. No state may substantially impair the natural use of the flow of such a river by its neighbors.[99]

While such decisions do not themselves constitute international law, international tribunals frequently have cited these national decisions as the writings of the most high qualified publicists—as evidence of customary international law.[100]

Writing on an individual basis, the most highly qualified publicists nearly unanimously support the theory of restricted sovereignty as the customary rule of international law.[101] A study by the United Nations Economic

RIVERS: LAW AND PRACTICE IN INDIA (1972); S.N. JAIN, ALICE JACOB, & SUBHASH JAIN, INTERSTATE WATER DISPUTES IN INDIA (1971); Hussain, *supra* note 8; Dietrich Schindler, *The Administration of Justice in the Swiss Federal Courts in International Disputes*, 15 AM. J. INT'L L. 149 (E.H. Zeydel trans. 1921).

99 Ann. Digest of Public Int'l law Cases, at 128.

100 *See, e.g.*, The Trail Smelter Arbitration, 9 INT'L L. REP. 315 (1941). *See also* BRUHÀCS, *supra* note 68, at 155; CAPONERA, *supra* note 24, at 194; SALIBA, *supra* note 80, at 64-66; Dominique Alhéritière, *International Cooperation and Inland Waters: The Influence of Federalism*, in WATER IN A DEVELOPING WORLD, *supra* note 87, at 166; R.D. Hayton, *The Formation of the Customary Rules of International Drainage Basin Law*, in INTERNATIONAL DRAINAGE BASINS, *supra* note 6, at 834, 845-47; Josef Kunz, *International Law by Analogy*, 45 AM. J. INT'L L. 329 (1951); Hersch Lauterpacht, *Decisions of Municipal Courts as a Source of International Law*, 10 BRIT. Y.B. INT'L L. 65 (1929); Lipper, *supra* note 8, at 31-33; Maluwa, *supra* note 68, at 25; McCaffrey, *supra* note 68, at 129-30; Schwebel, *supra* note 9, at 75-76; Utton, *supra* note 6, §§ 49.03(c), 49.07(a). *But see* BERBER, *supra* note 68, at 168-84 (*contra*).

101 *See generally* MAHMOUD ARSANJANI, INTERNATIONAL REGULATION OF INTERNAL RESOURCES (1981); BERBER, *supra* note 68, at 185-255; BRIERLY, *supra* note 22, at 231-32; BROWNLIE, *supra* note 27, at 271-76; BRUHÀCS, *supra* note 68, at 73-79, 155-73; CAPONERA, *supra* note 24, at 189-90, 212-14; BRIJ CHAUHAN, SETTLEMENT OF WATER LAW DISPUTES IN INTERNATIONAL DRAINAGE BASINS (1981); NATHAN FEINBERG, STUDIES IN INTERNATIONAL LAW WITH SPECIAL REFERENCE TO THE ARAB-ISRAELI CONFLICT 491-97 (1979); GODANA, *supra* note 68, at 8, 50-57, 338-44; DANIEL O'CONNELL, INTERNATIONAL LAW 556-558 (2nd ed. 1970); 1 LASSA OPPENHEIM, INTERNATIONAL LAW 313, 345-47, 474-476 (Hersch Lauterpacht ed., 8th ed. 1955); GEORG SCHWARZENBERGER, INTERNATIONAL LAW 13 (2nd ed. 1941); SMITH, *supra* note 68, at 148-51; TECLAFF, *supra* note 6, at 152; TECLAFF, *supra* note 77, at 424-56; 3 VERZIJL, *supra* note 35, at 103-220; Dominique Alhéritière, *Settlement of Public International Disputes on Shared Resources: Elements of a Comparative Study of International Instruments*, in TRANSBOUNDARY RESOURCES LAW 139 (Albert Utton & Ludwik Teclaff eds. 1987); Samir Ahmed, *Principles and Precedents in International Law Governing the Sharing of Nile Waters*, in THE NILE: RESOURCE EVALUATION, RESOURCE MANAGEMENT, HYDROPOLITICS AND LEGAL

Committee for Europe surveyed 75 publicists and found only four who favored either of the absolute theories.[102] A similar study by Stephen Schwebel as Special Rapporteur for the International Law Commission for the drafting of articles on the non-navigational use of international watercourses found a similarly one-sided pattern.[103] Schwebel, in that study, concluded that "the right of each state to share equitably in the uses of the waters of an international watercourse system is indisputable and undisputed."[104] Furthermore, every non-governmental international organization to consider internationally shared water resources has embraced the concept of equitable utilization as the governing law.[105]

ISSUES 225 (P.P. Howell & J.A. Alan eds. 1990); Juraj Andrassy, *L'utilisation des eaux des bassins fluviaux internationaux*, 16 REVUE ÉGYPTIENNE DE DROIT INTERNATIONAL 23 (1960); Austin, *supra* note 75; Eyal Benvenisti & Haim Gvirtzman, *Harnessing International Law to Determine Israeli-Palestinian Water Rights: The Mountain Aquifer*, 33 NAT. RESOURCES J. 543, 547-48 (1993); Richard Bilder, *International Law and Natural Resources Policies*, 20 NAT. RES. J. 451 (1980); C.B. Bourne, *The Columbia River Controversy*, 37 CAN. B. REV. 444 (1959); Guillermo Cano, *Laws of Nature and Water Laws*, 7 WATER INT'L 81 (1982); Hasam Chalabi & Tarek Majzoub, *Turkey, the Waters of the Euphrates and Public International Law*, in WATER IN THE MIDDLE EAST: LEGAL, POLITICAL AND COMMERCIAL IMPLICATIONS 189, 227-29 (J.A. Allan & Chibli Mallat eds. 1995) ("LEGAL, POLITICAL AND COMMERCIAL IMPLICATIONS"); Dellapenna, *Treaties*, *supra* note 65, at 35-38; Fahmi, *supra* note 83; Goldenman, *supra* note 4, at 775-79; William Griffin, *The Use of Waters of International Drainage Basins under Customary International Law*, 53 AM. J. INT'L L. 50 (1959); 48; F.L.E. Goldie, *Equity and the International Management of Transboundary Resources*, in TRANSBOUNDARY RESOURCES LAW, *supra*, at 103; Günther Handl, *The Principle of "Equitable Use" as Applied to International Shared Resources*, 14 REVUE BELGE DE DROIT INTERNATIONAL 40, 47 (1978); Eduardo Jiménez de Arechaga, *Normas jurídicas internacionales que regulan el aprovechamiento hidráulico*, 2 REV. JURIDICA INTERAMERICANA 320 (1960); A.P. Lester, *River Pollution in International Law*, 57 AM. J. INT'L L. 828, 832 (1963); Lipper, *supra* note 8, at 62-66; Maluwa, *supra* note 68, at 26-28; Ved Nanda, *Emerging Trends in the Use of International Law and Institutions for the Management of International Water Resources*, in WATER NEEDS FOR THE FUTURE 15 (Ved Nanda ed. 1977); Utton, *supra* note 6, § 49; Patricia Wouters, *Allocation of the Non-Navigational Uses of International Watercourses: Efforts at Codification and the Experience of Canada and the United states*, 30 CAN. Y.B. INT'L L. 43, 45 (1992); Sheng Yu, *supra* note 68, at 93-96.

102 ECE REPORT, *supra* note 81, at 57-68.

103 Schwebel, *supra* note 9, at 82-85, 87-88, 91-103. *See also* BERBER, *supra* note 68, 11-44 (noting that many early commentators supported one of the absolute theories, but that later commentators were coalescing around "restricted sovereignty" (equitable utilization); McCaffrey, *supra* note 68, at 127-29.

104 Schwebel, *supra* note 9, at 85.

105 *See generally* BRUHÀCS, *supra* note 68, at 77-79; CAPONERA, *supra* note 24, at 194-96; Utton, *supra* note 6, § 49.03(d).

2.3 The Helsinki Rules

One particularly influential form of expert opinion is a report by one or another of the international associations of legal experts that have flourished since the nineteenth century. Many of these groups have undertaken to synthesize the experience of nations in coping with the shared management of international surface water sources, including the Asian-African Legal Consultative Committee, *l'Institut de droit international,* and the Inter-American Bar Association.[106] While these groups have no official standing, the importance of the opinions of the "most highly qualified publicists" in customary international law gives them an importance that would be remarkable for a similar group in a national legal system. Their opinions carry special weight because of the stature of the members who worked on these projects, and because the approval of the end result carries the imprimatur of a large and diverse body of expert opinion.

The International Law Association, a highly-regarded nongovernmental organization of legal experts founded in 1873, completed the best known study of the customary international law of transboundary water resources in 1966. That study, known as the *Helsinki Rules on the Uses of the Waters of International Rivers,*[107] was the first codification of the law of international watercourses by an international association. These rules heavily influenced subsequent state practice and the efforts of other international associations examining the law of internationally shared fresh waters.[108]

The *Helsinki Rules* formulated the now standard phrase "equitable utilization" to express the rule of restricted sovereignty as applied to fresh waters: "Each basin state is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an international drainage basin."[109] The International Law Association continued to draft rules relating to activities not addressed directly or adequately in the original

[106] Asian-African Legal Consultative Comm., Report of the Fourteenth Session 100 (1974); Inter-American Bar Ass'n, Resolution on Principles of Law Governing the Uses of International Rivers and Lakes (1957); *Utilization of Non-Maritime International Waters (Except for Navigation) ("Salzburg Resolution"),* 40 Annuaire de l'institut de droit international 381 (1961). *See also* 3 Whiteman, *supra* note 78, at 922-24, 929-30; McCaffrey, *supra* note 68, at 124-27; Schwebel, *supra* note 9, at 84, 87.

[107] HELSINKI RULES, *supra* note 66. The project was begun in 1954 and produced an interim report to the Association's Conference in New York in 1958. INT'L L. ASS'N, RESEARCH PROJECT ON THE LAW AND USES OF INTERNATIONAL RIVERS 197-98 (1959) ("NYU CONFERENCE").

[108] *See* Charles Bourne, *The International Law Association's Contribution to International Water Resources Law,* 36 NAT. RESOURCES J. 155, 155-77, 213-16 (1996); Schwebel, *supra* note 9, at 83-84, 87-88.

[109] HELSINKI RULES, *supra* note 66, art. IV.

Helsinki Rules, including flood control (1972), pollution (1972 & 1982), navigability (1974), the protection of water installations during armed conflicts (1976), joint administration (1976 & 1986), flowage regulation (1980), general environmental management concerns (1980), ground water (1986), cross-media pollution (1996), and remedies (1996).[110] In these, the Association developed a second principle for the management of internationally shared water resources, that each nation not cause "substantial damage" to the environment or beyond the limits of the nation's jurisdiction.[111] The Association did not attempt, however, to work out the relation between the "no harm" rule and the "equitable utilization" rule, a failure that produced considerable confusion and difficulty in later years.

3. THE UNITED NATIONS CODIFICATION OF INTERNATIONAL WATER LAW

When first confronted with the *Helsinki Rules*, the United Nations General Assembly refrained from explicitly endorsing the *Rules*.[112] Instead, the General Assembly called upon the International Law Commission to prepare a set of "draft articles" on the "non-navigational uses of international watercourses.[113] The Commission produced a first draft of the *Draft Articles*

[110] The complete sets of rules (except those approved in 1996) are collected, with ample commentary, in INTERNATIONAL LAW ASSOCIATION RULES ON INTERNATIONAL WATER (Slavko Bogdanovic ed. 1999—published by the YugoslavAssociation for Water Law); and THE WORK OF THE INTERNATIONAL LAW ASSOCIATION ON THE LAW OF INTERNATIONAL WATER RESOURCES (E.J. Manner & Veli-Martti Metsälampi eds. 1988—published by the Finnish Branch of the International Law Association). For a summary of their provisions, see Bourne, *supra* note 108, at 177-208; McCaffrey, *supra* note 97, at 144-50; Schwebel, *supra* note 9, at 85.

[111] *See* International L. Ass'n. Complementary Rules Applicable to International Water Resources, art. I (Rep. of 62nd Conf., Seoul 1986) ("Complementary Rules"); International L. Ass'n. Rules on the Relationship between Water, Other Natural Resources and the Environment, art. I (Rep. of the 59th Conf., Belgrade 1980) ("Belgrade Rules"). *See also* Restatement (Third), *supra* note 27, § 601; Shaw, *supra* note 29, at 532-39; Utton, *supra* note 6, § 49.04. *See also* NYU Conference, *supra* note 107, at 197.

[112] BRUHÀCS, *supra* note 68, at 19.

[113] *Progressive Development and Codification of the Rules of International Law Relating to International Watercourses*, GA Res. 2669 (XXV), Dec. 8, 1970, UN Doc. A/8028; UN SECRETARIAT, *supra* note 56, at 27, 40. For summary histories of the Commission's work on international rivers, see Guillermo Cano, *The Development of the Law of International Water Resources and the Work of the International Law Commission*, 14 WATER INT'L 167 (1989); Stephen McCaffrey, *An Assessment of the Work of the International Law Commission*, 36 NAT. RESOURCES J. 297 (1996); Reaz Rahman, *The Law of International Uses of International Watercourses: Dilemma for Lower Riparians*, 19 FORDHAM INT'L

on Non-Navigational Use of International Watercourses in 1991,[114] and a final draft in 1994.[115] At that point, the General Assembly instructed its Sixth (legal) Committee to prepare a draft convention for the Assembly to consider. This produced a revised text that was approved as the *United Nations Convention on the Law of Non-Navigational Uses of International Watercourses* ("*UN Convention*") by the General Assembly on May 21, 1997, by a vote of 103-3.[116]

The International Law Commission embraced the principle of equitable utilization in article 5 of its *Draft Articles on the Law of Non-Navigational Use of International Watercourses.*[117] Article 5 requires watercourse states to utilize an international watercourse in an equitable and reasonable manner with a view to attaining optimal utilization and benefits consistent with adequate protection in the watercourse. Article 5 also provides that watercourse states shall participate in the use, development, and protection of an international watercourse in an equitable and reasonable manner. The right to participate includes both the right to utilize the watercourse and the duty to cooperate in its protection and development.

The International Law Commission also originally embraced a strong version of the "no harm rule." The Commission's article 7 originally provided "Watercourse States shall utilize an international watercourse in such a way as not to cause appreciable harm to other watercourse States."[118] This proposition appeared to contradict directly the rule of equitable utilization and therefore generated considerable controversy.[119] Strict

L.J. 9. 10-17 (1995); James Westcoat, jr., *Beyond the River Basin: The Changing Geography of International Water Problems and International Watercourse Law*, 3 COLO. J. INT'L ENVTL. L. & POL'Y 301 (1992).

[114] Int'l L. Comm'n, Draft Articles on the Law of Non-Navigational Use of International Watercourses, arts. 8-19, 26, 27, UN Doc. A/CN.4/L.463/Add.4 (1991) ("Draft Articles I").

[115] Int'l L. Comm'n, *Draft Articles on the Law of Non-Navigational Use of International Watercourses* ("*Draft Articles II*"), art. 1, in REPORT OF THE 46TH MEETING OF THE INTERNATIONAL LAW COMMISSION, 2 May - 22 July, 1994, A/49/10 ("ILC REPORT"), at 195.

[116] *UN Convention, supra* note 69. The three negative votes were by Burundi, the People's Republic of China, and Turkey.

[117] Draft Articles I, supra note 114, art. 5. See also Draft Articles II, supra note 115, art. 5; UN Convention, supra note 69, art. 5.

[118] Draft Articles I, supra note 114, art. 7.

[119] See, e.g., Charles Bourne, The International Law Commission's Draft Articles on the Law of International Watercourses: Principles and Planned Measures, 3 COLO. J. INT'L ENVTL. L. & POL'Y 65 (1992); Dellapenna, Rivers, supra note 65; Günther Handl, The International Law Commission's Draft Articles on the Law of International Watercourses (General Principles and Planned Measures): Progressive or Retrogressive Development of International Law?, 3 COLO. J. INT'L ENVTL. L. & POL'Y 123, 129-33 (1992); Stephen

application of a "no harm" rule would prohibit any meaningful use by an upper-riparian state, turning the rule into merely a variant form of the absolute integrity claim. But the barring of all development in an upstream state would be a harm to that state, just as a reduction in the quantity or quality of flow reaching the downstream state is an injury to it. Either the "no harm" rule had to incorporate some measure of flexibility into its application or the rule is strictly binding with "equitable utilization" being somehow aberrational, coming into to play only in certain (unspecified) peculiar circumstances.

As a result, the International Law Commission adopted a completely rewritten article 7 in 1994 that required watercourse states to exercise due diligence in utilizing an international watercourse so as not to cause significant harm to other watercourse States.[120] The meaning of the substituted article 7 was not altogether clear.[121] One need not resolve these uncertainties, however, as the article was rewritten again when the UN General Assembly converted the *Draft Articles* into the *Convention on the Law of Non-Navigational Uses of International Watercourses.*

The Assembly, while making no material change to article 5, approved a new article 7 that made clear the subordination of the "no harm" rule to the rule of equitable utilization.[122] The new article 7 requires watercourse states, in utilizing an international watercourse, to take all appropriate measures to prevent the causing of significant harm to other watercourse States. If significant harm nevertheless is caused to another watercourse state, the state whose use causes such harm must, in the absence of agreement for the use, take all appropriate measures, having due regard for the provisions of articles 5 and 6 in consultation with the affected state, to eliminate or mitigate the harm and, where appropriate, to discuss the question of compensation. The duty to take "all appropriate measures" incorporates the relative standard of "due diligence," and the duty not to cause harm is expressly limited in subsection (2) by "due regard for the provisions of articles 5 and 6"—the articles on equitable utilization. The rule of equitable utilization seems unquestionably to be the primary rule with any obligation to prevent harm being subordinated to that primary rule.

McCaffrey, The International Law Commission and Its Efforts to Codify the International Law of Waterways, 47 ANNUAIRE SUISSE DE DROIT INTERNATIONAL 32 (1991); C.O. Okidi, History of the Nile and Lake Victoria Drainage Basins through Treaties, in THE NILE, supra note 101, at 193; Wouters, supra note 101. See also Attila Tanzi, The UN Convention on International Watercourses as a Framework for the Avoidance and Settlement of Waterlaw Disputes, 11 LEIDEN J. INT'L L. 441 (1998).

[120] Draft Articles II, supra note 115, art. 7.

[121] Dellapenna, *Designing, supra* note 65, at 84-85.

[122] *UN Convention, supra* note 69, arts. 5, 7.

The *UN Convention* became open for signature on the day it was approved, remains open for signature until May 21, 2000, and would come into effect upon ratification by 35 nations.[123] This might not happen. As of November 4, 1999,[124] only 12 nations had signed the *UN Convention,* and only six—Finland, Jordan, Lebanon, Norway, South Africa, and Syria—have ratified it. Even if the *UN Convention* never comes into effect, however, it likely will be taken as the final word on the customary international law of transboundary water resources. Some evidence of this is found in the treatment of the *UN Convention* by the International Court of Justice its decision in 1997 in the *Danube River Case.*[125] In that case, the Court treated the *UN Convention* as setting forth the relevant customary international law and found that Slovakia had violated the rule of equitable utilization by appropriating the whole flow of the Danube for its sole use.[126] On the other hand, the Court completely ignored the "no harm" rule despite Hungary's strong reliance on that premise.[127] The Court thereby confirmed the primacy of the rule of equitable utilization over the "no harm" rule.[128]

[123] *Id.*, art. 34.

[124] *UN Treaty Collection, Status of Multilateral Treaties Deposited with the Secretary-General*, at http://www.un.org/Depts/Treaty/final/ts2/newfiles/part_boo/xxviiboo/xxvii_html.

[125] Case concerning the Gabcíkovo-Nagymaros Project (Hungary v. Slovakia), 1997 ICJ No. 92, http://www.icj-cij.org/idocket/ihs/ihsjudgement.1.htm ("*Danube River Case*"), reprinted in 37 INT'L LEGAL MAT'LS 162 (1998).

[126] *Id.*, ¶¶ 78, 85, 141.

[127] *See Danube River Case,* Memorial of the Republic of Hungary (May 2, 1994), at 219.

[128] For commentary on the *Danube River Case*, see generally Afshin A-Khavari & Donald Rothwell, *The ICJ and the* Danube Dam Case: *A Missed Opportunity for International Environmental Law?*, 22 MELBOURNE U. L. REV. 507 (1998); Peter Bekker, Gabcíkovo-Nagymaros Project (Hungary/Slovakia), *Judgment*, 92 AM. J. INT'L L. 273 (1998); Ida Bostian, Note, *Flushing the Danube: The World Court's Decision Concerning the Gabcíkovo Dam*, 9 COLO. J. INT'L ENVTL. L. 401 (1998); Charles Bourne, *The Judgment in the Case Concerning the Gabcíkovo-Nagymaros Project: An Important Milestone in International Water Law*, 8 Y.B. INT'L ENVTL. L. 6 (1997); Alan Boyle, *The* Gabcíkovo-Nagymaros Case: *New Law in Old Bottles*, 8 Y.B. INT'L ENVTL. L. 13 (1997); Paulo Canelas de Castro, *The Judgment of the Case Concerning the Gabcíkovo-Nagymaros Project: Positive Signs for the Evolution of International Water Law*, 8 Y.B. INT'L ENVTL. L. 21 (1997); Jan Klabbers, *The Substance of Form: The* Case Concerning the Gabcíkovo-Nagymaros Project, 8 Y.B. INT'L ENVTL. L. 32 (1997); Adriana Koe, Note, *Damming the Danube: The International Court of Justice and the Gabcíkovo-Nagymaros Project (Hungary/Slovakia)*, 20 SYDNEY L. REV. 612 (1998); Phoebe Okawa, *Case Concerning the Gabcíkovo-Nagymaros Project (Hungary/Slovakia)*, 47 INT'L & COMP. L.Q. 689 (1998); Daniel Reichert-Facilides, *Down the Danube: The Vienna Convention on the Law of Treaties and the* Case Concering the Gabcíkovo-Nagymaros Project, 47 INT'L & COMP. L.Q. 837 (1998); Stephen Stec, *Do Two*

4. THE CUSTOMARY INTERNATIONAL LAW OF GROUND WATER

As was already noted, ground water makes up about 97 percent of the world's fresh water apart from the polar ice caps and glaciers, yet there has been remarkably little state practice regarding share underground sources of water.[129] This was only to be expected given the late development of the turbine pumps that first allowed truly large-scale exploitation of under sources of water.[130] With the newer technologies, and with the exponential growth in the demand for water of the last several decades, ground water has emerged as a critical transnational resource that has increasingly become the focus of disputes between nations yet for which arguably no consistent body of state practice has yet emerged.[131]

The most highly qualified publicists have concluded that sovereignty over ground water must be restricted in the same way it is over surface water, subjecting ground water to the same rule of equitable utilization as applies to surface sources.[132] They reason that as the hydrologic, economic, and engineering variables involved are similar for surface and subsurface water sources, the law must also be the same for both sources. They do not refer, however, to any clearly established pattern of state practice, let alone the discovery of a pertinent *opinio juris* as very little in the way of practice or *opinio juris* can fairly be said to exist. About the only real state authority these scholars can point to regarding transboundary ground water is a single German court decision in the *Donauversinkung Case* holding that the same international legal principles applied to waters above the ground must also

Wrongs Make a Right? Adjudicating Sustainable Development in the Danube Dam Case, 29 GOLDEN GATE L. REV. 317 (1999).

129 See the text *supra* at notes 15-26.

130 HILLEL, *supra* note 16, at 192.

131 See the text *supra* at notes 24-26.

132 *See generally* CAPONERA, *supra* note 24, at 254-55; INTERNATIONAL GROUND WATER LAW (Ludwik Teclaff & Albert Utton eds. 1981); Julio Barberis, *The Development of the International Law of Transboundary Ground water*, 31 NAT. RESOURCES J. 167 (1991); Eyal Benvenisti, *Collective Action in the Utilization of Shared Freshwater: The Challenges of International Water Resources Law*, 90 AM. J. INT'L L. 384, 398-99 (1996); Dante Caponera & Dominique Alhéritière, *Principles of International Ground water Law*, 18 NAT. RESOURCES J. 589 (1978); Dellapenna, *Jordan Valley*, *supra* note 65; Robert Hayton, *The Law of International Aquifers*, 22 NAT. RESOURCES J. 71 (1982); Cecil Olmstead, *Introduction*, in INTERNATIONAL DRAINAGE BASINS, *supra* note 6, at 1, 4; Rodgers & Utton, *supra* note 25; Schwebel, *supra* note 9, at 95; Ludwik Teclaff, *Evolution of the River Basin Concept in National and International Water Law*, 36 NAT. RESOURCES J. 359, 372-74 (1996); Albert Utton, *The Development of International Ground water Law*, 22 NAT. RESOURCES J. 95 (1982); Wenig, *supra* note 103, at 346.

be applied to water below the ground in a dispute between two German states.[133] Indeed, properly speaking, ground water and surface water are not merely similar, they are in fact the same thing. Ground water and surface water are simply water moving in differing stages of the hydrologic cycle—what today is the one will tomorrow be the other.

Because of the dearth of relevant state practices, the International Law Association initially took a more cautious approach to the question of whether equitable utilization applied to ground water. The *Helsinki Rules* included only those ground waters that form part of an international drainage basin, that is, that either contribute "subflow" to the streams or lakes, or otherwise drain into common terminus of the relevant watershed.[134] Twenty years later, the Association was ready to apply the rule of equitable utilization even to "non-tributary" ground water, although state practice still had not developed very much. The Association then adopted the *Seoul Rules on the Law of International Ground water Resources* which address "international aquifers" rather than drainage basins, that is any body of ground water that is intersected by an international boundary.[135] The *Seoul Rules* declare that an international aquifer is an "international drainage basin" subject to the *Helsinki Rules* even if the ground water in no way connects to internationally shared surface waters.[136] A gathering of experts on the law of international water recently confirmed this conclusion in a meeting at Bellagio, Italy, where they drafted a model treaty to assure the equitable utilization and management of internationally shared ground waters.[137]

The United Nations as a whole has never taken a position on international ground waters generally. At the Mar del Plata Conference, the delegates did adopt a resolution did endorse equitable utilization as the governing principle for sharing water resources, but without any express mention of ground water.[138] The International Law Commission, in its *Draft Articles on the Non-Navigational Use of International Watercourses,* adopted an approach that was even more restrictive than the original approach of the

[133] The Donauversinkung Case (Württemberg & Prussia vs. Baden), 116 RGZ 1 (SGH 1927), ANN. DIGEST PUB. INT'L L. CASES 128 (Hersch Lauterpacht ed. 1931).

[134] HELSINKI RULES, *supra* note 66, art. II.

[135] International Law Ass'n, The Seoul Rules on the Law of International Ground water Resources (Report of 62nd Conf., Seoul, 1986) ("SEOUL RULES").

[136] *Id.*, art. II (2).

[137] Robert Hayton & Albert Utton, *Transboundary Ground waters: The Bellagio Draft Treaty*, 29 NAT. RESOURCES J. 663 (1989).

[138] Report of the United Nations Water Conference, Mar del Plata, 14-25 March, 1977, at 53, UN Doc. No. E.77.II.A.12 (recommendations 90, 91).

Helsinki Rules, including only ground water that drains to a "common terminus" with the surface water within its definition of a "watercourse."[139]

The failure to address all ground water was one of the most serious failings of the *Draft Articles*. Apparently the *Draft Articles* would not apply even to ground water intimately connected to watercourses covered by the *Articles* so long as they did not drain to a "common terminus," thus precluding effective, system-wide management. For example, the *Donauversinkung* case involved a dispute that arose because part of the ground water underlying the upper Danube discharge into the Aach River which feeds into the Rhine and not into the Danube.[140] Furthermore, as the *Seoul Rules* recognized, even ground water that has no significant connection to surface watercourses can be international in its effects, and thus should be international in its management.[141] Only at the very end of its deliberations on the law of international watercourses did the International Law Commission finally address the problem, but only through a resolution that reads, in relevant part, as follows:

> [T]he principles contained in its draft articles ... may be applied to transboundary confined (*sic*) ground water and ... the Commission:
>
> 1. *Commends* States to be guided by the principles contained in the draft articles on the law of non-navigational uses of international watercourses, where appropriate, in regulating transboundary ground water;
> 2. *Recommends* States to consider entering into agreements with the other State or States in which the confined transboundary ground water is located;
> 3. *Recommends also* that, in the event of any dispute involving transboundary confined ground water, the States concerned should consider resolving such dispute in accordance with the provisions contained in article 33 of the draft articles, or in such other manner as may be agreed upon.[142]

[139] Draft Articles II, supra note 115 art. 1; Draft Articles I, supra note 114, art. 1.

[140] The Donauversinkung Case (Württemberg & Prussia vs. Baden), 116 RGZ 1 (SGH 1927), ANN. DIGEST PUB. INT'L L. CASES 128 (Hersch Lauterpacht ed. 1931). *See also* TECLAFF, *supra* note 6, at 9.

[141] SEOUL RULES, *supra* note 135.

[142] ILC REPORT, *supra* note 115, at 326. *See* McCaffrey, *supra* note 113, at 316-18; Robert Rosenstock, *The Forty-Ninth Session of the International Law Commission*, 89 AM. J. INT'L L. 390, 392 (1995).

As Stephen McCaffrey—the principle Special Rapporteur of the *Draft Articles*—commented, "It appears to be exactly what it is: a hasty effort tacked onto the draft articles at the conclusion of the Commission's work."[143]

The possibility that equitable utilization is applicable to aquifers as a rule of general customary international law is supplemented by the growing recognition of a right to development and even of a possible human right to water.[144] Space does not allow an analysis and evaluation of these claims.

[143] McCaffrey, *supra* note 113, at 318.

[144] Hatim Kanaaneh, Fiona McKay, & Emily Sims, A Human Right Approach for Access to Clean Drinking Water: A Case Study, 1 HEALTH & HUM. RTS. 191 (1995); Stephen McCaffrey, A Human Right to Water: Domestic and International Implications, 3 GEO. INT'L ENVTL. L. REV. 1 (1992. See also SMITH, supra note 70, at 96; Benvenisti, supra note 132, at 405-08; Bourne, supra note 108, at 192-95; Dellapenna, Legal Structures, supra note 65, at 246-47. On the asserted right to economic development generally, see Declaration on the Right to Development, GA Res. 41/128 (Dec. 4, 1986; vote: 146-1). See also Charter of Economic Rights and Duties of States, GA Res. 3281 (XXIX), UN Doc. A/9631 (1974); Programme of Action on the Establishment of a New International Economic Order, GA Res. 3202 (S-VI), UN Doc. A/9559 (1973); Declaration on the Establishment of a New International Economic Order, GA Res. 3201 (S-VI), UN Doc. A/9559 (1973); Declaration of UN Development Decades, GA Res. 2626 (XXV), Oct. 24, 1970; Declaration on Social Progress and Development, GA Res. 2552 (XXIV) (1969); BRUHÀCS, supra note 68, at 140-42; HUMAN RIGHTS AND DEVELOPMENT: INTERNATIONAL VIEWS (David Forsythe ed. 1989); THE RIGHT TO DEVELOPMENT AT THE INTERNATIONAL LEVEL (René Dupuy ed. 1980); UN SECRETARIAT, THE INTERNATIONAL DIMENSIONS OF THE RIGHT TO DEVELOPMENT AS A HUMAN RIGHT, UN Doc. E/CN.4/1334 (1979); UN SECRETARIAT, REGIONAL AND NATIONAL DIMENSIONS OF THE RIGHT TO DEVELOPMENT AS A HUMAN RIGHT, UN Doc. E/CN.4/1421 (1980); Mohammed Bedjaoui, The Right to Development, in ACHIEVEMENTS AND PROSPECTS, supra note 27, at 1177; Mohammed Bennouna, International Law and Development, in ACHIEVEMENTS AND PROSPECTS, supra, at 619; Rhoda Howard, Women's Rights and the Right to Development, in WOMEN'S RIGHTS, HUMAN RIGHTS: INTERNATIONAL FEMINIST PERSPECTIVES 301 (Julie Peters & Andrea Wolper eds. 1995); R.N. Kiwanka, Developing Rights: The UN Declaration on the Right to Development, 28 NETHERLANDS INT'L L. REV. 257 (1987); Kéba M'Baye, Le droit au developpement comme un droit de l'homme, 5 REVUE DES DROITS DE L'HOMME 505 (1972); Daniel Barstow Magraw, International Pollution, Economic Development, and Human Rights, in INTERNATIONAL LAW AND POLLUTION 30 (Daniel Barstow Magraw ed. 1991).

The claimed human right to development in turn can be seen as an application of human rights to economic, social, and cultural well-being generally. *See International Covenant on Economic, Social, and Cultural Rights*, opened for signature Dec. 19, 1966, 993 UNTS 3; A. GLENN MOWER, JR., INTERNATIONAL COOPERATION FOR SOCIAL JUSTICE: GLOBAL AND REGIONAL PROTECTION OF ECONOMIC/SOCIAL RIGHTS (1985); HENRY SHUE, BASIC RIGHTS: SUBSISTENCE, AFFLUENCE, AND U.S. FOREIGN POLICY (1980); Steven Rosenbaum, *Lawyers* Pro Bono Publico: *Using International Human Rights Law on Behalf of the Poor*, in NEW DIRECTIONS IN HUMAN RIGHTS 109 (Ellen Lutz *et al.* eds 1989); Symposium, *The Implementation of the International Covenant on Economic, Social and Cultural Rights*, 9 HUM. RTS. Q. 121-273 (1987).

The arguments are complex and controversial. Here we need only note that neither social and economic development, nor even the satisfaction of basic survival needs, are possible if only one community sharing an aquifer monopolizes its waters. Such supposed human rights, even if they do not provide satisfactory means for resolving disputes over aquifers, at the least lend weight to the supposition that the waters of those aquifers must be shared equitably.

Foremost among the problems in applying equitable utilization to an aquifer is the relative lack of firm knowledge of the hydrologic characteristics of the resource.[145] We know quite a lot about surface water sources, having made accurate and ongoing measurements of these sources for a century or more. We can observe where surface water flows and what variables affect its behavior. Ground water is different. Ground water, like surface water, responds to gravity, seeking its lowest level, yet it does not move as freely as surface waters. The structure, porosity, and slope of the rocks or soil through which it seeps or percolates also determine the path of movement for ground water. Because of the variability of subsurface conditions, often not observable from the surface, we often simply do not know much about the characteristics of particular aquifers. To acquire more knowledge is expensive. Water managers and legal institutions are only able, then, to make tentative allocations that informal processes as are found in customary regimes are ill adapted to revise or supplement.

When the General Assembly undertook to convert the *Draft Articles* into the *UN Convention*, it only slightly modified the language relating to ground water. The *UN Convention* defined included waters thusly:

> Article 2
> *Use of Terms*
> "Watercourse" means a system of surface waters and ground waters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus; ...[146]

While the *UN Convention's* addition of the word "normally" opens the text up to a broader application to ground waters than the definition in the *Draft Articles*, just how far it goes is far from clear. The definition still requires that the surface and ground waters form "a unitary whole" because of their physical relationship. Whether, for example, this would reach an aquifer underlying part of the Danube basin but draining into the Rhine, is

[145] HILLEL, *supra* note 16, at 194. *See generally* Earl Finbar Murphy, *Geology and Hydrology*, in 3 WATERS AND WATER RIGHTS, *supra* note 6, § 18.03; Yacov Tsur, *Uncertainty and Irreversibility in Ground water Resource Management*, 29 J. ENVTL. ECON. & MGT. 149 (1995).

[146] *UN Convention*, *supra* note 69, art. 2.

questionable.[147] And the language certainly does not reach so-called confined aquifers—aquifers that do not, in any meaningful sense, connect to surface waters. Nor is there any appended resolution or similar document that would serve to clarify the answers to these questions. Thus, for some ground waters, and perhaps for a great deal of ground water, there is no relevant (albeit unratified) treaty to provide the governing law. For these ground waters, states must continue to look to customary international law to resolve their disputes. This would appear to be the case with at least some of the aquifers shared by the Israelis and the Palestinians, as well as some aquifers shared by the Egyptians, the Israelis, the Jordanians, and Saudis near Aqaba/Eilat.

5. APPLYING THE RULE OF EQUITABLE UTILIZATION AND THE FAILURE OF THE CUSTOMARY INTERNATIONAL WATER LAW

Reliance on customary international law to allocate surface or subsurface waters among states simply has not worked very well.[148] The system is too informal, lacks precise rules, and also lacks the means of effectuating and enforcing such rules as it does have. The remarkable thing is that this informal system has worked as well as it has in many parts of the world. To understand why the customary international regime fails, first consider the experience of the United states, a nation in which there has been so much litigation over "equitable apportionment" between states. These cases before the United States Supreme Court are often described as the origin of the international rule of "equitable utilization." Even with each state in the United States agreeing on the rule known there as "equitable apportionment," and with a highly effective federal judiciary exercising compulsory jurisdiction over competing states, equitable sharing simply has proven too cumbersome and too uncertain to satisfy states involved disputes over interstate sources of water.[149] The United States have seen frequent and

[147] The Donauversinkung Case (Württemberg & Prussia vs. Baden). 116 RGZ 1 (SGH 1927). ANN. DIGEST PUB. INT'L L. CASES 128 (Hersch Lauterpacht ed. 1931).

[148] Richard Kyle Paisley & Timothy McDaniels. *International Water Law, Acceptable Pollution Risk and the Tatshenshini River*, 35 NAT. RESOURCES J. 111. 124-26 (1995).

[149] See Joseph Dellapenna, The Delaware and Susquehanna River Basins, in 6 WATERS AND WATER RIGHTS, supra note 6, at 125; Scott Anderson, Note, Equitable Apportionment and the Supreme Court: What's So Equitable about Apportionment?, 7 HAMLINE L. REV. 405 (1984); Grant, supra note 8; A. Dan Tarlock, The Law of Equitable Apportionment Revisited, Updated, and Restated, 56 U. COLO. L. REV. 381 (1985).

recurring disputes over what should be the common standard for the states and the proper application of any applicable common standard.[150]

Similarly, considerable debate has always surrounded the application of the rule of equitable utilization. Some commentators argue that "equitable" sharing must mean equal sharing. The merest perusal of the standards for equitable utilization demonstrates that while access is guaranteed, equal shares are not. The underlying notion is one of fairness, not strict equality. Thus even if each interested state always agrees to the rule of equitable utilization, states would still dispute what should be the common standard for sharing and the proper application of the agreed standard. The rule of equitable utilization is simply too general and too vague to be applied without the interested states filling in the details in what remains merely an obligation of fairness. This uncertainty is illustrated by article 6 of the *UN Convention*, which contains a long shopping list of relevant factors:

geographic, hydrographic, hydrological, climatic, ecological, and other factors of a natural character;

the social and economic needs of the watercourse States concerned;

the effects of the use or uses of the watercourse in one watercourse State on other watercourse States;

existing and potential uses of the watercourse;

conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect; and

the availability of alternatives, or corresponding value, to a particular planned or existing use.[151]

Non-lawyers, particularly engineers and hydrologists, sometimes see in this list of factors a poorly stated equation. By this view, if one simply fills in numerical values for each factor, one could somehow calculate each watercourse state's share of the water without reference to political or other non-quantitative variables.[152] This simply ignores that the *UN Convention* is a legal document that ultimately is addressed to judges. Judges make judgments, and in the English language, at least, the word judgment carries a

[150] See the authorities collected *supra* at notes 8, 9.

[151] *UN Convention*, *supra* note 69, art. 6.

[152] Probably the most extreme version of attempting to reduce the rule of equitable utilization to an algorithm is found in J.W. Moore, *An Israeli-Palestinian Water-Sharing Regime*, in WATER AND PEACE, *supra* note 19, at 181. *See also* KLIOT, *supra* note 17, at 95-99, 167-72, 259-76; LONERGAN & BROOKS, *supra* note 18, at 171-73; Robert Hager, Note, *The Euphrates Basin: In Search of a Legal Regime*, 3 GEORGETOWN INT'L ENVTL. L. REV. 207, 219-20 (1990); Niva Telerant, *Riparian Rights under International Law: A Study of the Israeli-Jordanian Peace Treaty*, 18 LOY. L.A. INT'L & COMP. L.J. 175, 194-95 (1995); Hisham Zarour & Jad Isaac, *Nature's Apportionment and the Open Market: A Promising Solution to the Arab-Israeli Water Conflict*, 18 WATER INT'L 40, 50-51 (1993).

strong connotation that the result is not dictated in any immediate sense by the factual and other inputs that the judge relies upon in exercising judgment.[153] As Herbert Smith pointed out nearly 70 years ago, "The practical value of legal discussion is in direct proportion to its concern with actual facts, and experience has shown that all attempts to solve river problems by dogmatic insistence upon abstract legal principles have been either futile or mischievous."[154] In short, any attempt to treat the list of relevant factors as an algorithm simply misses the point entirely.

All of this suggests that the rule of equitable utilization is one that cannot be applied in some easy, mechanistic fashion. Nor is there a neutral decision-making institution, like a court or an arbitral panel, that the parties to disputes over transboundary waters could use to resolve their difficulties. This is particularly true for the Middle East. Yet without a legal resolution of disputes over water, the disputes can only lead back to the law of the vendetta. Serious conflict in one form or another cannot be avoided under the rule of equitable utilization without a clear definition of the precise standards for managing the shared waters and a peaceful mechanism for the orderly investigation and resolution of the disputes characteristic of the rule.

Most disputes over international river systems have eventually produced just such a *modus vivendi* on the basis of equitable utilization, and several hundred such treaties now have entered into force regarding internationally shared waters. Elsewhere I have analyzed in detail the logical progression of these treaties from simple promises to consult before changing a water source, to promises not to interfere in water uses in the other state, to attempts to partition the waters or their benefits, to cooperative management, and finally to integrated management.[155] While the progression is logical, it is not always the actual sequence that a particular evolving treaty regime follows. Treaties reflect not logic, but need and power.

[153] *See* Benvenisti & Gvirtzman, *supra* note 101, at 548; Bourne, *supra* note 108, at 199; Griffin, *supra* note 101, at 78-79; Elizabeth Picard, *Aspects of International Law of the Water Conflict in the Middle East*, in WATER AS AN ELEMENT OF COOPERATION, *supra* note 1, at 213; Jonathan Wenig, *Water and Peace: The Past, the Present, and the Future of the Jordan River Watercourse: An International Law Analysis*, 27 NYU J. INT'L L. & POL'Y 331, 349, 351, 357-61 (1995). The classic statement of this reality in more general contexts is Joseph Hutcheson, jr., *The Judgment Intuitive: The Function of the "Hunch" in Judicial Decision*, 14 Cornell L.Q. 274 (1929).

[154] SMITH, supra note 70, at vi. See also Sharif Elmusa, Towards an Equitable Distribution of the Common Palestinian-Israeli Waters: An International Water Law Framework, in WATER AND PEACE, supra note 19, at 451, 456-60; Courtney Flint, Recent Developments of the International Law Commission Regarding International Watercourses and Their Implications for the Nile River, 20 WATER INT'L 197, 199-200 (1995); Hussain, supra note 8, at 47-48, 50-51.

[155] Dellapenna, *Treaties, supra* note 65. *See also* KLIOT, SHMUELI, & SHAMIR, *supra* note 5.

The Nile Valley states perfectly epitomize this scenario.[156] Egypt is not a wealthy state; its *per capita* gross domestic product ("GDP") is only US $630/year, making it one of the poorer states in the Middle East. Yet Egypt is wealthier than Sudan (with a GDP of US $540/year), and Egypt and Sudan are far wealthier than Ethiopia (with a GDP of US $120/year). In fact, a recent study by the World Bank ranked Ethiopia last among all nations in terms of national wealth *per capita*.[157]

Without a common border, Egypt cannot easily pose a military threat to Ethiopia. Ethiopia, on the other hand, has been simply too poor and too poorly organized to construct the dams and related infrastructure necessary to exploit the Blue Nile and the Atbara Rivers without outside financial assistance.[158] Egypt has succeeded in exploiting its greater political importance to block international financing of Ethiopian dams and related works. As part of this diplomatic program, Egypt has freely deployed legal arguments, particularly the so-called "no harm" rule in its stronger, more absolute version as expressed in the 1991 *Draft Articles*, arguing that Ethiopian development of the waters of the Nile would impair Egypt's

[156] KLIOT, *supra* note 17, at 15-99, 266-70; JOHN WATERBURY, HYDROPOLITICS OF THE NILE VALLEY (1979); WATER IN THE MIDDLE EAST, *supra* note 18, at 142-47; Ahmed, *supra* note 101; R.K. Batstone, *The Utilization of Nile Waters*, 7 INT'L & COMP. L.Q. 523 (1959); Daniel Chenevert, jr., Comment, *Application of the Draft Articles on the Non-Navigational Uses of International Watercourses to the Water Disputes Involving the Nile River and the Jordan River*, 6 EMORY INT'L L.J. 495 (1992); Dellapenna, *Rivers*, *supra* note 65, at 237-44; Dellapenna, *Nile*, *supra* note 65, at 121-34; Awad El Morr, *Water Resources in the Middle East: Some Guiding Principles*, in LEGAL, POLITICAL AND COMMERCIAL IMPLICATIONS, *supra* note 101, at 293; Fahmi, *supra* note 82; Flint, *supra* note 154; Albert Garretson, *The Nile Basin*, in INTERNATIONAL DRAINAGE BASINS, *supra* note 6, at 256; Sayed Hosni, *The Nile Regime*, 17 REVUE ÉGYPTIENNE DE DROIT INTERNATIONAL 70 (1961); Raj Krishna, *The Legal Regime of the Nile Basin*, in THE POLITICS OF SCARCITY: WATER IN THE MIDDLE EAST 23 (Joyce Starr & Daniel Stoll eds. 1988); Yahia Abdel Mageed, *The Nile Basin: Lessons from the Past*, in INTERNATIONAL WATERS OF THE MIDDLE EAST: FROM EUPHRATES-TIGRIS TO NILE 156 (Asit Biswas ed. 1994); C.O. Okidi, *History of the Nile and Lake Victoria Drainage Basins through Treaties*, in THE NILE, *supra* note 103, at 193; Imeru Tamrat, *The Constraints and Opportunities for Basin-Wide Cooperation in the Nile: A Legal Perspective*, in LEGAL, POLITICAL AND COMMERCIAL IMPLICATIONS, *supra*, at 177.

[157] Peter Passell, *The Wealth of Nations: A "Greener" Approach Turns List Upside Down*, N.Y. TIMES, Sept. 19, 1995, at C1 (the title refers to dropping Japan and the United States out of the top two spots; not to the ranking of Ethiopia last). According to the World Bank, Ethiopia has "wealth" of only US $1,400 *per capita* compared to US$704,000 *per capita* for Canada (ranked first), US$565,000 *per capita* for Japan (ranked fifth) or US$421,000 *per capita* for the United States (ranked twelfth). In this study, "wealth" is estimated on the basis of the market value of natural resources and capital investment in the society, not in terms of GDP.

[158] KLIOT, *supra* note 17, at 67-69; Flint, *supra* note 154, at 201.

"natural and historic rights."[159] Egypt most recently did not object to a loan application by the Ethiopians for a small-scale irrigation project, suggesting that there might be some truth to rumors of a secret agreement between the two states regarding development of the Nile.[160] If so, one suspects that Ethiopia has largely conceded the need to obtain Egyptian consent to any project Ethiopia wants to undertake.

Ultimately, the Egyptian claim comes down to a claim of an absolute right to the integrity of the river because of the priority of their use.[161] Priority of use, while undoubtedly relevant to an equitable allocation of water among national communities, has never been treated as dispositive in international law.[162] Any other approach would simply negate the concept of "equitable utilization" that is the controlling customary international law. Furthermore, for priority in time to override all other values, or even to dominate other values, would hardly be conducive to achieving the

[159] *See* GODANA, *supra* note 68, at 39; WATERBURY, *supra* note 156, at 68; Batstone, *supra* note 156, at 540; El Morr, *supra* note 156, at 297-98; Okidi, *supra* note 156, at 201-02; Mohammed Abdel Hady Rady, *Satisfying National and International Water Demands*, 20 WATER INT'L 9, 10 (1995); Tamrat, *supra* note 156, at 183-84.

[160] Personal communication from an officer of the World Bank. Some Egyptians long ago realized that they would have to accept some Ethiopian withdrawals from the Blue Nile and the Atbara. *See* Mamdouh Shahin, *Response to Jovanovic*, 11 WATER INT'L 317 (1986).

[161] GODANA, *supra* note 68, at 143-44; Ahmed, *supra* note 101; Dellapenna, *Nile*, *supra* note 65, at 126-28; Dellapenna, *Rivers*, *supra* note 65, at 243-44; Fahmi, *supra* note 82; Hosni, *supra* note 156.

[162] This is implicit in the text of the *Draft Articles*, and explicit in the commentary to those articles as adopted on the second reading. *Draft Articles II*, *supra* note 115, art. 6(1)(e) (requiring consideration of "existing and potential uses of the watercourse"); *Draft Articles I*, *supra* note 114, art. 6(1)(e) (same); ILC REPORT, *supra* note 115, at 233 (explaining the text as having been adopted "in order to emphasize that neither is given priority..."). *See also* BRUHÀCS, *supra* note 68, at 132-40; ELMUSA, *supra* note 17, at 36; SMITH, *supra* note 70, at 40, 146; Benvenisti, *supra* note 132, at 408-09, 411; Bourne, *supra* note 108, at 233, 257; Dante Caponera, *The Legal-Institutional Issues Involved in the Solution of Water Conflicts in the Middle East: The Jordan*, in WATER AND PEACE, *supra* note 19, at 174; Dellapenna, *Rivers*, *supra* note 65, at 247-49; Garretson, *supra* note 156, at 287-89; Hussain, *supra* note 8, at 51; Lipper, *supra* note 8, at 57-58; Maluwa, *supra* note 68, at 30-33; Hillel Shuval, *Approaches to Resolving Water Conflicts between Israel and Her Neighbors—A Regional Water-for-Peace Plan*, 17 WATER INT'L 133, 136-38, 141-42 (1992); Wouters, *supra* note 101, at 82. For a contrary view, see Fahmi, *supra* note 82, at 51-54. For the importance of prior uses under international law without treating it as the determining factor in the allocation of water, see GODANA, *supra* note 68, at 62; Batstone, *supra* note 156, at 529; Benvenisti, *supra*, at 408-09; Benvenisti & Gvirtzman, *supra* note 101, at 548-49; D.M.M. Goldie, *Effect of Existing Uses on Equitable Apportionment of International Rivers: A Canadian View*, 1 U.B.C. L. Rev. 399 (1959); R.W. Johnson, *Effect of Existing Uses on the Equitable Apportionment of International Rivers: An American View*, 1 U.B.C. L. Rev. 389 (1959).

developmental equity proclaimed under various banners at the United Nations.[163] To accord such priority to existing uses in the Nile Basin would condemn Ethiopia to remain impoverished and dependent on international food aid to stave off mass starvation, for the benefit of the relatively richer Egyptians and Sudanese. In the Jordan Valley, this approach would condemn the Palestinians to remain a colonial society utterly dependent on Israeli largesse, and would leave the Jordanians only marginally better off.

The tension between protecting "historic rights" and providing for developmental equity is tractable only if the water is managed cooperatively by the several national communities in such a way as to assure equitable participation in the benefits derived from the water by all communities sharing the basin. Customary international law is simply too primitive to solve continuing water management problems in a timely fashion. Relying upon an informal legal system alone to legitimate and limit claims to use shared water resources is inherently unstable. Such a system comes unsettled either when one or more states consider that it is so militarily dominant that it can disregard the interests of its neighbors, or when one or more states consider that their interests are so compromised by the existing situation that even the risk of military defeat is more tolerable than continuing the present situation without challenge.[164]

The closest analogues in national law to the rule of equitable utilization is the riparian rights system as applied in the eastern United States (and its interstate analogue of "equitable apportionment"). We have already noted the difficulties in making the "equitable apportionment" system work between states of the United States.[165] The "reasonable use" version of riparian rights applied in the eastern United States is perhaps an even more instructive example of why such vague rules cannot survive as water allocation systems in regions where demand consistently approaches or exceeds supply. The "reasonable use" theory of riparian rights barely functioned in areas of the United States that are without chronic water shortages and that have strong judicial structures.[166] Whenever water use in the eastern United States outstrips the available sources of water, traditional riparian rights have been abandoned in favor of a new system of water rights that are administered by state agencies that allocate water to particular uses

[163] See the authorities collected *supra* at note 144.

[164] Water in the Middle East, *supra* note 18, at 161. *Cf.* William Mark Habeeb, Power and Tactics in International Negotiations: How Weak Nations Bargain with Strong Nations (1988).

[165] See the text *supra* at notes 149-50.

[166] See generally Joseph Dellapenna, The Right to Consume Water under "Pure" Riparian Rights, in 1 WATERS AND WATER RIGHTS, supra note 6, ch. 7.

by time-limited permits and that determine the most socially beneficial ("reasonable") use of the water.[167]

As these American examples suggest, no solution is possible without the creation of the necessary law. While uncertainty of legal right can induce cooperation among those sharing a resource, it can also promote severe conflict.[168] Nor can a partitioning of the waters be an adequate resolution when there simply is too little water to divide. To create the sort of regime necessary to allay conflict and optimize the use and preservation of the resource will require a new treaty, one that includes all basin communities, creates appropriate representative basin-wide institutions, and has the clout to enforce its mandates.[169]

A cooperative management system for internationally shared fresh waters must include a legal mechanism for resolving disputes. While stress on water resources itself creates real pressures for cooperative solutions to the problems confronting the communities sharing the resources, the creation of a formal legal system is a necessary prerequisite to preventing conflict over water in any set of communities where water resource are under stress.[170] In disputes over international water sharing, the lack of an elaborate federal or cooperative institutional arrangements such as is found in the United States would ultimately lead back to the law of the vendetta.[171] The inevitably of recurring bitter disputes, even overt military conflict, would remain under the rule of equitable utilization even when water consumption is tied to some more or less objective record of need (historic use or the like) so long as

[167] *See generally* Joseph Dellapenna, *Regulated Riparianism*, in WATERS AND WATER RIGHTS, *supra* note 6, ch. 9.

[168] *See* Benvenisti, *supra* note 132; Radinsky, *supra* note 63. *See generally* Robert Axelrod, The Evolution of Cooperation (1984); Robert Ellickson, Order without Law: How Neighbors Settle Disputes (1991); Roger Fisher & Scott Brown, Getting Together 197-202 (1988); Jonathan Bendor, *Uncertainty and the Evolution of Cooperation*, 37 J. Conflict Resolution 709 (1993); Lewis Kornhauser, *Are There Cracks in the Foundation of Spontaneous Order? Order without Law: How Neighbors Settle Disputes* (book rev.), 67 NYU L. Rev. 647 (1992); LeMarquand, *supra* note 87; Young, *supra* note 87.

[169] Dellapenna, *Legal Structures*, *supra* note 65; Joseph Dellapenna, *Developing a Treaty Regime for the Jordan Valley*, in JOINT MANAGEMENT OF SHARED AQUIFERS: THE FOURTH WORKSHOP 203 (Eran Feitelson & Marwan Haddad eds. 1997).

[170] See generally Joseph Dellapenna, Adapting the Law of Water Management to Global Climate Change and Other Hydopolitical Stresses, 35 J. AM. WATER RESEARCH ASSOC. 1301 (1999).

[171] Greg Shapland, Policy Options for Downstream States in the Middle East, in LEGAL, POLITICAL AND COMMERCIAL IMPLICATIONS, supra note 101, at 301, 309; William Van Alstyne, The Justiciability of International River Disputes: A Study in the Case Method, 1964 DUKE L.J. 307; Utton, supra note 6, § 49.05. See generally Richard Falk, International Jurisdiction: Horizontal and Vertical Conceptions of Legal Order, 32 TEMPLE L.Q. 295 (1959).

there is no effective alternative mechanism for resolving the inevitable disputes. The situation will be even worse if the states measure the right to use water only by a vague concept of equity.

The *UN Convention* itself recognizes this reality. In paragraph 2 of Article 5—the article on equitable utilization—the *UN Convention* postulates a right in the following words:

Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present articles.[172]

Law professor Albert Utton has termed the right to participate a right to "equitable participation."[173] A right to equitable participation could only be realized through some sort of joint management regime, and numerous articles of the *UN Convention* attempt to spell out the obligation to cooperate in considerable detail.[174]

The *UN Convention* does not, however attempt to provide a template for what the resulting joint institutions should look like. Given the great variability among drainage basins and the nations sharing such basins, any attempt to provide a precise form for all basins would be futile.[175] On the other hand, international practice provides numerous examples as models for institution design.[176] Cooperative management has taken many forms around the world, ranging from continuing and unceasing consultations, to a system of active cooperative management that remains in the hands of the participating states, to the creation of a variety of forms of regional institutions capable of making and enforcing their decisions directly.[177]

6. A FINAL NOTE ON THE AQUIFERS OF THE JORDAN VALLEY

In the Jordan Valley, there is no arguable basis for a special custom relating to ground waters. Unlike surface waters in the Jordan Valley,[178] there

[172] *UN Convention, supra* note 69, art. 5(2).

[173] Utton, *supra* note 6, § 49.09.

[174] *UN Convention, supra* note 69, arts. 8, 9, 11-19.

[175] BERBER, *supra* note 68, at 148-59; BRUHÀCS, *supra* note 68, at 16-17, 60-61; GODANA, *supra* note 68, at 66; SMITH, *supra* note 70, at 56.

[176] *See* Kliot, Shmueli, & Shamir, *supra* note 5.

[177] See Dellapenna, Legal Structures, supra note 65.

[178] *See* Joseph Dellapenna, Middle East Water: The Limits and Potential of Law § 3.02(b) (forthcoming).

are no local patterns of state practice coupled with expressions of reasons for the state practice that might constitute a special customary rule for those states adhering to the practice. After 1967, the Israelis occupied all of the aquifers shared between themselves and the Palestinians, administering them primarily for their own benefit while deliberating squeezing down the amounts that others might draw from the common aquifers.[179] International legal disputes have focused on whether the Israelis were administering their occupied lands in a fashion that violated the laws of armed conflict. Whether the Israeli occupation policies dealt appropriately with the water needs of the local inhabitants was often dealt with as a secondary issue if at all.

With the opening of the Middle East Peace Process in 1991, attention necessarily turned to the allocation of the transboundary aquifers. As much as 80-90 percent of the rainfall that feeds the Mountain Aquifer falls on the West Bank hills, but around 80 percent of the water is extracted by the Israelis.[180] The recharge/consumption patterns regarding the Coastal Aquifer(s) are rather less clear. Regional commentators, whether Arab or Israeli, have unanimously assumed that the rule of equitable utilization applied equally to ground water as to surface waters.[181] These laws reflect

[179] *Id.*, §§ 2.04(d), 3.03(b). *See* BENVENISTI, *supra* note 18, at 12-15; HANDBOOK, *supra* note 18, at 1, 223-25; GHARAIBEH, *supra* note 18, at 62-63; KAHAN, *supra* note 18, at 27-28; DAVID KRETZMER, THE LEGAL STATUS OF ARABS IN ISRAEL 48, 118-120 (1987); 1986 REPORT, *supra* note 18, at 8-10, 20-22; DAVID OTT, PALESTINE IN PERSPECTIVE: POLITICS, HUMAN RIGHTS & THE WEST BANK 15-17 (1980); ROY, *supra* note 18, at 38-51; ROYAL SCI. SOC'Y, WEST BANK RESOURCES AND ITS SIGNIFICANCE TO ISRAEL 7-10 (1979); WOLF, *supra* note 17, at 60-61; WRAP, *supra* note 17, at 8-9; Hisham Arwatani, *A Projection of the Demand for Water in the West Bank and Gaza Strip, 1992-2005*, in WATER AND PEACE, *supra* note 101, at 9, 15-16; Uri Davis, Antonia Marks, & John Richardson, *Israel's Water Policies*, 9 J. PALESTINE STUD. 1, 19-22 (No. 2, 1980); Harold Dichter, Comment, *The Legal Status of Israel's Water Policies in the Occupied Territories*, 35 HARV. INT'L L.J. 565 (1994); Jeffrey Dillman, *Water Rights in the Occupied Territories*, 19 J. PALESTINE STUD. 46 (1989); Jamal el-Hindi, Note, *The West Bank Aquifer and Conventions Regarding Laws of Belligerent Occupation*, 11 MICH. J. INT'L L. 1400 (1990); Frederick Frey & Thomas Naff, *Water: An Emerging Issue in the Middle East?*, 482 ANNALS AM. ACAD. POLI. SCI. 65, 69 (1985); Fred Pearce, *Wells of Conflict on the West Bank*, NEW SCIENTIST, June 1, 1991, at 36, 39; Zarour & Isaac, *supra* note 152, at 44.

[180] LESLIE SCHMIDA, KEYS TO CONTROL: ISRAEL'S PURSUIT OF ARAB WATER RESOURCES 21-24 (1982); Benvenisti & Gvirtzman, *supra* note 101, at 557-62; Dichter, *supra* note 179, at 569-70; Haim Gvirtzman, *Ground water Allocation in Judea and Samaria*, in WATER AND PEACE, *supra* note 101, at 205, 205.

[181] *See* Eyal Benvenisti, *International Law and the Mountain Aquifer*, in WATER AND PEACE, *supra* note 101, at 229, 236-38; Elmusa, *supra* note 154; Haim Gvirtzman, *Ground water Allocation in Judea and Samaria*, in WATER AND PEACE, *supra*, at 205, 206; Jonathan Kuttab & Jad Isaac, *Approaches to the Legal Aspects of the Conflict of Water Rights in Palestine/Israel*, in WATER AND PEACE, *supra*, at 239, 246-48; Hillel Shuval, *Proposed Principles and Methodology for the Equitable Allocation of the Water Resources Shared*

common cultural and legal traditions relating to water found throughout the region.[182] The modern national laws of the several communities apply equally to ground water as to surface water,[183] suggesting a regional general principle of reasonable or equitable sharing that could close any gaps in the customary international law as such.

Jordan, Lebanon, and Syria have all ratified the *UN Convention.*[184] This at least suggests a willingness to reach a settlement on the basis of the principles set out in that document—including the rights to equitable utilization and to equitable participation.[185] Furthermore, the rule of equitable utilization was expressly adopted by the Israelis and the Palestinians in their *Declaration of Principles.*[186] Even though the *Declaration* is not explicit as to the waters to which these principles are to apply, the language is general and must have been intended to apply to the aquifers shared by the two national communities. These are the waters that were in dispute both before and after the *Declaration* was signed. Without resolving the debated question of whether the *Declaration of Principles* is a legally binding international treaty,[187] this agreement largely resolves any doubts over

by the Israelis, Palestinians, Jordanians, Lebanese, and Syrians, in WATER AND PEACE, *supra*, at 481.

182 Thomas Naff & Joseph Dellapenna, A Comparative Consideration of Western and Islamic International Fresh Water Law: Confluence or Collision? (forthcoming).

183 *See, e.g.*, Israeli Water Law, 13 LAWS OF THE STATE OF ISRAEL 173 (1959); Jordanian Water Law, Law No. 12 of 1968, & Regulation No. 88 of 1966; Law of Real Property Ownership § 77 (Lebanon). *See also* Abraham Hirsch, *Water Legislation in the Middle East,* 8 AM. J. COMP. L. 168, 169-73 (1959)

184 See the text *supra* at note 124.

185 *UN Convention, supra* note 69, art. 5. See the text *supra* at notes 171-74.

186 *Declaration of Principles on Interim Self-Government Arrangements,* signed Sept. 13, 1993, Israel-Palestine Liberation Organization, Annex III, reprinted in 32 INT'L LEGAL MAT'LS 1525 (1993), and in 4 EUR. J. INT'L L. 572 (1993).

187 *See generally* THE ARAB-ISRAELI ACCORDS: LEGAL PERSPECTIVES 199, 208 (Eugene Cotran, Chibli Mallat, & David Stott eds. 1996); Eyal Benvenisti, *The Israeli-Palestinian Declaration of Principles: A Framework for Future Settlement,* 4 EUR. J. INT'L L. 543 (1993); Antonio Cassese, *The Israel-PLO Agreement and Self-Determination,* 4 EUR. J. INT'L L. 564 (1993); George Gruen, *International Regional Cooperation—Preconditions and Limits,* in WATER AS AN ELEMENT OF COOPERATION, *supra* note 1, at 263, 274-77; Kathryn McKinney, Comment, *The Legal Effects of the Israeli-PLO Declaration of Principles: Steps toward Statehood for Palestine,* 18 SEATTLE U. L. REV. 93 (1994); Katherine Meighan, Note, *The Israel-PLO Declaration of Principles: Prelude to a Peace?,* 34 VA. J. INT'L L. 435 (1994) ; Raja Shehadeh, *Can the Declaration of Principles Bring about a "Just and Lasting Peace"?,* 4 EUR. J. INT'L L. 555 (1993); Justus Weiner, *Hard Facts Meet Soft Law—The Israel-PLO Declaration of Principles and the Prospects for Peace: A Response to Katherine W. Meighan,* 35 VA. J. INT'L L. 931 (1993); Jeffrey Weiss, *Terminating the Israel-PLO Declaration of Principles: Is It Legal under International Law?,* 18 LOY. L.A. INT'L & COMP. L.J. 109 (1995).

whether the rule of equitable utilization is applicable to ground water as between the Israelis and the Palestinians.

The obligations imposed by the rules of equitable utilization and equitable participation are supplemented by the growing recognition of a right to development and even of a possible human right to water.[188] Neither social and economic development, nor even the satisfaction of basic survival needs, are possible if only one community sharing an aquifer monopolizes its waters. Such supposed human rights, even if they do not provide satisfactory means for resolving disputes over the Coastal and Mountain Aquifers, at the least lend weight to the supposition that the waters of those aquifers must be shared equitably.

Foremost among the problems in applying equitable utilization to an aquifer is the relative lack of firm knowledge of the hydrologic characteristics of the resources in dispute.[189] We know quite a lot about the surface water sources in the region. Because of the variability of subsurface conditions, there is a great deal we do not know about the characteristics of particular aquifers, particularly in karstic limestone formations characteristic of the Jordan Valley, although we certainly know more about them than we did 30 or 40 years ago.[190] To acquire more knowledge will be expensive. We are only able, then, to make tentative allocations that informal processes, as in customary regimes, are ill adapted to revise or supplement.

Once we have the necessary knowledge, we then come to some questions that are tantalizing in their complexity almost to the point of paradox. For example, some Israelis insist that the optimum well-sites for the Coastal and Mountain Aquifers are all in Israel because the aquifers are relatively close to the surface there and can be tapped by shallow wells, while higher up the aquifers are very deep and can only be reached through deep wells that are difficult to drill. Therefore, it might make economic and ecological sense to pump the water out of relatively shallow wells in Israel even for water allocated to the Palestinians.[191] If so, do the Palestinians have a legal right to drill wells in Israel, with the water then pumped back up to the West Bank or

[188] See the authorities collected *supra* at note 144.

[189] HILLEL, *supra* note 16, at 194; Grey, *supra* note 17, at 226-27; Kuttab & Isaac, *supra* note 181, at 240-42; David Scarpa, *Eastward Ground water Flow from the Mountain Aquifer*, in WATER AND PEACE, *supra* note 101, at 193. See generally the text *supra* at note 145.

[190] *See* HILLEL, *supra* note 16, at 204-06; Robert Bisson & Peter Hofman, *Ground Water—The Paradoxical Economic Mineral*, 4 WATER & WASTEWATER INT'L 17 (1989).

[191] Eran Feitelson, *Joint Management of Ground water Resources: Its Need and Implementation*, in THE ARAB-ISRAELI ACCORDS: LEGAL PERSPECTIVES 213, 217 (Eugene Cotran, Chibli Mallat, & David Stott eds. 1996). *See also* Aaron Wolf, *Water for Peace in the Jordan River Watershed*, 33 NAT. RESOURCES J. 797, 828-29 (1993).

down to Gaza?[192] The answer would appear to be no, absent consent by the Israelis. States generally have no customary legal right to exploit their water resources through activities in another state without the consent of that other state.[193] Such consent usually is withheld unless one state is in a position to dominate the relationship.[194] While protecting each state's sovereignty, this approach guarantees less than optimal management of a resource. In the Jordan Valley, this would result in a sacrifice of economic and ecological efficiency on the altar of national sovereignty, hardly an unlikely result,

[192] For a similar argument regarding sharing the reservoir capacity of the Sea of Galilee rather than well drilling, see Norman Dudley, *An Innovative Institutional Arrangement with Potential for Improving the Management of International Water Resources*, in WATER AND PEACE, *supra* note 101, at 469.

[193] *See, e.g.*, HELSINKI RULES, *supra* note 66, art. 24; SEOUL RULES, *supra* note 135, art. 2.

[194] For examples of consent being withheld, see Additional Convention on the Management of the Rhine, signed July 16, 1975, France-German Fed. Rep., art. 3, 1025 UNTS 386; Convention on the Management of the Rhine, signed July 4, 1969, France-German Fed. Rep., art. 3, 760 UNTS 305; Convention Relative to the Breggia Torrent, signed June 23, 1972, Italy-Switzerland, art. 3(1), RECUEIL OFFICIEL DES LOIS FÉDÉRALES [Swiss], 2019 (1978); Treaty Concerning the Management of Frontier Waters, signed Dec. 7, 1967, Austria-Czechoslovakia, arts. 5, 7, 728 UNTS 313; Treaty Concerning the Water Economy in the Frontier Region, signed Apr. 9, 1956, Austria-Hungary, arts. 4, 6, 438 UNTS 123; Treaty on the Connection between the Scheldt and the Rhine, signed May 13, 1963, Belgium-Netherlands, arts. 6, 13, 540 UNTS 3. For examples where consent was given, see Agreement Concerning Frontier Watercourses, signed Apr. 24, 1964, Finland-USSR, art. 9, 884 UNTS 57; Exchange of Notes Regarding the Owens Falls Dam, May 31, 1949, Egypt-United Kingdom, ¶ 4, 226 UNTS 273.

suggesting again the limitations of the rule of equitable utilization for managing transboundary water resources.

As should by now be clear, what is necessary for the transboundary ground water resources of the Jordan Valley to become a building block for peace rather a stumbling block leading towards the road to renewed conflict is a properly structured legal regime for accomplishing joint management of the resources. That would be a delicate and difficult, but not impossible, goal.[195] After all, there is no reason to expect the rule of equitable utilization to work in itself any better for ground water than for surface waters, and it might prove even more difficult to apply in that context. Yet, given the need to drink with one's enemies and the common relevant cultural and legal traditions throughout the region, devising such a regime for the shared waters of the Middle East thus might prove to be easier than one might expect. All that is needed is the political will.

[195] *See* DELLAPENNA, *supra* note 178, ch. 5; Dellapenna, *Legal Structures*, *supra* note 65.

Chapter 13

Water Rights

Functions, Conditionalities, Administration

Miguel Solanes
Division of Environment & Development, ECLAC, Casilla 179-D, Santiago, Chile

1. INTRODUCTION

1.1 Water Rights

In Western, Roman-based legislation, the economic aspects of water resources were relevant enough for them to be included within public or private ownership and for systems of rights on water to have existed since Roman times. However, a full "econominization" of water resources may be a complex task in countries with a Muslim, Hindu or traditional Chinese background. Full econominization may also be prevented by the environmental and social aspects of the resource.

At present most legal systems recognize and protect the property aspects of rights to use water, which is the manner in which law reacts to the economic concept of scarcity. At the same time, water law systems acknowledge the social and environmental dimensions of water through norms intended to protect third parties, the environment and the resource base, as noted in references to France and the Mono Lake in the US.

An important social dimension of water rights, closely associated to the economic dimension of the resource, is a definite intent in most legislations, to prevent water hoarding, speculation, monopolies and waste. With world-wide privatization of water related services, monopolistic control of water rights configures a typical case of barrier to entry. Therefore the requirement of effective and beneficial use of water rights is a main principle of water law, both at national and international level.

In the single known case of non-existence of this provision, Chile, the system has resulted in speculation, hoarding and impaired water management, to the detriment of water sources. Proposals to amend the system are presently before Congress.

However, the manner in which the rights were granted may make legal change extremely laborious. Proposals to tax water rights in order to promote their more efficient and equitable use by holders have been attacked on constitutional grounds. The now-private electrical utilities argue that since original water rights were not conditioned to effective and beneficial use, the use of taxes to induce behavior other than the one unilaterally fitting the company would be an infringement of its property rights, which are constitutionally protected as granted.[1]

A corollary of the economic character of water is the existence of water markets. They are a useful tool to economically optimize the use of water. However, since the many roles of water and its peculiar features make it a very special commodity, mature systems of water marketing regulate its performance in light of social, economic and environmental considerations.

Finally, there are proposals to charge for water according to its opportunity cost. Examples of this approach are not abundant. However there are examples of charges intended to recover costs, pay for treatment of wastes, cover administrative expenses and induce environmentally sound behavior. More analytical work seems to be required in order to refine criteria for inception, procedures for application and consideration of issues of opportunity and equity when dealing with opportunity cost pricing.

1.2 Common Good and Sustainability

Comparative reviews of water law systems show, with varying degrees of comprehension and depth, according to different national systems, that there are water policies and legislation concerned with integrated water management; water quality protection; flow and landscape considerations; ecological requirements; rational and guided water use; integration among soil, water and other natural resources; protection of water supplies; water planning; recognition of the river basin; groundwater protection; mandatory assessment of water policies, plans, programs and projects and mandatory assessment of water related subsidies.

[1] At least three cases decided by Chilean courts and anti-monopoly organs have acknowledged the relationship between water rights and monopolization: Comisión Preventiva Central Res. 992/636; from 25/11/96; Comisión Resolutiva Res. 480, 7/1/97; Court of Appeals of Puerto Montt, "Endesa Vs. Dirección General de Aguas," Jan. 7, 1997.

There are also examples of legislation specifically concerned with the needs of all citizens, the common interest, the benefits of individual users and the livelihood of the population. Concrete examples of social concerns in water legislation are the preference often found for drinking water supply and sanitation, and the requirement of public access and availability of British law.

The link with development is also a tenet of water law. Legislative requirements for optimal use and full realization of the economic benefits of water were found. Some systems relate water planning to economic improvement and economic regions. Economic considerations are, in a few countries, main normative criteria for decision making and program and project evaluation.

1.3 Institutional Aspects

Legislation relating to public participation in water management also exists, under the assumption that water related activities are not confined to the interests of limited groups of users, geographical boundaries, sectoral institutions or national jurisdictions.

Generally, meaningful participation is associated to well defined national policies, for which water is either a main component or a relevant input. Policy implementation is usually associated with socially acknowledged, relatively well informed government organizations, with adequate capabilities and appropriate legal mandates. These institutions are evolving from sector-oriented to resource-oriented, with strong indications that the concept of the river basin is steadily, albeit laboriously, coming into the institutional scene.

The review of experiences strongly suggest that the institutional dimension of water management is a system, where relatively successful water management experiences (success in this context is contingent to what a system knew and sought at specific times) have included a balance of government institutions and policies and stakeholders participation.

Such experiences, drawing from places as far apart as California and South Africa, indicate that meaningful stakeholder participation requires at the least a certain degree of government overseeing and sometimes support. Such support may consist of dissemination of information, promotion and encouragement of involvement. Otherwise there is an ever present risk of participation becoming coopted by well-informed, intent-specific, special interests groups.

Conciliation of interests, public consultations and hearings are some of the manners in which interested parties and stakeholders, not necessarily having a conventional (in the sense of typical) proprietary interest in water, are able to participate. More formal structures include advisory boards, integration within government bodies and associations and districts with field goals and responsibilities.

Interestingly, some legislations acknowledge the globality of water issues, and corresponding affected interests, through references to international treaties and obligations.

Some laws recognized the intimate connection existing between participation and information at all levels.

Some systems, where agricultural and other subsidies have traditionally coexisted with relatively strong participation, seem to indicate that a main, although not necessarily exclusive, prompt to participate is economic self-interest.

Finally, on account of Mexican experiences, it seems relevant to note that technical needs, opportunities for economies of scale and scope, and other factors need to be taken into account when applying the concept of the lowest appropriate level. Also, lowest appropriate level and private sector are not synonymous: Water corporations purveying water services are private, but many of them are global.

2. THE ECONOMIC VALUE OF WATER AND WATER RIGHTS

In this paper the expression economic value of water refers only and exclusively to water as a natural resource, without addressing the issue of water related-services and connected added value and expenses. This distinction is important to clearly focus the issue of the economic value of water and its legal implications.

Property is to law, what scarcity is to economics. Law and economics are not separate and mutually exclusive, but interdependent regarding form and content and ends and means.[2]

Traditionally, law has not been interested in granting individual rights to the use of resources plentiful enough not to have apparent actual economic value. In European-based western law, as resulting from Roman law, these resources were known as "common resources."[3] The typical examples were the high seas and the atmosphere: of such magnitude that they were deemed

[2] L. Gray & K. Nobe (1975). *Water Resources Economics, Externalities and Institutions in the United States.* Paper discussed at the International Conference on Global Water Law Systems, Valencia, Spain, p. 1.

[3] The concepts of common, public and private goods in law do not strictly coincide with the concepts of common, public and private in economics.

neither appropriable nor vulnerable; of such abundance that they were owned by nobody because no restrictions applied to the use of unlimited supplies, which were free for all. The actual existence and meaning of a third category, "acqua profluens", are debated. In this report the writer suscribes to the opinion of Bonfante.[4]

Apparently, in China water was an element within the concept of universal harmony, subject to public control. Fulfillment of individual duties in relation to water would satisfy the greatest good for the social system.

In earliest Muslim Law water was the common entitlement of all Muslims.[5] Similarly, in early Hindu law water had a fluid and purifying nature, and could not became an object of appropriation.[6]

In Roman law, terrestrial waters were either public or private. The distinction was based on magnitude, perenniality and the opinion of local inhabitants (*existimatio circumcolentium*). References to the common character of flowing waters (*acqua profluens*) have been understood to refer to common use of such waters, and not to ownership.[7] However, whatever the categorization of any specific body of water, the main fact for the purpose of this discussion is that in Roman law water was considered important enough, scarce enough, and useful enough, to be publicly or privately owned. Here we find an early indication that water was granted, albeit implicitly, an economic value.

However, water is not an ordinary commodity. The peculiar characteristics of water resources stem from its polyvalent environmental, economic and social roles. They include, *inter alia*, public good aspects; external effects; imperfect competition; risk, uncertainty and imperfect information; potential for social and environmental inefficiencies and inequity, and vulnerability to monopolization.[8] These peculiarities have resulted in water rights systems which are hard pressed to strike a balance among the different demands and requirements resulting from polyvalency and unique physical chemical and biological attributes.

4 P. Bonfante (1929). *Instituciones de Derecho Romano*. Trad. de la 3a ed. ital, de Bacci, Luis y Larrosa. Andres, revisada por Campuzano Horma, Fernando, Madrid, pp. 313-314, 322.

5 Le Cheik El-Charani. (1898). *Kitab al Mizan (Balance de la Loi Musulmane)*. Translation of Perron, Algiers, 1898, p.388 quoted by Caponera, D. In: *Principles of Water Law and Administration*, Balkema, Países Bajos, 1992.

6 B.J. Wohlwend (1975). *Hindu Water and Administration in Bali*. Proceedings of the Conference on Global Water Law Systems, Valencia.

7 See note 4 above.

8 See, generally, B. Colby-Saliba& D. Bush (1987). Water Markets in Theory and Practice: Market Transfers, Water Values and Public Policy. *Studies in Water Policy and Management*, 12, Westview Press, Boulder, Colorado, USA.

Thus, water rights perform, or should perform, two main functions: i) a structural role; and ii) a regulatory function. The structural role is crucial to investment, since it determines the manners in which private users will relate to the resource and invest in water-related development. In this regard water rights are institutional socioeconomic tools. Security and transferability are the two main attributes of this function. According to some authorities the structural attributes do also impinge on conservation. In some systems, recognition and acknowledgment of traditional customary rights are important elements in the structural design of water rights.

Regulatory aspects of water rights intend to conserve the water source, ensure sustainability and protect the rights of third parties, the public and, increasingly, the environment.

2.1 Water Rights

While in most countries water belongs to the public domain, water use rights granted to private individuals or corporations are protected under the property provisions of national and, in the case of federal countries, state or provincial constitutions. The Mexican water law of 1992 has incepted a system of water rights, their registration and transfer, with a view to promote security and stability in water management and use.

Thus, stability of water rights is an important principle in water law, which some authorities have traced back to Roman law.[9] The impossibility to grant stable water rights negatively affects development. In Zimbabwe, difficulties in acquiring reliable water rights are a main constraint to new viable agricultural investment.[10]

A system of stable water rights is an incentive to invest in the development and conservation of water resources. Stable water rights are useful collaterals, assets or appurtenances for credit purposes, and also important elements when assessing properties for taxation. Additionally, the stability and certainty of water rights and appurtenant uses provide recognition to existing economies and prevent social unrest.[11]

9 Lex Coloniae Genetivae Iulae. 43 A.D. according to which waters in public lands open to colonization were subjected to the same uses and charges existing under previous ownership, according to Costa. (1918). *Le Acque nel Diritto Romano*. Bologna, Italy, pp. 16-18, according to quotation by D. Caponera, *op. cit.*, pp. 30, 50.

10 T.P.Z. Mpofu (1995). Communication to Ms. Beatrice Labonne, UNDDSMS, August 1.

11 US Supreme Court, (1984). *Syllabus and Opinions*. No 80; Argentinean Supreme Court (1987). *La Pampa Vs Mendoza*. L-195-XVIII; F. Conac (1989). Land and Water Rights Issues in Irrigated Schemes. In: Sub-Saharan Africa: Conflicts to be Avoided. *DVWK*. 16, Verlag Paul Parey, Hamburgh, Berlin; R. Beck, & R.C. Goplerud (1991). *Waters and*

A water right usually is a right to use, and ownership of a water right does normally means a usufructuary power, and not ownership of the corpus of water itself. In some legislations the usufructuary power can be traded.

2.2 Effective and Beneficial Use

The relevance of water rights as property assets is related to the availability of the resource. The scarcer resource is the most valuable. Therefore, most water laws have provisions that require the effective use of water entitlements, either for a right to be born and kept, or for the maintenance of a valid water right.

The principle of effective and beneficial use is widespread. While the terminology is not uniform the notion that water rights risk forfeiture if not used, or if not used according to the terms of a license or permit, is found in the German law, as amended on September 23, 1986, the Spanish law of 1985, the Mexican water law (art. 27. III), the legislation of most Argentinean provinces, and the laws of the states of the American West. The legislation of Zimbabwe specifically considers the economic aspects of applications for water rights.[12]

The rationale behind the principle has been precisely and clearly constructed by the authorities, judges and legislation of the United States. A typical statement of the rule of beneficial use is: "Beneficial use is the basis, the measure, and the limit of all rights to the use of water in this state...consistent with the interest of the public in the best utilization of water supplies." Beneficial use is an evolving concept. At present it may include wildlife, water quality, recharge, navigation, recreation, scenic, and aesthetic values. Water is not to be wasted.[13]

The tenets of the doctrine of effective and beneficial use are: a) water is not to be obtained for speculation or let run to waste (reality of use); b) the end use must be a generally recognized and socially acceptable use; c) water is not to be misused (reasonable efficiency); d) the use must be reasonable as compared with other uses;

A common idea was that the quantity of water was to be no more than needed, the concern being with the possibility of "vesting an absolute

Water Rights, The Michie Company Charlottesville, Va. USA, Vol. 1, p. 366 and following.

12 See Mpofu, *op.cit.*

13 See Beck & Goplerud, Vol. 2, p. 106 and following; also D. Getches (1990). Water Law. West Nutshell Series. St. Paul Minn, p. 97/99.

monopoly on a single individual."[14] This antimonopoly-antispeculation concern where claimants do not have an specific use in mind continues today.

For a long time it was difficult to assess what happens in practice when water legislation does not have a requirement of use, the reason being that national systems of water legislation did not normally grant exclusive-nonriparian-based water rights, without adding the requirement of effective and beneficial use. At present, the state of flux of water legislation in general, and legislation related to water-based public services in particular, has prompted specific research on the subject of water rights and on the consequences of creating water rights severed from the requirement of effective and beneficial use. It has helped that assessments of the Chilean experience (where water rights are not conditioned on effective and beneficial use) are becoming widely available.

Natural resources economists notice that non-use, if not penalized with forfeiture may result in "sleeper rights" which increase uncertainty on the quantities of available waters.[15]

The Chilean experience on the issuance of non-conditioned water rights is an apparent validation of the forebodings behind the requirement of effective and beneficial use. A study on the impact of the legal system for water allocation in Chile has found that:

"It is also common a state-owned monopolies that benefitted from exclusive rights be privatized with them, creating legal barriers to entry that maintain the monopolistic characteristics of the sector"... "As mentioned above the regulatory framework [for electricity] is based on the existence of competition in the generation of electricity"..."However, competition practically does not exist in Chile"... "The water rights of the main hydroelectrical projects belong mainly to...[a single corporation]"... "The implication of this is that the largest generator has an incentive to appraise projects considering the effects that they will have on the profitability of its intramarginal capacity. It can obtain the monopoly equilibrium overtime by postponing investments. New entrepreneurs will be unable to enter [into the generation market] because they do not have the water rights to undertake the more efficient projects"...."Water rights should have been returned to the state prior to privatization, which in turn could have granted them subject to

[14] See Beck & Goplerud, Vol. 2, pp. 107-108.

[15] See M.L. Livingston (1993a). *Designing Water Institutions Market Failures and Institutional Responses*. Originally prepared for World Bank Policy Paper, no place or data of printing available, pp. 8-9; M.L. Livingston (1993b). *Normative and Positive Aspects of Institutional Economics: The Implications for Water Policy*. Water Resources Research, USA, Vol. 29, No 4, pp. 815/21, April.

the conditionality of their timely development ...[through new projects] by existing producers or new comers."[16]

Thus, the actual operation of the Chilean system appears to confirm the rational behind the requirement of effective and beneficial use.

Monopolization through the creation of barriers to entry, resulting from the control of essential production inputs and natural resources, are standard fare in economics literature.[17] The existence of water markets does not alleviate the situation since in fact "crucial inputs of this kind are not usually traded on competitive markets".[18] Also, water markets do not reallocate large quantities of water. To the contrary, the amounts historically traded are limited enough for these markets to have been identified as "thin" markets, by a leading expert on the subject.

Furthermore, for large institutional users the incentives to sell water rights, without the penalty of forfeiture for non-use, are minor if compared to the strategic advantages that control of a key production input represents within the market power policies of corporative practices. Hence, it appears that the absence of a requirement of effective and beneficial use does have a negative effect on water transactions, on water markets and on efficient water allocations. Empirical evidence on the actual working of water markets in Chile shows that with a few local exceptions market transactions of water rights in Chile have been limited.[19]

2.3 Conditionalities on Water Uses

In addition to the requirement of effective and beneficial use there is general trend to condition the use of water. This conditioning includes

[16] E. Bitran & R. Saez (1993). *Privatization and Regulation in Chile*. Brookings Institution Conference on the Chilean Economy, Washington DC, April 22-23, pp. 50-55.

[17] L.A. Sullivan (1977). *Antitrust*. West Publishing Co., St. Paul, Minn. USA, 1977, pp. 25, 31, 77, etc.

[18] M. Armstrong et al. (1994). *Regulatory Reform: Economic Analysis and British Experience*. The MIT Press, USA, pp. 117 and note 24 below.

[19] See C. Bauer (1995). *Against the Current: Privatization, Markets, and the State in Water Rights, Chile, 1979-1993*. Berkeley, California, USA, p. 2. "Private bargaining and exchange cannot coordinate overlapping resources without continues State intervention, through the courts, if not through other political organs": p. 57..."these features [of the law] stimulate speculation..." they have been favored [by supporters of the law] saying that speculation improves market operations and price signals"..."they deny criticisms that speculation might distort prices through unequal bargaining power or monopoly control"... p.171 ..."the government virtually guaranteed the under-valuation of water rights [resulting in relatively few transactions] when it privatized them without imposing any taxes, fees, or other obligations to the public interest."

formal (obtaining a permit) and substantive requirements (i.e., no harm to third parties, environmental protection, efficiency).

German Water law, which provides a good example of trends, attaches a number of conditions to water use, permits and licenses. These conditions include effective use, prevention of detrimental effects, payment of compensations, preventive assessment, appointment of caretakers, remedial measures and payment of common control costs (Art. 4). A particular feature of the German legislation is the possibility to impose new conditions **after a permit or license has been granted.** Ex post facto conditions may refer to the environmental or the economic requirements of water resources management (Art. 5). A water right can be revoked for nonuse, lack of need, change of use by the permittee, use beyond the allocation under the permit, etc. (Art. 15). Permits are required to either withdraw water or to effect discharges into water. However, as far as regards the relationship between the administration and a water user, a water right is not an entitlement to any specific water quantity or quality (Art. 2). Applications can be rejected and permits and licenses can be granted for specific purposes, in a specific manner, and to a specific extent. They are revocable (Arts. 6 & 7). Use of water by property owners and riparians shall not adversely affect other persons, cause detrimental change to water, adversely alter water balance or substantially reduce water flows (Art. 24).

A common feature of water law is to establish preferences among uses in order to allocate water at times of scarcity, or to grant water rights in case of competing applications. An example of this feature, which incidentally is a major element in Muslim law ("right to thirst"), is Article 58 of the Spanish law of 1985 granting a preference for drinking purposes.

2.4 Water Markets

Marketing of water rights is being paid increased attention as a useful, and economically efficient, alternative for the improvement of water allocations. As supplies diminish relative to demand markets become not only an efficient alternative, but also a necessary solution to problems of water scarcity. Thus, new legislation, such as the Mexican water law, allows water transfers, subject to administrative authorization, should such transfers affect the rights of third parties, the environment or the regime of water resources. Should the transfer not change the conditions of the original title, or existing regional agreements, water rights may be transferred by registration in the Public Water Rights Registry. Thus, the formalities of water transfers are established by regional regulations established by the National Water Commission according to the requirements of individual regions. However, countries such as the People's Republic of China, while acknowledging the need to develop water markets, emphasize the need for macromanagement of water resources, to avoid harmful impacts on the environment and social development.[20]

2.5 The American Experience

Water markets are an important feature of the legal system of the states of the American West. A review of this experience is important to the understanding of the subject and its complexities. In the United States reallocation of water rights may be "with the possible exception of water quality... the most pressing matter facing the arid west."[21]

For a reallocation to be legally valid some requirements must be fulfilled: a) water must have been beneficially used and must continue to be beneficially used after the reallocation; b) such reallocation must not affect other users and must be in the public interest; c) in many jurisdictions, interbasin transfers or transfer outside the area-of-origin can only take place with due consideration to local interests; b) in some jurisdictions appurtenance statutes prevent water reallocation.[22]

Marketing of water rights is a complex process, which is affected and influenced by several factors, including: (1) the priority of the transacted right; (2) the profile of the parties; (3) geographic flexibility; (4) size and economic value of the transaction; (5) reliability of the marketed water right; (6) buyer characteristics; (7) volume of water transferred; (8) changes in regional economies; (9) system for water administration; (10) availability of infrastructure to effect a change; (11) environmental impacts.[23]

While water rights markets are strongly advocated by reputable experts, there are also reservations. Conflicts over water transfers occur in the American West as large metropolitan areas look to the water supplies of rural areas. The public values at stake include the economic development of urban areas, culture, way of life, environment and the future of rural communities built around agricultural uses. "It is becoming increasingly apparent that current water law and water market oriented behavior are incapable of solving this conflict in an equitable manner."[24] Therefore, according to some authorities, oversight and regulatory approval for water

[20] See China: *Capacity Building on Law and Institutions for Water Management*, p.21, note submitted to UNDDSMS on August 23, 1995.

[21] Beck & Goplerud, Vol. 2, p. 234.

[22] Ibid.

[23] B.G. Colby et. al. (1993). "Water Rights Transactions: Market Values and Price Dispersion." In: *Water Resources Research*, 29(6):1565-1572, June.

[24] H.M. Ingram et al. (1989). *The Trust Doctrine and Community Values in Water*. III World Conference on Water Law and Administration, Alicante, Valencia, Spain, pp. 10-11.

transfers and markets is required. A result of the complexities of water marketing is that the activity has been subjected to regulations in the interest of third parties and the public.[25]

Broadly stated, regulations include: a) the appurtenacy principle, which prohibits the transfer of water rights if not as an appurtenance to the land where they are used. Its purpose was to prevent land speculation; b) transfers are to be approved by judicial, legislative or administrative authorities (the approving authority varies according to the law of each state); c) public notice of the intent to transfer, with the possibility of filing protests granted to either any interested person or only to holders of water rights (again standing to oppose varies according to the legislation of each state); d) administrative recording of the transfer and filling with the authority for water management; e) issuance of permits to reallocate and use subject to existing or new conditionalities, including proof of completion of work and beneficial use; f) forfeiture of water right (and in some states charges for misdemeanor), if prior approval is not obtained; g) limitation of transferable entitlement to historic consumptive use; h) requirement that transfer does not injure other appropriators who, even if junior, have a right to the substantial maintenance of the stream conditions existing at the time of their appropriations. Injury might result from changes in volumes, timing, storage, means of diversion, quality, deprivation of return flows, point of diversion or a combination thereof; i) accommodation of uses through conditions intended to mitigate or prevent injury; j) compensation and payment of expenses;

In addition to the above mentioned regulatory examples, there are also **considerations of public interest** which apply to the review of applications to transfer water rights. They apply to the review of **public value externalities.** They include: a) effect of the economic activity resulting from the application; b) effects on fish and game resources and on public recreation; c) effect on public health; d) opportunity cost of the use; e) harm to other persons; f) intent and ability to use; g) effect on access to public and navigable waters; h) need for water conservation; i) factor of local relevance.

Accordingly, reallocation would not be allowed if it results in the violation of minimum health, environmental or safety standards. However, the public interest element can be accommodated by conditioning a requirement for reallocation to measures to mitigate public interest concerns.

While there are no questions on the substantive legitimacy of public interest concerns questions on the appropriate fora and means for their consideration have been raised. While there is always an administrative and

[25] See L.O. Anderson et. al., "Reallocation." In: Beck & Goplerud, *op. cit.*, Vol. 2, p. 234 and following.

judicial role, for some authorities such means and fora should include water planning and public participation.

Additional considerations may include the assessment of the impacts that a transfer may have on the environment, and the tax base or the local economy of the area of origin of the water allocation to be transferred.

Finally it is worth noting that research on water markets in the American West, California and Chile have concluded that requirements of effective and beneficial use of waters encourage water transfers;[26] that the existence of subsidies to specific activities affects water transfers;[27] and that the absence of requirements of effective and beneficial use negatively affects water markets.[28]

2.6 Charging for Water

Charging for or pricing water is a vexing problem. There are technical complications about what is the price that would best reflect the value of water. Economists specializing in water resources notice that water has a relatively low economic value at the margin. While the value of the first unit of water to be used by a city may be very high, the value of additional units may be quite low.[29]

Additionally, it seems that by nature water markets are thin markets, with a relatively low number of transactions performed in each one of them. Moreover, water markets are not classical markets in the sense of having quick and clear agreements, anonymity, instant exchange, and no further dealings among the parties.[30] Therefore, it may be argued that water markets are not perfectly competitive, and consequently do not necessarily reflect full costs of transactions.[31]

Many systems charge for the cost of administering water resources. There are also charges for water related services, and to protect and recover water when affected by environmental deterioration.

[26] See Colby-Saliba & Bush, *op. cit.*, p. 81; also G.D. Weatherford & S.J. Shupe (1986). "Reallocating Water in the West". *American Water Works Association Journal*, 78:63-71. October.

[27] B.M. Haddad (1996). *Evaluating the Market Niche: Why Long Term Rural to Urban Inter-Regional Markets for Water Have not Formed in California*. University of California at Berkeley, p. 393.

[28] Bauer, *op. cit.*, pp. 10, and 11; also Haddad, *op. cit.*, pp. 389, 390.

[29] R.A. Young (1986). Why are There so Few Transactions Between Water Users? *American Journal of Agricultural Economics*, 67:1143-1151, December; also Colby-Saliba & Bush, *op. cit.*, pp.1-6.

[30] Haddad, *op. cit.*, p. 379.

[31] See, generally, Livingston (1993b), pp. 815-821; also Livingston (1993a).

Thus, the German water law requires payment of common control costs (Art. 4). Also in Germany, the Act on Waste Water Charges, of November 6, 1990, provides for water charges to be paid by water polluters. Charges are based on noxiousness levels, which depend on oxidizable substances, phosphorous, nitrogen, mercury, cadmium, chromium, nickel, lead, copper and their compounds; as well as on toxicity to fish (Arts. 1 to 3, Act of November 6, 1990). They also consider the classification of particular river basins and the number of units of noxious elements in the water body downstream of the river classification basin. Water charges are to be paid by anyone discharging waste water. The revenue resulting from water charges shall be used in measures to improve water quality (Arts. 9 & 13 Act of November 6, 1990).

The cost of pollution control and environmental protection in the Netherlands are financed through the general budget (taxpayers) or through a special budget financed by specific levies or charges. Pollution levies and charges are raised from polluters.

Examples like these cases, where charges are used to recover costs or to promote environmental protection, are relatively numerous.

However, legislation charging for water as such is not so abundant. A recent case is the Mexican Water Law of December 1, 1992, which charges for the exploitation, use and enjoyment of surface and groundwaters. Payments are also established for discharges into bodies of water (Art. 112). Water prices and values are established according to regional water availability. The goals of the system are a) to relate water charges to benefits resulting from services and water works; b) to integrate the financial system within an overall strategy for water resources management, including the solution of structural problems; c) to promote rational water use and conservation; d) to adjust water price to cost; e) to strengthen the National Water Commission, which collects and manages water related revenues. The system intends to charge according to the opportunity cost of water, allowing adjustments according to regional conditions, and taking into consideration the social and political situation of different groups of users. The charge is a main source of financing for the activities and investments of the National Water Commission.

The Spanish water law of 1985 provides for the payment of fees for the use or occupation of public waters. The base value to calculate the charge is the value of the capital asset which is utilized by the user. Such value is estimated on the basis of the economic returns generated by the asset. The rate to be collected is 4% of the base value. Revenues are collected and managed by Water Confederations, which are the water authorities at basin level (Arts. 104 & 105).

3. SUSTAINABILITY

3.1 Water Policies

Several countries state the purposes and objectives of their water policies in their water legislation. The statement of policies is relevant to the interpretation, application and enforcement of legislation. Several of the statements reflect awareness of the interrelationships resulting from the principle.

Several laws include policy principles where the multiple roles of water are recognized. Thus, the Canadian Water Act of 1970 encourages optimum use of water resources for the benefit of all Canadians (Art.1). The water law of Germany (as amended on September 23, 1986) requests that water (both surface and groundwater) be managed in a manner that serves the common interest, benefiting individual users while preventing avoidable harmful impacts (Art. 1a). The Netherlands' "Policy Document on Water Management" sets up a policy of integrated water resources management which includes the quantitative and the qualitative aspects of water management.[32] The policy of the water law of China of 1988 is to ensure the rational development, utilization and protection of water resources, fully realizing the benefits of water, for economic development and the livelihood of the population. The policies of the Mexican water law of 1992 include the preservation of water quality and the promotion of sustainable development.

3.2 Quality Controls and Environmental Concerns

The environmental dimension of water is rapidly becoming a major component of water legislation. As water becomes scarcer, relative to demand, as externalities increase, and as knowledge improves, the need to control the deterioration of water quality is translated into more detailed and demanding legislation. Permits, prohibitions and charges are used to curb the deterioration of water and related natural resources and environmental assets.

The Canadian Water Act provides for the designation of water quality management areas and the implementation of water quality management programs (Art. 11). Water quality management agencies plan, initiate and carry out programs to restore, preserve and enhance the quality of the waters within the water quality management area (Art 13).

[32] *Water Management in the Netherlands: Policy, Measures, Funding*. November 1991. No Author or Place of Publication, p. 4.

The German water law imposes a general duty to prevent water contamination and detrimental changes of its properties, requiring "an economical use of water in the interest of natural water resources" (Art. 1a). Discharges into water are subject to maximum loads and technological requirements. Hazardous wastes must be treated using the best available technology (Art.7). Art. 22 provides for strict, joint and liability resulting from damages caused by introducing or throwing any substances into water. Discharges causing not merely insignificant detrimental changes, shall only be allowed when overriding public interest thus requires it. Waters can be subject to characterization parameters issued by the federal government (Art. 36b). The law also provides for proper flow conditions, maintenance of navigation, ecological requirements, landscape features, protection of banks, and self purification (Art. 27).

The policies on environment and water of the Netherlands aim primarily at having and maintaining a safe and habitable country and to develop and maintain healthy water systems which guarantee sustained use.[33] Three parameters are established: 1) reduction of pollution at the source; 2) hydraulic design; 3) rational or "guided" use of water resources, in particular groundwater. Quality objectives and monitoring methods and procedures have been established. The system includes licensing of discharges into water and, for specific industrial sectors, into sewers; payment of pollution charges and the preparation, every five years, of action plans to combat water pollution.[34] The policies do also address diffuse pollution, like atmospheric deposition, tars (utilized on protection materials for wooden shore and bank facilities), and agricultural run-off and leachates. Some pesticides have been absolutely prohibited, others are restricted, and some are subject to application according to best environmental practices. Additional measures, intended to control environmentally negative effects, include friendly environmental design and sedimentation and eutrophication control.

The Water Act of England of 1989 provides for the classification of water quality, in relation to controlled waters (Sect. 104), the establishment of water quality objectives (Sect. 105), controlling and remedying pollution (Sect.107), protection from sedimentation and refuse or waste vegetation (Sect. 109), protection against pollution (Sect. 110), creation of water protection zones (Sect. 111), establishment of nitrate sensitive areas (Sect. 112), establishment of minimum acceptable river flows (Sect. 127), enactment of codes of good agricultural practices, with a view to protect water resources (Sect. 116). The Water Resources Act of 1991 imposes

[33] Ibid.

[34] Ibid., pp. 8-9.

conservation and enhancement duties on the Ministers and the National Rivers Authority, with a view to protect amenities, flora, fauna, historical places and other environmental interests. Public access and public availability are also taken into account. These duties are also to be considered when dealing with those who undertake the management of waters and lands and their proposals (Sect. 16). Additional duties refer to environmental concerns for sites of special interest and for the enactment of codes of practice with respect to environmental and recreational duties (Sects. 17 & 18).

The water law of China creates a state duty to protect water resources and adopt effective measures to protect flora, conserve water sources, control soil and water losses and improve the ecological environment. Water pollution is to be prevented and controlled, with a view to protect and improve water quality. Supervision and management of prevention and control of water pollution is to be strengthened (Arts. 5 to 7). Agriculture must be practiced with a view to promote stable and high agricultural yield (Art. 15). Hydropower development is to be achieved in accordance with protection of the ecological environment (Art. 16). Fish ladders must be constructed when needed (Art. 18). Adverse environmental impacts in the implementation of interbasin transfers (Art. 21) must be prevented. Additional rules control disposal of refuse, mining activities, land reclamation, construction of projects and creation of management and safeguard zones (Arts. 24 to 29).

In some systems environmental concerns are the basis on which existing water rights can be amended, restricted, subjected to prorata or cancelled. The French water law of 1992 authorizes changes in water rights when public health, or safety so requires, or when water environments are threatened (Art. 10.iv). In the United States the public trust doctrine has been utilized to limit prior appropriation rights when the full exercise of such rights would lead to the drying up of a lake.[35]

3.3 Protection and Management of Water Supplies

Protection of water sources has been a traditional concern of water law. Increasing demand and externalities have strengthened this concern. The Mexican water law reflects this dimension of water legislation through the regulation of the use and development of national water resources.

The German water law provides for the creation of water protection areas, within which certain activities cannot take place or certain measures

[35] Mono Lake. National Audubon Society vs. Superior Court of Alpine County, 33 Cal.3d 419, 189 Cal. Rptr. 346, 658 P.2d 709 (1983).

have to be tolerated (Art. 19). The law requires the licensing of pipeline systems conveying substances constituting a hazard to water. These licenses are subject to conditions that can be changed even after a license has been issued (Art. 19). Use of, and discharges into, groundwater are subject to permit and licensing (Arts. 32 & 34).

Groundwater is increasingly controlled and protected. A number of countries have enacted legislation requiring permits, creating administrative devices to control the use of groundwater in special management areas, and restricting the expansion of high consumption activities, like irrigation. Management measures include the issuance of certification of assured water supplies, which are required for the approval of subdivision plots, registration and recording of wells, control of water storage and recovery, control of well drillers, protection of preexisting uses, use of groundwater charges, measurement of withdrawals, estimations of supply and demand, stopping and reducing withdrawals in order to allow replenishment, granting emergency powers in case of drought, granting of permits at the discretion of water administrators (except in cases of clear abuse of discretion), deadlines for waterworks and activities, monitoring, possibility to amend and forfeit water rights, conjunctive use of surface and groundwater, control of discharges into groundwater and allocation of groundwater to preferred uses like drinking water supply.[36]

The Water Resources Act of England of 1991 provides the National Rivers Authority with a general mandate of proper management, which includes conserving, redistributing, augmenting, and securing the proper use of the water supplies for England and Wales. Water resources management schemes can be entered into for this purpose.

4. INSTITUTIONAL ASPECTS

4.1 Vesting Responsibility for Overall Water Management

The functional organization for policy-making, water allocation, water management and monitoring of users plays an important role in the implementation of a sustainable water development system. Where these

[36] Space limitations prevent a full listing of laws and countries in the text. However, more detailed information about current practices in groundwater management can be found in Beck & Goplerud, *op. cit.*; and *in Groundwater Legislation in the ECE region*. Economic Commission for Europe, ECE/WATER/44.

functions are vested in institutions with functional responsibilities for specific water uses, or for discrete economic activities, water planning and management might not be objective. In these cases each concerned party may tend to support projects or allocations of waters according to vested functional interests, without regard to the source of supply or the soundness of investments and projects.

To avoid such problems, many jurisdictions allocate responsibility for policy-making, water allocation, and program and project evaluation to a non-user agency or ministry. A recent publication of the World Bank emphasizes the need to separate policy, planning and regulatory functions from operational functions at each level of government. In so doing the Bank agrees with the United States National Water Commission, which in 1972 was already recommending that "Policy planning and sectorial planning must be separated from functional planning, design and construction, and operation by action agencies".[37] Other important consideration is that, due to the complexities of water management, a number of countries tend to defer to administrative judgement on technical issues: "... findings of fact must be determined in the first instance by the officers charged with the administration of the stream...this finding of fact is final...unless it appears unreasonable or arbitrary..."[38]

Yet, other systems, like Chile, have chosen to limit administrative roles in water related matters. As a result, Bauer argues that many water conflicts have gone to higher courts, whose performance have been quite uneven.[39] At least one working paper has suggested that the administrative set up in Chile be given greater powers, as exemplified by the case of Mendoza in Argentina.[40] In California, it has been suggested that increases in the effectiveness and neutrality of overseeing institutions is one of the conditions leading to the formation of water markets.[41]

In a majority of the American states water planning and allocation are separate from functional, discrete, sectoral activities.[42] A similar pattern is found in Canada and its provinces.[43]

[37] The World Bank, Water Resources Management, Policy Paper, p. 45, The World Bank, Washington, DC., 1993; Water Resources Planning, PB-211921, p. 46, National Water Commission, June 1972, NTIS, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield Va. 22151.

[38] F. Trelease (1974). Quoted by Supreme Court of Nebraska. In: *Water Law, Resource Use and Environmental Protection*. West Publishing Corporation, Minn. USA, p. 97.

[39] C. Bauer (1996). *Water Markets and the Principles of Dublin*. Berkeley, California, September.

[40] J. Briscoe (1996). Water Resources Management in Chile: Lessons from a World Bank Study Tour. Working Paper. The World Bank, January, p. 9.

[41] Haddad, *op. cit.*, p. 390/91.

[42] See Beck & Goplerud, *op. cit.*, Vol. 6, on State Surveys.

Some Middle East countries, like Oman, have created Ministries of Water Resources, in an effort to improve the management of scarce and imperiled water resources. The Ministry is separate from functional, sectoral, water activities, its main function being overall water management.[44] Other Middle East Countries, like Yemen, have followed a similar pattern. A Yemeni authority states that "... responsibility for water management at national level is not to be delegated to a water using sector, but to an independent authority".[45]

The Chinese water law entrusts long-term national water planning to the Ministry of Water Resources. The Ministry was created as a response to the problems created by a fragmented institutional system, where water was managed by sectoral ministries, including, ***inter alia***, Agriculture, Industry, Communication, and Construction. This fragmented use-oriented institutional system resulted in imbalances between supply and demand, water pollution, reduced flood discharging capacities, overdraft of groundwater, intractable and protracted water disputes, and ecological deterioration. Water resources units have also been created at the local level.[46]

In the Netherlands the central government manages the most important surface waters (state-waters) and determines the general policy, while local authorities and public bodies are responsible for regional waters, drinking water supply, sewer systems and municipal waste water treatment. There is a process of transfer of functions to the regional level (police force and planning) as a tool to foster a more integrated approach to water resources management. Therefore, water planning in the Netherlands is a multiparty process which includes the central, regional and local levels of government, both for surface and groundwater and for quantitative and qualitative aspects.[47]

In Mexico, the National Water Commission is the institutional focus for water resources. Guatemala has recently created a Water Resources

[43] Economics and Conservation Branch, Environmental Conservation Service, Environment, Canada, Ottawa., *Major Water Related Legislation and Institutions in Canada* (1993). Prepared for UN Secretariat, Committee on Natural Resources of the ECOSOC, Canada, October.

[44] *Oman'90* (1990). Sultanate of Oman, Ministry of Information, Oman, p. 115.

[45] M. Al-Eryani (1993). Policy and Institutional Aspects of Water Resources Management and Development in Yemen. In: *Water Resources in the Middle East: Policy and Institutional Aspects*, p. 159, Urbana, Illinois, October.

[46] Ke Lidan (1988). *Water Resources Administration in China*, also Water Law of the People's Republic of China, January 21.

[47] *Water Management in the Netherlands: Policy, Measures, Funding*, November 1991. Also B. Barraque (1992). *Water Management in Europe: Beyond the Privatization Debate*. In: *Flux*, January – March, p. 16, Paris, France

Secretariat. The Secretariat has overall responsibilities for water planning and policy making. Brazil is considering the implementation of a National Water Management System. The system would include, ***inter alia***, a National Water Resources Council, responsible for the national water policy, arbitration of conflicts, national water planning, amendments to water legislation and other functions. The main purpose of the process is to find solutions to traditional conflicts and overcome limitations imposed by a system where main water sectors have so far been entrusted to different functional ministries, fragmenting water management. The proposed system strongly relies on the river basin as the appropriate unit for water management.[48]

4.2 Conciliation of Interests and Consultations

Governments are resorting to conciliation mechanisms and preventive strategies in order to manage water related differences and coordinate activities, with a view to achieve the several objectives and satisfy the multiple demands, usually associated with water resources.

The federal government and the states of Australia recently signed an "Intergovernmental Agreement on the Environment" (May 1, 1992). The Agreement intends to provide a cooperative national approach to the environment, a better definition of the role of the respective governments, a reduction in the number of disputes, greater certainty and better environmental protection. The agreement acknowledges the role of state governments in developing national and international policies; the global character of environmental concerns; the need for ecologically sustainable development; the need to conserve and improve biota, soil and water resources; the relationship between efficiency and clear definition of the roles of different levels of government; the need to have explicit accounts of costs and benefits; the relationship between effectiveness and cooperation and the need for accountability.

The agreement determines the responsibilities and interests common to all levels of government and those which are the concern of specific levels of government (the commonwealth, the states, the local governments). It also states procedures for the accommodation of interests.

The German water law provides for the reconciliation of rights and authorizations for the use of water when either the qualities or the quantities of existing supplies do not allow the satisfaction of all uses. Compensations can be paid (Art. 18).

[48] Brazil: *Law Proposal No 2249-A, 1991, and substitutive*, of June 1993.

The water law of China provides for the settlement of disputes among districts through consultations, in adherence with a spirit of mutual understanding and accommodation, solidarity and cooperation. Only after consultation fails are disputes referred to the next level of government. Projects cannot be implemented when disputes have not been settled, unless there is an agreement between the parties, or an approval is granted by the next higher level of government (Art. 35). Consultations are required for projects with intersectoral or interregional impact (Art. 22). There are provisions for the relocation of populations displaced by water projects (Art. 23). Lacking agreement on mediation and consultation, or if they are not successful, the dispute can be referred to adjudication by either the administration or a court. Administrative decisions can be referred to court when a party refuses to accept the administrative decision (Art. 36). The water regime cannot be unilaterally altered pending a decision. Temporary measures can be authorized by the government.

The Canadian water act establishes a system of agreements between the federal government and the provinces for the management of any waters where there are significant national interests. The agreements shall include the responsibilities of the parties; the allocation of costs and the terms of payment; the provision of labor, land and materials to be done by each party; the proportion of any compensations to be paid by each party; the conditions of loans, if any; the responsible authorities; and the general terms and conditions of the program. There are also references to the conditions of the boards, commissions or other bodies to be created under the agreement, where applicable (Art. 7). Water quality management agreements are also provided for (Art. 9). Under special circumstances the federal government can create federal water quality management programes for interjurisdictional waters (Art.11).

4.3 Concern for International Issues

Growing scarcity, competing demands and transfer of externalities occur not only within national boundaries, but also at international level. In addition, in common market areas differing regulations may either curb imports or give a competitive advantage to exports. With the worldwide privatization of water-related services there are worldwide possibilities for advice and provision of services. Therefore, countries are increasingly referring to extraterritorial factors or elements in their national water legislation.

The German water law provides for refusal of pipeline licenses when there are concerns about parts of the pipeline which are constructed or operated outside the area of application of the act (Art. 19). Specific water management schemes shall be drawn up in order to fulfill international obligations (Art. 36b).

The 1989 Water Act of England authorizes the Authority to provide international assistance, training and advice (Sect. 144). The appropriate Minister is granted powers to issue regulations to give effect to any community obligation, and to any international agreement to which the United Kingdom is, for the time being, a party (Sect. 171). The activities of water service companies are affected by the requirements of the Economic Community directives, such as the ones on drinking and bathing waters.

Chinese water legislation anticipates the possibility of conflict between national water law and treaties to which the People's Republic of China is a party. In these cases the provisions of international treaties or agreements prevail (Art. 51).

4.4 Stakeholders Participation

There is a process at work to democratize decision-making on water and water-related activities. It takes place through public hearings, stakeholders involvement in administrative bodies, organization of users' associations and, for general environmental concerns, a greater permissiveness in the rules governing standing to act in either administrative or judicial fora. Thus, stakeholders may participate in policy making, legislative discussion, general water administration, and field level activities. In Mexico, participation includes the establishment of formalities for the transfer of water rights within irrigation units and irrigation districts. The system intends to promote participation, while facilitating water transfers.

Stakeholders and water users may participate in public hearings or consultations intended to discuss policies, programs, projects or legislation. While the mechanism is fundamentally apt to open venues for participation, the fact of inception does not necessarily mean that every stakeholder will necessarily participate.

In fact, some argue that government can encourage empowerment of interested parties by providing access to data, standing in meetings and, generally, providing opportunities for interested parties to express opinions and positions.[49] This suggestion of an active government role in promoting participation seems to be confirmed in practice, by a recent experience in South Africa: In public consultation on forthcoming water legislation industries submitted comprehensive responses, while a number of organizations and individuals also responded in a positive manner. Yet, it was noticed that no comments were submitted by community-based

[49] Haddad, *op. cit.*, p. 389.

organizations, rural communities or village-level water committees. Very few submissions came from NGOs.[50]

In Mendoza, Argentina, representatives of water users contribute to the Tribunal and the Council of the Department of Irrigation through important functions such as work plans, budgets, tariffs and appeals. Representatives of agricultural users sit at the Directive Council of the Ecuatorian Institute of Water Resources. The Spanish water law of 1985 provides for users participation in basin authorities and, through them, in the National Water Resources Council. Representatives of users, local communities and the central administration take part in the river basin committees of France.[51]

Water users also participate at field level. Both the European and the American experience coincide in that the most effective institutional manners of users involvement are the ones taking place through some sort of public organization. They assure economies of scale and mandatory dispute resolution processes, essential where a large number of diverse water users are involved.[52]

In a number of places where public participation is relevant it is associated with institutional environments where water is an important part of national policies and public water-related organizations have an established and acknowledged role. In addition, in some countries, such as Chile, the United States, the Western Provinces of Argentina, France and South Korea, it has been possible to identify present or historical subsidies to water development and use.

4.5 Information

To be effective, a system of participatory planning and management of water resources must be able to provide timely information on what kind and quality of water is available where and who is using the water and for what purposes. Therefore, effective water management systems require adequate official surveys, inventories and cadastres of water sources and water supplies, as well as up-to-date registers and records of water uses and

[50] South Africa: Report to the Minister of Water Affairs and Forestry on the Water Law Review Panel: *Fundamental Principles and Objectives for a New Water Law in South Africa*, 1995, pp. 3-4.

[51] M. Solanes (1993). *Descentralization of Water Management: The Case of Water Users' Associations*. discussion paper prepared for the 14th World Bank Agricultural Symposium. Agriculture in Liberalizing Economies: Changing Roles for Governments. New York, p. 4.

[52] F. Hellinga (1960). *Local Administration of Water Control in a Number of European Countries*. H. Veenman & N.V. Zonen Wageningen. The Netherlands, p.13, 38; also J. Davidson. Distribution and Storage Organizations. *In: Water and Water Rights*. Beck & Goplerud, Vol. 3, p. 469.

discharges into waters, water rights, and beneficiaries of such rights with their respective water allocations.

The Water Law of England of 1989 provides for registers with information on water quality objectives, applications, consents, certifications, water samples, etc. The registers are available for inspection by the public, free of charge. The members of the public can obtain copies of entries for a reasonable fee (Sect. 117). English legislation also requires that the Authority and every water user keep records of underground works, maps of water mains and sewers, and that this information be made available to the public free of charge (Sect. 165). The Water Resources Act of 1991 creates registers of abstraction and impoundment licenses, pollution control and discharge works; and also mapping systems of freshwater limits, main rivers and waterworks (Sects. 191 to 195).

The objective of information is to allow appropriate decisions by policy makers, administrators, managers, users and the public. Therefore, legislation requiring the submission of information by managers to policy makers, users and the public at large, and by users and the public to managers is becoming part of modern water law. The English Water Resources Act of 1991 requires the National Rivers Authority to provide information to policy makers and undertakers and also to the public (Sects. 196-197). The Authority does, in turn have powers to obtain information about surface and groundwater. Information is timely and adequate, and there are provisions on the kind of information to be collected and the manner in which the information must be organized (Sects. 197-203). The English system is complemented by norms on confidential and reserved information and penalties for false statements (205-206). Public participation is sought through a system of enquiries (Sects. 213-215).

The Water Act of Canada sets up public information programes under which the public is informed about water conservation, development and utilization (Art. 27). The Act also requires the Minister responsible for water to inform the Parliament on the operations carried out under the Act each fiscal year (Art. 36).

4.6 The Lowest Appropriate Level

In Germany water plans are produced by the Lander, according to federal directives (Art. 36). Water management schemes, to be produced by the Lander, considers the role of water within ecosystems, the rational use of groundwater and the requirements for various uses (Art. 36b).

In at least one country (New Zealand) the river basin has become not only the unit for water planning and management, but also the main focus of Regional Councils having the greatest responsibilities for the implementation of sustainable management. They are responsible for water resource development, water and soil conservation, geothermal resources, pollution control and regional hazard mitigation.[53]

Levels lower than provinces, regions or states have been the focus of particular water related services, like drinking water and sanitation. However, in countries such as Mexico vesting of power for these systems in municipal governments has drawn severe criticism: It resulted in a fragmented water industry, unable to take advantage of economies of scale; local governments were afraid of political reactions to raising charges; and financing, management and other skills were in short supply. This prompted a major change in the water industry.[54]

Changes in the European context include the reorganization of water management in England, separating water services from planning, control and regulation. Water services are provided by private limited companies, while water management and control are reserved for public organizations like the National Rivers Authority and the Office of Water Services.[55]

[53] O. Furuseth & C. Cocklin (1995). An Institutional Framework for Sustainable Resource Management: The New Zealand Model. *Natural Resources Journal*. University of New Mexico School of Law, 35(2):243-272. Spring.

[54] C. Casasus (1994). Privatizing the Mexican Water Industry. *Journal of the American Water Works Association*. March.

[55] Barraque, *op. cit.*, p. 7: Laws of England (4th Edn) Supp. Vol. 49, para 201-218.

Chapter 14

Droughts, Crisis Management and Water Rights

An International Perspective

Ariel Dinar
The World Bank

1. INTRODUCTION

When searching for alternative institutional arrangements to cope with drought, it is important to realise that drought is only an exacerbation of resource issues which are often already present during normal, non-drought periods. Conflicts within and between sectors, states, and countries, which already exist, are certain to be intensified during drought.

Drought is one of the most devastating phenomena that mankind witnesses, occurring throughout the world. A drought may shock the water sector and induce behavioral changes for both private and public decision makers (Wilhite & Glantz, 1985). As a global phenomena, drought has been experienced in many countries, and lessons have been accumulated. The ability to adapt experiences and drought mitigation efforts from one region, or country, to another depends on ones ability to understand the mechanisms involved in private and public decision-makers' responses, and the existing legal and institutional frameworks that may allow or prohibit transfer of responses from one place or situation to another (Wilhite, 1991).

Drought handling in the world can be divided into two main approaches: (1) planning for drought, and (2) responding to drought—crisis management. There are two basic perspectives which countries might take in the process of planning for drought. One perspective is to consider drought as a random natural disaster. Based upon this approach, planning tends to be ad hoc, with a focus on implementation of assistance measures, such as subsidies and food aid, only when drought has created a noticeable problem for all or part of the population. Similarly, weather-dependent producers may fail to take precautionary measures (e.g., grain stocking, increasing water efficiency or diversifying sources of income) that could buffer their losses when drought recurs. As long as weather conditions are favorable, governments are often apathetic and reluctant to develop long-term drought mitigation plans (Wilhite, 1993).

An alternative perspective is to treat drought as a recurring phenomenon with likely effects on the population and the economy. This suggests a more proactive approach to drought management based upon assessment of the potential for drought to occur and estimation of its duration and severity. Such a system entails defining strategies and policies to implement both before and during a drought.

In general, a crisis management approach to drought long dominated policy making in developed and developing countries alike (Wilhite, 1993). Perhaps because of the devastating impacts of drought in the 1970s and 1980s, an increasing number of countries are pursuing a more proactive approach that emphasizes the principles of risk management and sustainable development (Wilhite, 1993).

Legislative responses to drought management are also part of crisis management. Among legal measures one may include preventive measures: water regulating, water rationing and reallocating measures; measures regulating the output of water-related activities and distribution; and measures regulating the human-environmental relationship (Solanes, 1986).

The comprehensive drought/hazard management and crisis response framework for a ground water aquifer (in chapter 6), suggested by Kahane (1994), includes:

- Determination and maintenance of pumping reserves
- Purchase of water from adjacent water supply systems
- Identification of less costly water use alternatives

The drought crisis response measures include preventive and corrective measures.

The preventive measures are:

- Optimum disposal means
- Suitable location of industries
- Pretreatment of industrial wastes
- On-line groundwater quality monitoring

The corrective measures are:

- Identification of the pollutant and pollution source
- Dissemination of information on the hazard situation
- Provision of alternative supply source
- Mitigation of the damaged aquifer

These and other means to cope with drought/crisis situations will be reviewed in this paper based on experiences from different countries.

2. VARIOUS INSTITUTIONAL-ECONOMIC INSTRUMENTS

2.1 Determining an Equitable and Stable Allocation of Shared Groundwater

Prior to evaluating institutional arrangement for managing joint groundwater under drought crisis situation is the question of how the water rights are determined. Moore (1994) suggests and compares a set of factors used for determining groundwater allocation (factors suggested by the International Law Committee), with application to the case of Israel and the Palestinian Sovereign Authority (PSA). Table 1 presents the factors and the resulting allocations.

Table 1. Allocation Schemes for the Case of Shared Groundwater Between Israel and Palestine Authority

Allocation Factor	Israel Share (Million m^3/year)	PSA Share (Million m^3/year)
Recharge area: a measure of the inflow to the aquifer	25	475
Storage area: proxy to the amount of water stored in porous aquifer	398	102
Domestic needs: for all uses	331	169
Industrial needs:	440	60
Agricultural needs: using present structures and technologies	428	72
Existing utilization: given existing institutions and access	445	45

Source: Modified from Moore, 1994.

Although Moore (1994) examines the allocations on an equitable basis, it is recognized that the dynamic nature of the factors used necessitates a flexible allocation scheme. For example, changing water availability conditions, such as in the case of drought, may shift equitable outcomes measures significantly. To account for the stochastic nature of the water supply (e.g., drought), and the dynamic nature of the demand for water, Kilgour and Dinar (1995) developed an approach[1] for determining stable allocations of water among riparians. They show that a seasonal adjustable allocation scheme that reflects total flow volume results in improved total welfare, relative to the best fixed scheme.

[1] Although their approach was developed for river geography, it can easily to be modified to account for the case of groundwater aquifers.

2.2 Optioning Qater Rights

Inter-sector transfer of water rights is one of several market-based crisis-management options to deal with drought. As Michelson and Young (1993) suggest, the concept of "dry year options" proposes temporary transfer of irrigation water to provide secure water supplies to nonagricultural users during droughts. They use as an example a negotiated deal between the Metropolitan Water District (MWD) of Southern California and farmers in the Palo Verde Irrigation District of Southern California, which did not materialized because the MWD's offer to the farmers was too low.

In addition to economic justification, necessary conditions for drought water right options include: (1) a sure enough water supply source, (2) definable property rights, (3) water transfer mechanisms, both institutional and physical, (4) full information on water conditions, (5) agreed upon definitions and operational rules for management of water transfers, at relatively low transaction costs.

In a simulation of drought water rights option in Fort Collins, Colorado, between the urban and the irrigation sector it was found by Michelson and Young (1993) that the feasibility of this arrangement depends heavily on drought probability and on the level of the conveyance cost.

2.3 Groundwater Institutions and Legislation for Drought in India

A specific policy and institutional drought-proofing responses came in the wake of the 1979 and 1987 droughts – two of the most severe droughts in the recent history of India. Not surprisingly, all these responses were in the realm of groundwater – the resource most likely to be under heavy pressure during droughts. In the immediate aftermath of the 1979 drought, the then Ministry of Agriculture and Irrigation mooted the idea of establishing "groundwater sanctuaries" where groundwater would be used only during very dry years, and even then only when other sources of water are completely exhausted (Saleth, 1996).

From the legal and institutional viewpoints, the Union Ministry of Water Resources has also formulated the Model Groundwater (Control and Regulation) Bill of 1992 to regulate and monitor groundwater withdrawal in areas drought-prone and water scarce areas. The basic mechanism proposed under the Bill is the establishment of a Groundwater Authority that will administer a "well licensing system." Since the installation of water meters is also stipulated, there seems to be a scope for the introduction of some sort of water quota system. States like Gujarat, Tamil Nadu and Maharashtra have also enacted groundwater legislations applicable in special areas, particularly with a view to protect water quality and drinking water supply. For instance, the Gujarat Act that limits well depth to 45 meters is applicable only in and around the city of Ahmedabad. Similar is the case with the Tamil Nadu Act as it is applicable only in Chennai (formerly Madras) and its environs known as perpetually vulnerabile to sea water intrusion and water quality deterioration (Saleth, 1996).

Apart from the formal and macro level responses, to droughts in water-short and ecologically fragile parts of India like Rajasthan, many states in the Deccan plateau and coastal regions, various kinds of informal, local level and people-managed institutional mechanisms for dealing with water scarcity during drought years exist. Such mechanisms are essentially related to water use codes and water sharing conventions. Two notable cases of such grassroots level informal approaches which deserve mention here are the *Pani Panchayat* (Water Council) system and the Ralegaon Siddi village – both in Maharashtra and both involving community participation in water harvesting, water conservation and water sharing (Saleth, 1996).

2.4 Drought Banks/Temporal Transfers of Scarce Water

During drought, the value of irrigation water is higher than in water scarce years. For example, the share of irrigated agriculture output in Victoria, Australia, rose from 23% in 1980/81 and 1981/82 to 30% of total agricultural production in 1982/83 (Alaouze, 1991). Furthermore, projected "farm gate" price increase due to drought, given the 1991 drought assumptions in California, were between 1.8% and 12.8% for a variety of crops (UCAIC, 1991).

For that reason, temporary transfer of water rights might mitigate negative drought impacts. In fact, temporary transfer of water rights was permitted in New South Wales, Australia, during the droughts of 1966/67 and in 1972/73, and in Victoria during the drought of 1966/67 and in a restricted version during the period 1982/83 to 1986/87.[2] As mentioned elsewhere in this paper, water transfers in California took place in 1991 in response to the crisis situation resulted from the prolonged drought of 1987-1992. An estimate of the statewide benefits from the 1991 water transfers in California is presented in Table 2.[3]

[2] In both Victoria and New South Wales water transfers are only permitted out of irrigation areas affected by salinity and water logging.

[3] It should be noted that there were indirect third party externalities to the water transfer in California (See Howitt, 1994).

2.5 Groundwater Recharge During "Wet" Years

Kern County in California is an agricultural region that relies very heavily on ground water. The Kern groundwater aquifer is part of the Tulare Basin system which comprises 7,900 square miles. The degree of reliance on groundwater (35-55% of total applied water for irrigation in 1994) depends on the availability of surface water supply, which in turn is affected by drought conditions in certain years. In the last 20 years, average water level in the Kern County portion of the aquifer has changed dramatically, with a deep decline during drought years (1977-8, 1982-3, 1987-92). Water for irrigation and other consumption uses is provided by several water agencies including the Kern County Water Agency (KCWA) that served nearly 910,000 acres in 1975 and 814,000 acres in 1986.

In 1986 the California Department of Water Resources (DWR) had proposed constructing and operating the first stage of the Kern Fan Element (KFE), which is part of the Kern Water Bank (KWB). The KWB is a conjunctive use groundwater program that will augment State Water Project supply by storing water during wet years in the Kern County groundwater basin, and may be pumped and recharged into the system in dry years.

Table 2. Statewide Net Benefits from the 1991 Water Transfer in California (US$ million)

Exporting regions		
Income lost from crops		76.02
Income gained from water sales		63.27
Exporting regions income gains	-12.75	
Importing regions		
Income gained in agriculture		45.40
Urban consumer surplus gain		58.77
Benefits to importing regions	104.17	
Net benefits		
Agricultural benefits		(45.40-12.75=) 32.65
		58.77
Value of surplus water		14.40
Total net benefit	**105.82**	

Source: Adapted from Howitt (1994)

3. LESSONS FROM DROUGHT EVENTS IN VARIOUS COUNTRIES

3.1 Drought Management Practices in India

The drought response system in India has changed from famine relief (during the pre-independence era), to scarcity relief (until the mid-1960s), and finally to drought relief (until mid-1970s), to drought management (at present). Drought management practices include both planning and crisis management components: (1) meteorological monitoring, (2) hydrological monitoring, (3) agricultural monitoring, (4) early warning, (5) food security system, (6) employment project, (7) contingency crop plan, (8) social security schemes, (9) infrastructure arrangements, (10) water conservation measures, (11) drinking water supply, and (12) preservation of assets and infrastructure. The combination of both planning and crisis management proved to be successful, given the high frequency of drought events in India (Subbiah, 1993).

3.2 Assistance Measures Under the Disaster Drought Assistance Scheme in South Africa

A disaster drought in the Republic of South Africa is declared when farming conditions, consisting of availability of natural and cultivable pastures, fodder production and water supplies in a specific area, have deteriorated to the extent that natural agricultural resources and livestock are seriously affected. At that stage, a disaster drought assistance scheme becomes available to needy farmers, subject to availability of state funds. It comprises a set of monetary incentives/compensation such as: (1) rebate on transport of stock feed, (2) a state contribution to the maintenance of a nucleus herd, (3) an incentive on stock reduction, and (4) a grazing lease scheme (Bruwer, 1993).

It is believed (Bruwer, 1993) that a disaster drought aid scheme based on a well-conceived drought policy will prevent continuous degradation of resources and will reduce of political pressure on the government.

3.3 State and Federal Level Institutional Changes During California's 1987-1992 Drought

There were several institutional changes at the Federal, State and municipal levels in California during the 1987-1992 drought worth mentioning (Zilberman et al., 1997). The major institutional changes that have occurred are the creation of the California Drought Water Bank (see above) and the enactment of the Federal (Bradley-Miller Law 102-575, Title 34 Central Valley Project Improvement Act, 1992). This legislation requires a minimum of 800,000 acre-feet (AF) [4]of agricultural water to be set aside for in-stream use, and the inclusion, by law, of conservation measures into water development projects by the State of California (Assembly Bill 3616; Added Stats to Assembly Bill 1160). The bills would require the California Department of Water Resources (DWR) to take all possible actions to achieve water conservation, as defined in the bills.

The Water Bank provided a means for transferring water from those districts with water surpluses to those with shortfalls. In 1991 the seller price was $125/AF and the buyer price was $175/AF at the Delta; 820,805 AF were purchased and 435,000 AF were sold. Metropolitan water districts purchased 370,000 AF (85% of the total) and the remaining 82,000 (15%) went to agriculture. The remainder (unsold) was used for environmental purposes. These included amendment of the water flow in the rivers for fish and wildlife. The massive sale of water to the Bank resulted in fallowing of 166,000 acres. In 1992 the Bank purchased 177,595 AF, allowing transfer of water between water right holders. (For analysis of state-wide benefits from the 1991 water transfer, see Table 2).

In response and in continuation to Assembly Bill 3616 (Efficient Water Management Practices For Agricultural Water Suppliers), and the stats to Assembly Bill 1160 (Agricultural Water Conservation and Management Act of 1992), a memorandum of Understanding regarding urban water conservation in California (U.S. Army Corps of Engineers, 1993) was signed in late 1991. In addition, a memorandum of understanding regarding agricultural water management for water suppliers in California was being prepared. These actions, both legislative and voluntary reflect behavioral change on part of all water related agencies and individual users.

3.4 Impact of Drought on Various Water Right Holders During California's 1987-1992 Drought

Deliveries of water to irrigation districts declined at an increasing rate as the drought progressed (Zilberman et al., 1997). Annual Central Valley Project (CVP) water deliveries to water districts responding to the survey which had junior water rights were over 2 million AF annually from 1987 through 1989, but declined to 1.66 million AF in 1990 and to 1.03 million AF in 1991.

[4] 1 acre-foot = 1235 m^3.

Junior water right holders[5] were the first affected by the drought. Federal and State project water allocations fell very rapidly compared to non-project water (that is considered as senior right water). For example, Westlands Water District as a CVP contract holder, received its average entitlement of approximately 1.2 million AF in 1987, 1988, and 1989, but only received 0.92 million AF in 1990 and 0.34 million AF in 1991. Water districts holding senior rights (such as riparian and appropriative rights) also experienced cutbacks in water deliveries, but nowhere near the degree experienced by the junior water rights holders. The Imperial WD, as a counter example, has appropriative rights to Colorado River water and thus maintained a stable level of approximately 5 million AF throughout the period of the drought.

Looking at a sample of water districts serviced by the CVP, there was an almost 80% increase in the volume of ground water pumped between 1989 and 1990, and a 9% increase in the number of wells used between 1989 and 1991. Junior water rights districts significantly increased pumping in 1989, 1990 and 1991, adding a significant number of wells only in 1991.

4. LESSONS FROM GROUND AND SURFACE WATER MANAGEMENT INSTITUTIONS IN VARIOUS COUNTRIES

4.1 Managing Groundwater Basins in Southern California

The institutional arrangements for managing groundwater in seven river basins in Southern California were compared (Blomquist, 1995), using the following criteria: compliance, effectiveness, administrative efficiency, allocative efficiency, equity and adaptability.

In the San Gabriel River watershed, groundwater problems were addressed through adjudication and limitation of rights to local water suppliers, creation of districts to pay for supplemental water supplies from outside the basin, and imposition of a pump tax to purchase imported water for basin replenishment. The basin safe yield is adjusted each year to the water conditions, and pumping rights are adjusted in accordance, as a share of the safe yield. Parties may exchange their assigned, fixed pumping rights through sale or lease. A water master was appointed to impose regulations

[5] Junior/senior water right holder are users holding low/high priority rights to water.

and advise the policy-making body. The regulatory bodies stabilize basin water levels by purchasing imported and reclaimed water for artificial replenishment, using proceeds from the pump tax.

In the Santa Ana River watershed, some pumpers are assigned fixed and transferable rights – defined as the appropriative pool. The agricultural pumpers, for example, do not have individually assigned rights, but instead the agricultural pool has an aggregate fixed pumping right. Non-agricultural pumpers have individual fixed, but non-transferable, assigned rights. The parties also have storage rights and the right to transfer the stored water.

The cost of administering the basin water ranged in 1985 between \$0.0028 and \$0.12 per cubic meter of water. The total cost of using water in the seven Southern California basins ranged from \$0.15 and \$0.21 per cubic meter. It was estimated that the efficient management institutions saved the difference between \$0.61 and the total cost reported earlier per cubic meter of water. However, the adjudication of pumpers rights during drought and crisis situations have caused 500 small pumpers to cease pumping in Orange County in the Santa Ana Basin. Although the social cost associated with such consequence was not estimated, it is a substantial one.

4.2 The Interstate Commission on the Potomac River Basin

The Potomac River Basin crosses jurisdiction of: the District of Columbia, Maryland, Pennsylvania, Virginia and West Virginia. In 1982, an agreement was reached that implements operating rules for the Potomac water. One main feature of these operating rules is a two tier rule system. A dormant interstate commission is in place and under regular circumstances monitors the water quantity and quality of the river, develops contingency plans and improves existing decision-making models. Water users (water supply companies) operate according to a certain set of rules without any regulation by the commission. As the flow of the river reaches a certain low level, a crisis management tier enters into effect. Under crisis conditions, the commission implements different rules and regulates their existence. It is estimated that the joint crisis management of the Potomac River Basin has delayed investment in storage necessary for water supply of the growing population in the Washington metropolitan area by 45 years (Steiner, 1996).

5. LESSONS FROM INTERSTATE/INTERNATIONAL AGREEMENTS

5.1 The Ganges Treaty of 1996 between Bangladesh and India

The headwaters of the Ganges and its tributaries lie primarily in Nepal and India, where snowmelt and rainfall are the main source of the river that flows to Bangladesh and to the Bay of Bengal. A barrage at Farakka, about 17 kilometers from the border, that was built by India, diverts 40,000 cusecs[6] out of a dry season average flow of 50,000 cusecs from the Ganges into the Bhagirathi-Hooghly tributary, to provide silt-free flow into Calcutta Bay, which would improve navigability for the city's port during dry months and keep saltwater from the city's water supply.

In March 1972, the governments of India and Bangladesh agreed to establish the Indo-Bangladesh Joint Rivers Commission, "to develop the waters of the rivers common to the two countries on a cooperative basis." The question of the Ganges, however, was specifically excluded, and was exclusively handled by the two prime ministers.

On December 12, 1996, the two sides signed a 50 year treaty between the Government of the Republic of India and the Government of the People's Republic of Bangladesh on sharing of the Ganges waters at Farakka. The Treaty sets a schedule for the dry months, January 1 – May 31, which allocates the flow at Farakka according to the schedule in Table 3.

Table 3. The Ganga Water Sharing Treaty of 1996

Availability at Farakka (Cusecs)	India's share	Bangladesh's share
< 70,000	50%	50%
70,000-75,000	balance of flow	35,000 cusecs
> 75,000	40,000 cusecs	balance of flow

Source: Modified from Salman, 1997.

The treaty addresses the dry season of the Ganges regime. The lowest tier is further subject to the condition that the two countries each shall receive a guaranteed 35,000 cusecs in alternate three 10-days periods during the March 1 to May 10 period. Further to that the treaty also states that in the event that the flows fall below 50,000 cusecs in any 10-day period, the two

[6] Since all negotiations were in English units, that is what is reported here. 1 Cusec = cubic feet per second = 0.0283 cubic meters per second.

governments will enter into immediate consultation to make adjustments on an emergency basis.

Analysis in Rogers and Harshadeep (1997) suggests that the two countries will need to negotiate in 8% of the 10-day periods, on the average, between March 1 and May 31. However, institutions for such negotiations have not been set in the treaty, so that it still needs to be seen how crises situations will be handled in the future between the two governments.

5.2 US-Mexico Shared Aquifers and the Salinity Crisis of 1961-73

The complications of groundwater are exemplified in the border region between the United States and Mexico where, despite the presence of an active supra-legal authority since 1944, groundwater issues have yet not been resolved. Mentioned as vital in the 1944 Treaty, and again in 1973, the difficulties in quantifying the ambiguities inherent in groundwater regimes has eluded legal and management experts ever since.

The border region between the United States and Mexico has fostered its share of surface-water conflict, from the Colorado to the Rio Grande/Rio Bravo. It has also been a model for peaceful conflict resolution, notably the work of the International Boundary and Water Commission (IBWC), the supra-legal body established to manage shared water resources as a consequence of the 1944 US-Mexico Water Treaty. Yet the difficulties encountered in managing shared surface-water pale in comparison to trying to allocate groundwater resources – each aquifer system is generally so poorly understood that years of study may be necessary before one even knows what the bargaining parameters are.

While the 1944 Treaty mentions the importance of resolving the allocations of groundwater between the two states, it does not do so. In fact, shared surface-water resources were the focus of the IBWC until the early 1960s, when a US irrigation district began draining saline groundwater into the Colorado River and deducting the quantity of saline water from Mexico's share of freshwater. In response, Mexico began a "crash program" of groundwater development in the border region to make up the losses.

Ten years of negotiations resulted in a 1973 addendum to the 1944 Treaty – Minute 242 of the IBWC, which limited groundwater withdrawals on both sides of the border, and committed each nation to consult the other regarding any future groundwater development. Allocations were not quantified and negotiations to do so have continued ever since.

A 1979 agreement grants the IBWC comprehensive authority to resolve conflicts arising from border water pollution. It has been suggested that this authority may be extended to encompass groundwater overpumping.

It is testimony to the complexity of international groundwater regimes that despite the presence of an active authority for cooperative management, and despite relatively warm political relations and few riparians, negotiations have continued since 1973 without resolution (Dinar et al., 1997).

Table 4. Types of crisis/hazard-related policies

Policy	Description
Action-forcing policies	Adopted by higher level jurisdictions and intended to force loss-reducing activities by lower units and jurisdictions.
Disaster recovery policies	Intended to assist community and state recovery from the damages sustained as a result of a natural crisis.
Technology development policy	Focused on development of new knowledge and technology to support hazard/crisis mitigating situations.
Regulatory policies	Regulate the decisions and behaviors of private parties and governmental entities to reduce losses from crisis/hazard situations.
Investment and cost allocation policies	Specify conditions governing acquisition and allocation of resources to sustain activities intended to cope with crisis situations
Direct action policies	Authorize direct governmental action to implement a policy, such as physical construction or removal of structures.

Source: Modified from Petak and Atkinson (1982, reported in Kenney, 1994)

5.3 The Colorado River Drought Prospect

The Colorado River institutions to deal with drought among five riparian states are not confined solely to the issue of groundwater or drought, but offer a potential to improve the ability of the riparians to cope with a variety of resource crisis/hazard conditions. Based on Petak and Atkinson (1982, reported in Kenney, 1994) there are several types of crisis/hazard-related policies identified during the drought of 1991 in the Colorado River region (Table 4).

6. CONCLUSIONS

This paper, drawing on international experience, focuses on drought crisis management and water priority rights. Cases presented include instruments that have been applied to drought and other water crisis situations at local, national and international levels, lessons from drought events in various countries, and lessons from ground and surface water institutions in various countries.

One overarching conclusion from the experiences reviewed in this paper is that existence of crisis management rules with clear parameters for what is crisis, what are the institutions for the crisis management implementation plan, and how crisis will be handled, are a prerequisite to a successful handling of water-crisis situations.

Several crisis management arrangements that were discussed in the paper assume that water rights have already been assigned. Therefore, the question of how water rights are allocated is not considered here. However, as in some cases (see Moore, 1994), water rights must be assigned prior to the implementation of any drought crisis management plan.

Some of the arrangements that have been successfully implemented at crisis times are water rights optioning, water transfer and recharge. However, one must take into account the transaction costs associated with these arrangements. For example, in the case of the drought water bank in California, the direct transaction cost was $0.04 out of a cost of $0.14 per cubic meter, and in the case of the Santa Ana River Basin the administrative cost ranges from $0.0028 and $0.12 per cubic meter.

It may be noted in many cases reviewed here that the flexibility to transform between the crisis/no-crisis situation is a crucial one. Not only it is important to agree upon crisis definition, but to a greater extent the identification of institutions that allow a smooth transformation and operation of the crisis regime may support the sustainability of such operation. For example, the dry-season agreement between India and Bangladesh does not provide adequate institutions to carry out the consultation and execution of the treaty. It still remains to be seen how it will operate in crisis situation.

REFERENCES

Alaouze. C. M. (1991). Intertemporal Water Transfer and Drought. *Australian Economic Papers* 30:114-127.

Blomquist, W. (1995). Institutions for Managing Groundwater Basins in Southern California. In: Dinar, A. & E. T. Loehman (Editors), *Water Quantity/Quality Management and Conflict Resolution*, Praeger, Westport, Connecticut, 43-59.

Bruwer, J. J. (1993). Drought Policy in the Republic of South Africa. In: Wilhite, D. A. (Editor), *Drought Assessment, Management, and Planning: Theory and Case Studies*. Kluwer Academic Publishers, Boston. Chapter 11.

Dinar, A., Kaufman, E., Oppenheimer, J. & Wolf, A. (1997). *Transboundary Fresh Water Disputes: Conflict Resolution Through An Integrated Approach*. A proposal Submitted to the Research Committee of the World Bank.

Howitt. R. E. (1994). Empirical Analysis of Water Market Institutions: The 1991 California Water Market. *Resources and Energy Economics* 16:357-371.

Kenney. D. (1994). Institutional Options for the Colorado River: A Drought Prospect. In: Young, R. A. (Compiler), *Coping with Severe, Sustained Drought in the Southwestern United States*. Utah Water Research Laboratory. Chapter 5.

Kilgour, D. M. & Dinar, A. (1995). *Are Stable Agreements for Sharing International River Water Now Possible?* Policy Research Working paper No. 1474. World Bank, Washington, DC.

Michelson, A.M., & Young, R.A. (1993). Optioning Agricultural Water Rights for Urban Water Supplies During Drought. *American Journal of Agricultural Economics*, 75:1010-1020.

Moore, J. W. (1994). Defining National Property Rights to a Common Property Resource: The Case of the West Bank Aquifers. *Resource and Energy Economics*, 16:373-390.

Petak, W.J. & Atkisson, A.A. (1982). *Natural Hazard Risk Assessment and Public Policy*. New York, Springer-Verlag.

Rogers, P. & Harshadeep, N. (1997). *The Farakka Ganges Water Sharing Treaty: Some Implications for India and Bangladesh*. Mimeo, ASTEN, The World Bank, Washington DC.

Saleth, M.R. (1996). *Water Institutions in India: A review of Issues and Reform Options*. Institute of Economic Growth, University Enclave, Delhi, India.

Salman, S. (1997). *The Ganges River Treaty of 1996: A Comparative Analysis*. Mimeo, Legal Department, The World Bank, Washington DC.

Solanes, M.R. (1986). Legislative Approaches to Drought Management. *Natural Resources Forum*, 10(4):373-378.

Steiner, R.C., *Cooperative Water Resources Management in the Potomac River*. Personal Communications, Interstate Commission on the Potomac River Basin, 6110 Executive Boulivard Suite 300, Rocknile, MD, 20859-3903.

Subbiah, A. R. (1993). Indian Drought Management: From Vulnerability to Resillience. In: D.A. Wilhite (ed.), *Drought Assessment, Management, and Planning: Theory and Case Studies*. Kluwer Academic Publishers, Boston.

UCAIC (University of California Agricultural Issues Center), (1991). *Water in California: A Resilient System under Pressure*. University of California, Davis, CA., Position Paper, 91(1):10pp.

US Army Corps of Engineers, Institute for Water Resources, (1993). *Lessons Learned from the California Drought (1987-1992)*. National Study of Water Management During Drought, IWR Report 93-NDS-5.

Wilhite, D.A., & Glantz, M.H. (1985). Understanding the Drought Phenomenon: The Role of Definitions. *Water International*, 10:111-20.

Wilhite, D.A. (1991). Drought Planning: A Process for State Government. *Water Resources Bulletin*, 27(1):29-38.

Wilhite, D.A. (1993). "The Enigma of Drought." In: D. Wilhite (ed.). *Drought Assessment, Management, and Planning: Theory and Case Studies*. Boston, Massachusetts, Kluwer Academic Publishers.

Zilberman, D., Dinar, A., MacDougall, N., Khanna, M., Brown, C. & Castillo, F. (1997). *How California Responded to the Continued Drought of 1987-1992*. United States Department of Agriculture, ERS Staff Paper.

IV

MONITORING, MODELING AND DATA COMPILATION AS PREREQUISITES FOR GROUNDWATER MANAGEMENT

Chapter 15

From Monitoring and Modeling to Decision Support Frameworks for the Joint Management of Shared Aquifers

Jac A.M. van der Gun
TNO Institute of Applied Geoscience, Delft, The Netherlands

1. INTRODUCTION

Managing ground water resources in a semi-arid environment with high demands being made on water is a complex and difficult task. More than in humid climates, semi-arid environments are characterized by restrictive measures (in particular by demand management), because the mean rates of ground water renewal are low, and sooner or later they tend to be exceeded by the steadily growing demands on ground water. Measures restricting individual freedom and aspirations are unpopular and can only be adopted and implemented successfully if the persons involved at the different levels - politicians, administrative officials, technical water resources management staff, water users and other stakeholders - have compatible and coherent attitudes on the issues, priorities, constraints and preferred actions in ground water resources management. The situation becomes even more complicated if the aquifers concerned are shared by different nationalities, as in the case of the mountain aquifer shared by the Israelis and the Palestinians.

Conflicts of interest - between the present and the future (water use versus water conservation), the individual and the collective, mutually competing water users, different water use sectors, regions and nationalities - are notable examples. Appropriate legislation, government policies and, if applicable, international agreements provide the boundary conditions for dealing with these conflicts of interest, and contribute to the consistency and acceptance of the measures decided upon. Institutional responsibilities and mandates have to be defined for the different tasks in water resources management, so that action may be taken.

But these steps are not enough. Even if all these requirements were to be fulfilled, it is still very difficult to get ground water resources management to move ahead. This is in part because this form of shared management is so complex: it spans the entire field from broad government policy objectives to very specific interventions at specific locations, and deals with processes that extend over large ranges in scale in space and time. A multitude of opinions, data, interests and preferences may appear and possibly lead to confusion and stagnation, unless they are structured as inputs into a process that converges into consistent plans and decisions. A few technical tools and methodologies that may be helpful in this respect will be reviewed below: round water monitoring, modeling, and decision support frameworks. Selected examples will be used as illustrations.

2. GROUND WATER MONITORING AND MODELING

2.1 Monitoring

Adequate monitoring of ground water levels and quality - state variables of a ground water system - seem straightforward and simple at first, but those with experience know better. Apart from measurement and operational problems, the following aspects invariably call for attention: do we know exactly what we are measuring? Are we sure that we are measuring what we think we are measuring? How are the monitored variables to be sampled satisfactory in time and space? And how is the resulting data to be interpreted?

To understand the differences in these ground water state variables, additional information is needed, not only on the 'fixed' properties of the ground water system considered, but also on the time-depended variables that cause the variation in time of ground water levels and quality. These 'explaining variables', such as ground water abstraction, diffuse and point-source pollution of ground water, and variables related to ground water recharge or discharge (rainfall, base flow, etc.) constitute a second category of variables to be monitored.

It may seem hard to believe that all over the world enormous amounts of monitoring data have never been inspected and interpreted: they have just been stored in 'data graveyards'. Standard processing, inspection and interpretation routines, in particular, are therefore needed to ensure the effective use of the data.

2.2 Modeling

The use of models may help in the interpretation of the observed variations in time and/or space of ground water levels and quality. By grasping cause-effect relationships they are potentially capable of making predictions on future conditions under alternative sets of assumed boundary parameters. This makes the use of such models an advantageous factor in water sources planning. Depending on the objective in mind and the available data, expertise and time, different categories of models can be considered. A brief description of the three model categories of transfer/noise models, balance models, and numerical simulation models is given below.

2.3 Transfer/noise Models

The transfer/noise models (Van Geer and Defize, 1987) together make for a convenient tool for use in time series analyses. These models 'decompose' the time series considered to a number of deterministic components and a random stochastic residual series (white noise). The general modeling principle can be seen in Figure 1.

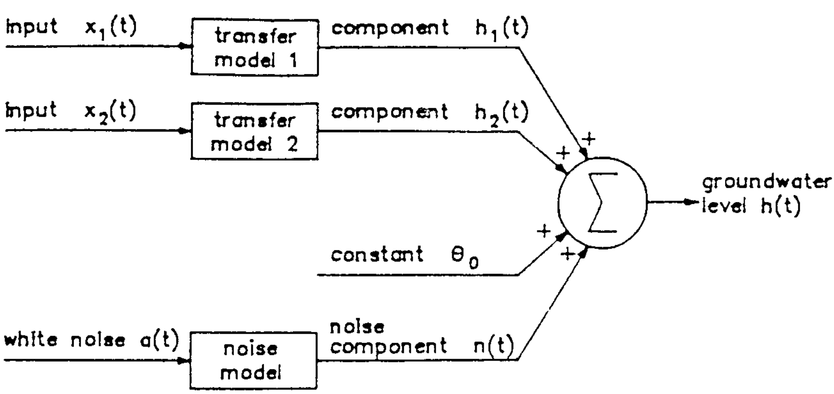


Figure 1. Principle of Transfer/Noise Modeling
Source: Van Geer and Defize, 1987

The deterministic components are modeled on the basis of auto-correlation (within the time series studied e.g., a ground water-level series) and cross-correlation to one or more explaining variables X_i (e.g., rainfall, rainfall minus evapotranspiration, abstraction rates on river levels). The corresponding transfer model has the following general shape expressed thus:

$$h_i(t) = \alpha_{i,1} h_i(t-l) \alpha_{i,2} h_i(t-2) + \ldots + \alpha_{i,r} h_i(t-r) + w_{i,0} x_i(t-\tau)$$
$$- w_{i,1} x_i(t-\tau-l) - \ldots - w_{i,1} x_i(t-\tau-s)$$

where:

$h_i(t)$	= i-th output series
$\alpha_{i,1}, \alpha_{i,2}, etc.$	= autoregressive coefficients
$w_{i,0}, w_{i,1}, etc.$	= moving average coefficients
$x_i(t-\tau)$	= I-th input series (explaining variable)
t	= time
τ	= time lag

The transfer equation exhibits certain similarities with conventional equations in parametric hydrology, which combine Markov chains and transfer functions of the 'unit hydrograph' type. At the same time, it is not essentially different from a multiple linear regression equation. After subtracting all detectable deterministic components from the original time series, a residual series remains, which is then tested for randomness.

Experience shows that the reliable determination of the coefficients of a transfer model - if done in a rigorously statistical manner - requires that the period length of the series is at least three to four times that of the correlation. This often translates into a minimum length of time of some ten years needed for the successful application of transfer noise/models in ground water-level analysis, which is a limiting factor to using this technique. On the other hand, transfer/noise models require much less data and modeling effect than numerical simulation models do. They are strong in detecting trends and in assessing the influence of individual explaining variables. An example of transfer/noise modeling of a ground water level series recorded in The Netherlands is shown in Figure 2.

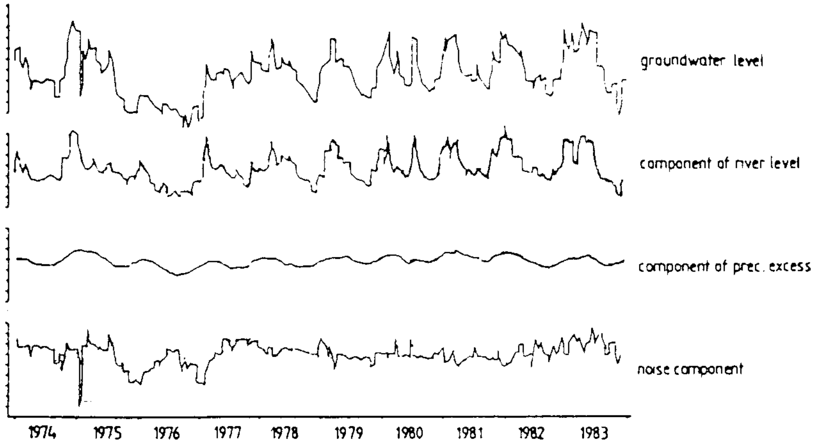


Figure 2. Transfer/noiseModeling of a Ground Water-level Time Series near the River Ijssel
Source: Van Geer and Defize, 1987.

2.4 Balance Models

Such models can often be of assistance in the early interpretation of the time series. Conceptually they are extremely simple:

Inflow – outflow = change in storage

Where all terms relate to the same substance (e.g., water, dissolved solids, heat, etc.) within specific boundaries in space and time. Balance models require reliable and comprehensive field information on all relevant in - and outflows. Information on internal dynamic processes is not needed because only the principle of mass conservation is being used. Balance models can be particularly strong in detecting or predicting trends.

2.5 Numerical Models for the Simulation of Flow or Transport

Numerical simulation models based on deterministic principles, such as the equations for continuity and motion, may further improve interpretation and analysis, also allowing for predictions to be made on future aquifer behavior. They deal with interrelations in time, as well as with interdependencies. In principle, they are an extremely valuable tool, but demand a huge amount of data on the ground water system, its state and boundary condition. Hydro-geologists and planners have mixed feelings about the value of ground water model studies because the usual data scarcity encountered and model code limitations have often produced modeling results of questionable reliability. Nevertheless, model codes and modeling practices have improved considerably over the years, and the awareness of the presence and impact of uncertainties have resulted in attempts being made to reduce the level of uncertainty and to assess the reliability of modeling results.

2.6 Examples

2.6.1 Ground Water Depletion in the Sadah Area of Yemen

Figure 3 shows a few short time series of the ground water level monitored at three observation wells in the Sadah area of the Yemen. Ground water levels as obtained by the end of 1984, raided questions for water resources management:

1. What is the reason for the observed downward trends in the hydrographs: Are they related to climatic variation or do they indicate the over-exploitation of ground water?
2. Are there any reasons for serious concern and is corrective action needed? If so, what impact can be expected from different kinds of measures being taken?

The continued monitoring of ground water level and impacts will in principle produce the answers, but waiting until the data speaks for itself would require many more years, and undesired developments may by then prove practically irreversible. Resorting to models is a logical step to pursue an early and reliable diagnosis and to predict the effects of possible corrective measures.

The time series shown in Figure 3 are too short for the successful interpretation by time series analysis. However, a water balance established by the end of 1983 - after extensive fieldwork in the area - already led to the firm conviction that the sandstone aquifer in which the observation wells, B2-277 and WRAY-I, are located was subject to severe over-exploitation. It was thus concluded that the downward trend in the ground water levels of that aquifer was primarily caused by pumping and not by climatic variation. This diagnosis did not apply to observation well B2-335, located in a zone where the generally poorly permeable limestone is locally faulted and weathered below the alluvial deposits of a small wadi bed.

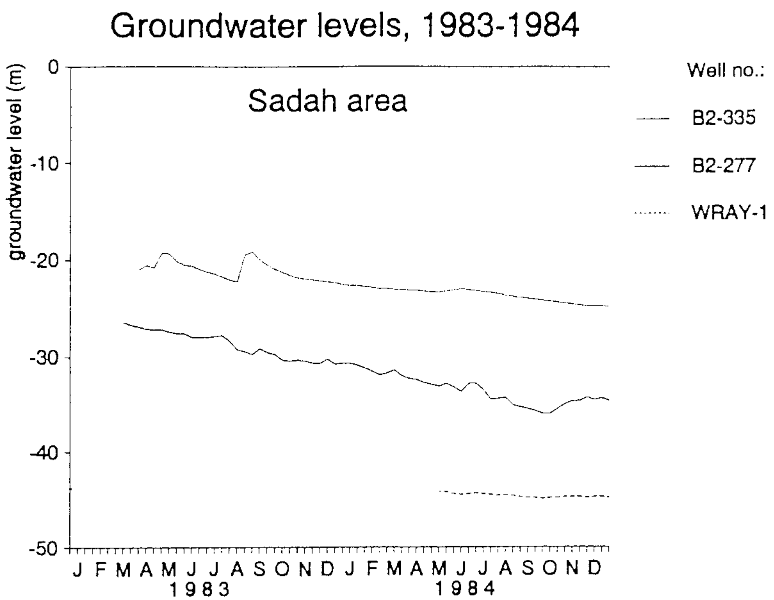


Figure 3. Ground Water-levels observed in the Sadah Region during 1983 and 1984

As a next step, a numerical model study, carried out during 1985, predicted a steady decline in the ground water levels in the Sadah Sandstone Aquifer, which was to occur if ground water abstraction was not be controlled. For that particular assumption, the model predicted for the first ten years after 1983 an average ground water-level decline of some three meters per year (Van der Gun, 1985).

What did in fact happen? During the period under consideration, there was a lack of almost every requirement for ground water resources management: problem awarness (at least in the beginning), political commitment, legislation, and an appropriate institutional framework for water resources management. Consequently, ground water over-pumping and the resulting declines in ground water levels continued more or less as predicted. This was confirmed by monitoring (Figure 4) and a new well inventory (DHV, 1993) which revealed an average ground water level decline of 35 meters of the period of 1983 to 1992. Well yields have decreased very substantially, but pumping costs have been rising at the same time. Ground water is now becoming too expensive for most irrigation activities and farmers are starting to abandon the area.

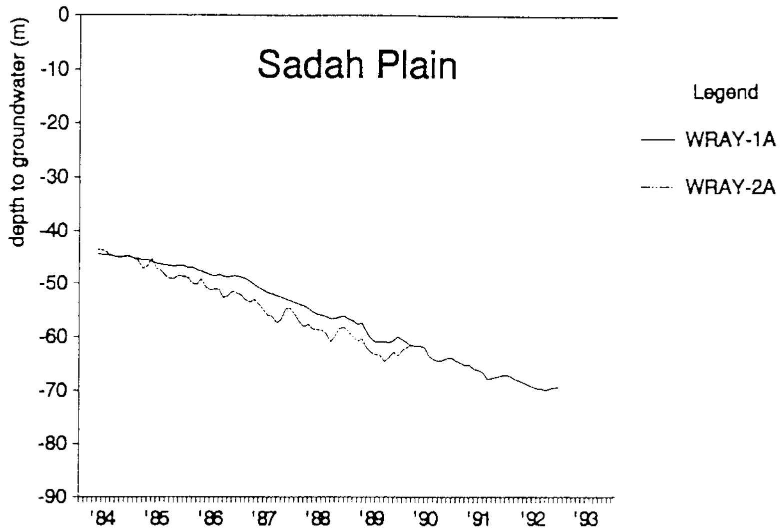


Figure 4. Groundwater Level Decline on the Sadah Plain, 1984-92
Source: Van der Gun and Abdul Aziz Ahmed, 1995

2.6.2 Cross-border on Groundwater in The Netherlands

The Netherlands is almost completely covered by an extensive multi-layer pilo-pleistocene aquifer system. This system extends only slightly beyond the national borders, except in the south-eastern part of the country, where north-west to south-east running graben systems connect with a relatively thick sequence of permeable Tertiary and Quaternary sediments of the Lower Rhine zone in Germany (Niederrheinische Bucht). To this day, there is only a low degree in the exchange of ground water related information between The Netherlands and its neighboring countries, Belgium and Germany. A network of special observation wells along the borders was established in The Netherlands around 1980, but its purpose was only to monitor possible cross-border impact, and not the joint management of shared aquifers. Even the risk created of the potential side effects of planned nuclear plants being built very close to the borders in Belgium and Germany never triggered off joint ground water management activities.

In the above-mentioned Lower Rhine zone of Germany, there are major deposits of lignite (brown coal), the largest in Europe (Figure 5). Relatively shallow layers were already exploited in the nineteenth century, but deposits buried under an overburden hundreds of meters thick have only been mined in the past few decades. The lignite is mined from huge open pits which have to be artificially drained, using enormous quantities of pumped ground water as part of the process. The total abstraction rate is of the order of one billion cubic meters per year.

in the Dutch part of this graben system show declining trends. The interpretation is not straightforward because ground water level declines can be associated not only with the lignite pit drainage, but also with the increasing rates of ground water pumped in the area from well-fields for public supply. An analysis of the time series by transfer modeling enabled the effects of these well-fields to be determined separately. The residual time series remaining after the deduction of these effects showed trends progressively diminishing from 0.35 meters per year at the border to 0.15 meters per year some 30 kilometers further on in a north-westerly direction (Rolf, 1991). The interpretation that this trend is being caused by lignite pit drainage is supported by the results obtained from ground water simulation models developed around 1985, both in Germany and The Netherlands. So far, however, attention has been mainly focused on discussions on discrepancies between impacts as simulated or predicted by different models. There are no indications that the acquired knowledge about these impacts will effectively change lignite exploitation practices.

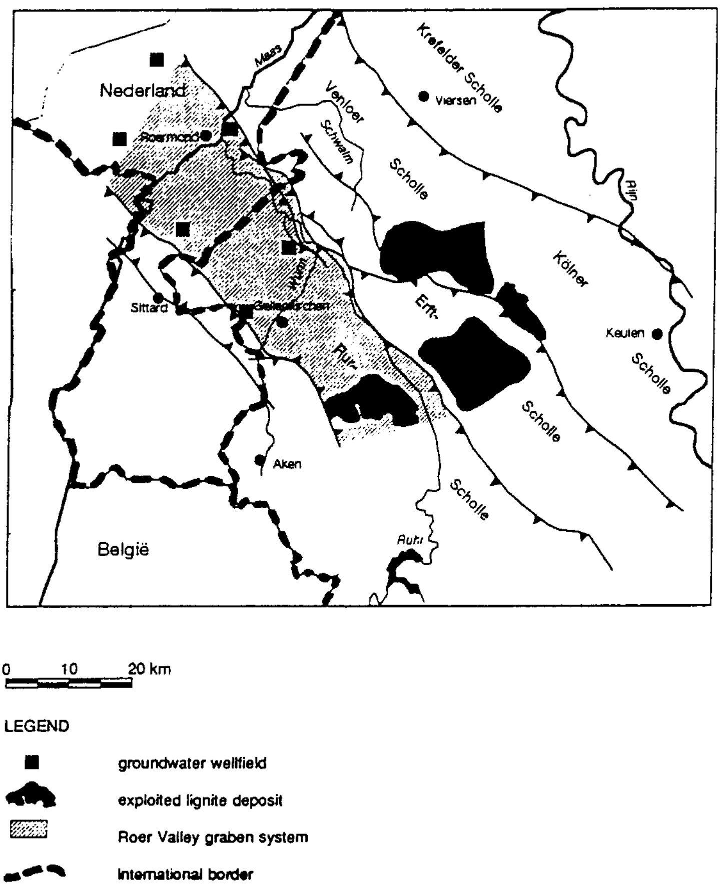


Figure 5. Lignite Deposits East of the Border Between Germany and The Netherlands
Source: Rolf, 1991

Ground water level time series measured from the mid-seventies onwards
Relevance of ground water monitoring and modeling

The relevance and power of ground water monitoring and modeling as a basis for ground water resources management is beyond doubt. The techniques involved are essential for detecting and explaining the changes in the ground water system's state, and provide a powerful means to predict future conditions as well. This is illustrated by the examples presented above. Although these examples deal with ground water depletion, the conclusion also holds for other ground water related processes that can be monitored and modeled, for example, ground water salination or pollution, or land subsidence. Hence, ground water monitoring and modeling are fundamental components for any information system intended to support aquifer management.

Nevertheless, the outcome of such ground water monitoring and modeling activities are purely descriptive and not prescriptive, and are thus not enough to trigger off appropriate responses and action in water resources management, even if there is a great deal at stake. This is demonstrated in the two examples presented above, where contributions to problem detection and awareness did not lead, or at least not yet, to decisions on corrective action and to the implementation of such action.

The decision processes in water resources management are very complex as it involves many people, and notably differing aspects and diverging interests. Information produced by ground water monitoring and modeling may have a strong appeal to technical specialists such as hydrologists, but much less to others. One may question whether such information - in spite of quality and relevance - is likely to have a significant impact on water resource management decisions. The chances seem very low, unless the water resources management process is well-structured and clear-cut. *Consequently, structuring the information system in a decision-oriented context is considered to be one of the keys to effective water resources management.*

3. DECISION SUPPORT FRAMEWORKS

3.1 General Characterization

A decision support framework is defined here as a procedure or information system which combines objective information (descriptive) with subjective information (normative, e.g., objectives, preferences, standards, etc.) in order to structure decision-making. It may be in the form of an integrated set of interrelated models (modeling framework or decision support system), including not only descriptive or simulation models, but also one or more decision models. Monitoring networks, databases and software packages, such as GIS, may be incorporated into the framework. It is essential that all elements are functionally linked.

A standardized engineering procedure where a design must meet a single objective (e.g., a given ground water abstraction capacity) at minimal cost, can already be designated a decision support framework. Ground water resources management is much more complex than conventional ground water engineering: Instead of a single objective it usually has multiple objectives; and multiple decision-makers rather than one. It does not follow a fixed design but should be adaptive to observed change over time, and so on. This means that the elements in a decision support system for ground water resources management will be different and more elaborate than those for standard engineering applications. The principle involved, however, is the same.

A characteristic element of a decision support framework is a decision model, or a methodology which assists in making a decision. A distinction can be made between singly criteria methods and multi-criteria methods.

In the first category - corresponding to the category of mathematical optimization methods - the decision is assumed to be governed by a single objective, for example, minimizing costs or maximizing net benefits. An early application of optimization in ground water resources management is Burt's decision rule for the economically optimum inter-temporal allocation of ground water abstraction (Domenico, 1972). This decision rule takes into account externalities resulting from storage depletion. Hydro-geological decision analysis as promoted in more recent years by Freeze et al. (1990), also belongs to this category. The most interesting element in that approach is that it incorporates uncertainty by using a benefit-cost-risk criterion. Among its other uses, this methodology may be applied to guide decisions on whether or not additional field information should be collected to reduce the risk of poor decision-making.

Most decision processes in ground water resources management, in particular those in strategic planning, are governed by more than one objective. It is sometimes possible to reduce the corresponding decision problem mathematically to an optimization problem, for example, by transforming objectives into constraints or by bringing them under one single denominator. In many cases, however, multi-criterion decision approaches are more realistic and adaptive to the conditions at play.

3.2 Hierarchical Levels of Decision-making in Groundwater Resources Management

Ground water resources management requires decisions to be made at different levels. There are three distinguishable levels: General policy, area-specific strategic, and operational. These levels are interrelated, as Figure 6 shows: The higher levels impose boundary conditions on the lower levels; in turn, the latter provide feedback upwards. Feedback not only facilitates the correction of erroneous views, but also allows policies and plans to be adapted to changing conditions. This leads to the periodic updating of water resources policies and strategic plans.

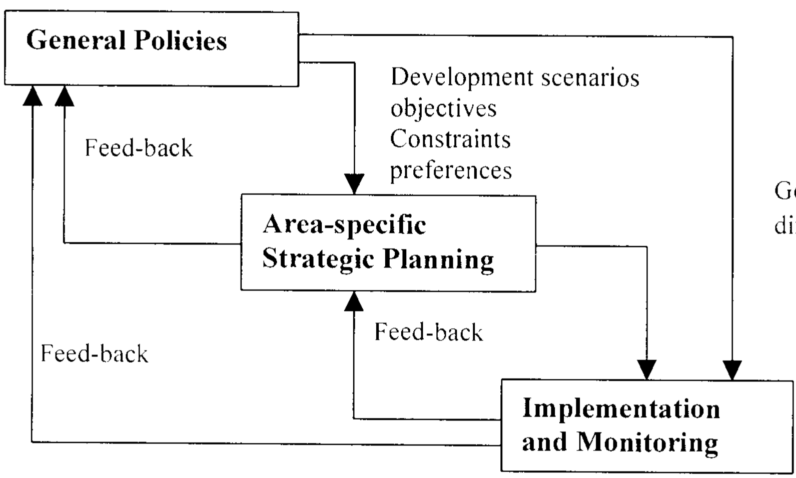


Figure 6. Hierarchical Levels in Water Resources Management

The general policy level is the highest hierarchical level and is closely related to politics. It deals with the articulation of a government's political preferences concerning the policy field considered and produces corresponding national plans which contain general policies and directives for a certain time period ahead. It also deals with the formation of legislation and other instruments needed to implement the necessary measures, and has a role in the preparation and negotiation of international treaties, if these are required for the protection of joint management of shared water resources. This general level is also the main one at which aquifer management is linked to overall water resources management and to other fields of government policy.

The *strategic level* as defined here is area-specific. Strategic plans for areas defined either by natural boundaries (catchment of aquifer boundaries) or by administrative boundaries are developed at this level. Strategic planning involves the analysis and evaluation of alternative strategies, finally defining the strategy considered to be the "best compromise" between the conflicting or diverging aspirations at both the political and stakeholder levels.

All ground water monitoring activities are carried out at the *operational level*, as are the area- and site-specific measures taken. This is the most technical level. Unlike with engineering works, not all ground water resources management measures are scheduled in advance, and operational decisions are continuously needed in reaction to what is happening at the field level. At this level, they are required to define responses to changing state variables (water levels or water quality parameters), applications for ground water abstractions, or cases of polluting accidents have to be defined. The strategic plan specifies the measures to be carried out in a generic or aggregated manner only: The operational decisions translate these into action for any specific case.

An example of the effective interplay between these three echelons can be observed in Oman (Hydroconsult, 1985; Mott MacDonald International, 1990; Ministry of Water Resources, Oman, 1995). Oman is a water-scarce country where ground water resources are threatened by high abstraction rates. A top-level policy of sustainable water resources development has been adopted. Professionals at the strategic level determine the zones where ground water inflows and outflows are unbalance; for these zones they define and analyze corrective measures, such as building recharge dams and sea water desalination plants to augment supplies, and imposing restrictions on new wells. Operational units then carry out the decisions and plans, for example, designing, constructing and operating a recharge dam.

3.3 Decision-making at the General Policy Level

At this level, decisions are made in a more or less political setting, so the relevance of technical tools is probably not very high. Strategic analysis of water resources management alternatives and feedback from the lower level, however, may contribute to the quality of the decisions.

Taking as an example the joint management of shared aquifers by Israelis and Palestinians, then, it seems that among the issues to be addressed at this level, allocation rules deserve special attention. Water resources management exists in a dynamic context. Water demands, uses, quantities, qualities, and related risks are constantly changing with time. And even social preferences and interpretations of what is an 'equitable apportionment' are not independent of time. Therefore, water resources management, including allocation, should be adaptive. Fixed allocation quantities like the ones mentioned in the Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip (1995) are practical for the short term because they are clearly defined. However, in time they will have to be adjusted to changed conditions. The principles underlying the currently agreed allocation will most likely remain valid for much longer than the volume of agreed-on quantities themselves. It is therefore advisable to adopt them as decision rules after some time, so that they can be modified as necessary and serve as a basis for the periodic adjustment of allocations. Strategic analysis under a wide range of assumed scenario conditions may provide 'a priori' information on the practical implications of the decision rules to be agreed upon.

3.4 Decision-making at the Area-specific Strategic Level

Comprehensive water resources management plans for specific areas are made at the area specific strategic level. This activity certainly may benefit from a decision support framework.

Figure 7 presents a generic outline of a decision support framework for this strategic level. It shows which information components to combine in order to derive decisions and it suggests a certain stepwise approach. Scenario assumptions, water resources management objectives and constraints, and standards and preferences produce an effective vertical link with the general policy level. The resulting water resources management plan, on the other hand, links it to the operational level.

The framework provides a suitable basis for the development if a decision support system. Figure 8 shows the structure of one such system which was mainly developed according to the first two blocks of this framework. It was used for the analysis and evaluation of water resources management strategies in the Wadi Surdud area in the Yemen (Van der Gun and Wesseling, 1991). The modeling framework consists of a floodwater allocation model (WATAL), an agricultural model (AGRIMOD), a fresh/saline ground water model (BADON), a cost-benefit model (ECOBEN), and a SHELL which facilitates data flow, communication between the models, and the production of alternative strategies. The system was designed in such a way that the user can focus his attention on strategic analyses, without having to worry about modeling procedures.

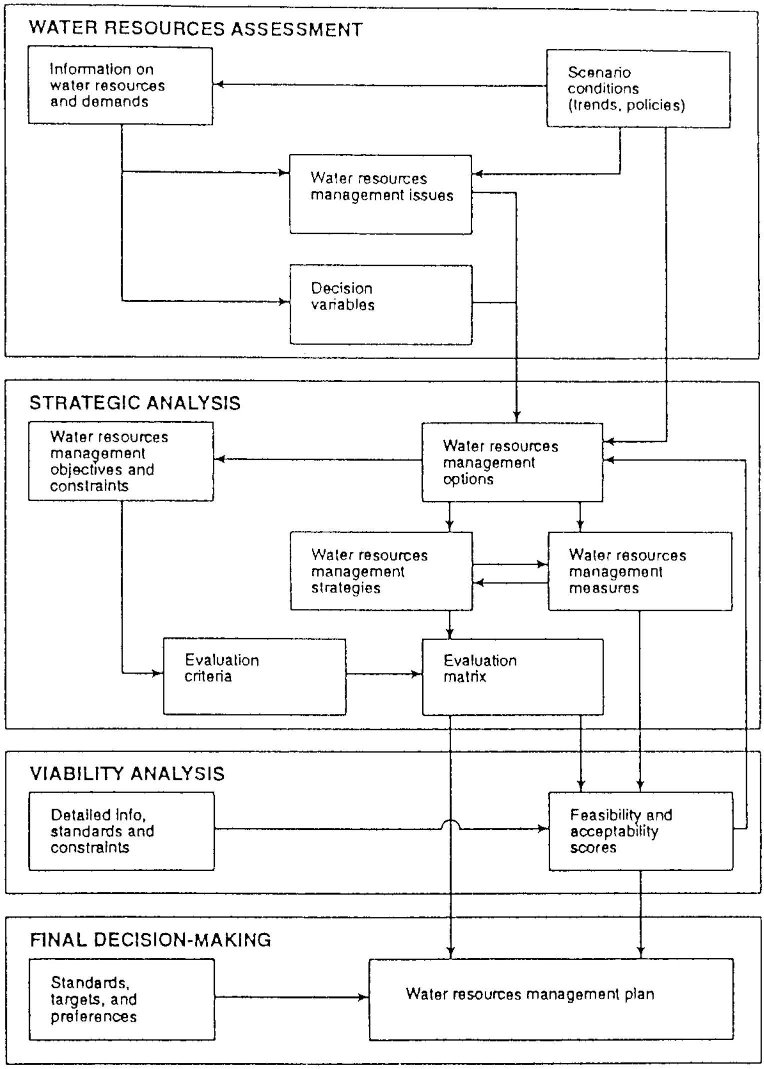


Figure 7. Outline of a Framework for Strategic Water Resources Management Planning

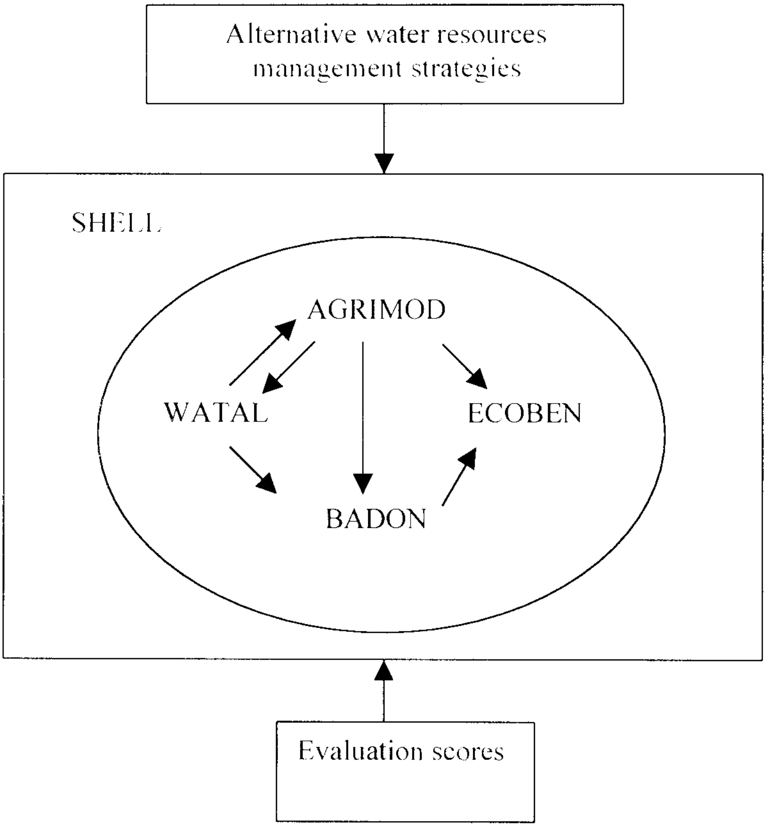


Figure 8. Computational framework developed for the water resources management analysis of Wadi Surdud
Source: Van der Gun and Wesseling, 1991

3.5 Decision-making at the Operational Level

The decisions to be made at the operational level are of a different nature. These do not concentrate on how to balance social preferences. They are primarily related to the diagnostics of observed change and to defining adequate action plans. The latter complies with the law and regulations of approved water resources management plans.

An example of an activity at the operational level is the licensing of ground water abstraction wells. General instructions on how to decide on applications for new abstractions are given by the higher echelons, perhaps partly conditional on the state of the ground water's system. At the operational level, a decision tree has to be developed which incorporates all aspects that are relevant for the decision to be taken. Crisis management, for example, during periods of drought or after accidental pollution, is another example. In the first instance, it has to be decided whether or not a crisis situation actually exists, and for this there must be unambiguous criteria on which to base a judgement. And if the crisis is confirmed, then again, a number of decisions have to be taken on the actions to be carried out.

As mentioned above, decisions must be taken quickly, especially in the case of crisis management. They should also be as objective as possible, and correctly reflect existing legislation, plans and regulations, otherwise, they can become a source of conflict. Here again, decision support frameworks or decision support systems are a promising tool for use to enhance the quality and efficiency of decision-making. Whereas the strategic planning level it is very important to work within an integrated framework, it may be more practical at the operational level to have separate frameworks for separate activities, such as well licensing, drought management, dealing with pollution, and so on.

4. CONCLUDING STATEMENTS

1. Ground water monitoring produces immediately available information on the state of an aquifer. General experience shows the need for procedures to ensure that the data is systematically inspected and interpreted.
2. Ground water monitoring and modeling are valuable and indispensable aquifer management. Nevertheless, they may have little or no practical impact if the ground water resources management processes are not sufficiently structured.
3. Decision support frameworks seem very promising in structuring the decision processes in ground water resources management. Among others, they help define the links between the different administrative and technical levels, and provide guidance towards logical decisions on the basis of relevant information, stated objectives and articulated preferences.
4. Aquifer management is very complex, with differences of opinion and conflicts of interests being inherent problems. Sharing aquifers between nations increases the scope for conflicts and disagreements. Adequate decision support frameworks can help prevent and solve conflicts and disagreements.
5. It is desirable to aim for conflict resolution at a high, generic level (i.e., for a consensus on principles), rather than at the level of the particular cases.

6. Whereas policy and strategic decisions on shared aquifers need to be jointly made, it seems that the activities at the operational level made by agencies of each of the parties can be quite independent, provided that the procedures followed are clearly defined (e.g., specified in a decision support framework), and that proper checks for verification are carried out.

REFERENCES

ANONYMOUS. 1995. Israeli-Palestinian Interim Agreement on the West Bank and Gaza Strip.

DHV CONSULTANTS BV. 1993. Ground water resources and use in the Sadah Plain. Final Report. Northern Region Agricultural Development Project. UNDP/SSHARDA

DOMENICO, P.A. 1972. *Concepts and models in ground water hydrology*. London: McGraw-Hill.

FREEZE, R.A., MASSMANN, J., SMITH, L., SPARLING, T., and JAMES, B. 1990. Hydro-geological decision analysis: 1. A. framework. *Ground Water* 28 (5): 738-66.

HYDROCONSULT CO. LTD. 1985. Catchment Water Conservation and Recharge Schemes for Irrigation. Prepared for the Ministry of Agriculture, Sultanate of Oman.

MINISTRY OF WATER RESOURCES (MWR). OMAN. 1995. Proceedings of the International Conference on Water Resources Management in Arid Countries. Muscat. Oman. 12-16 March.

MOTT MACDONALD INTERNATIONAL. 1990. National Water Resources Mater Plan. Sultanate of Oman. Draft version, prepared for MWR, Oman.

ROLF, H.L.M. 1991. Evaluation of the piezometry of deep ground water in the graben of the Roer Valley. Central Limburg. TNO Report OS 91-48B. (Dutch)

VAN DER GUN, J.A.M.. 1985. Water resources of the Sadah area. Main Report. Report WRAY-3. Sana'a/Delft: YOMINCO/TNO.

VAN DER GUN, J.A.M. & WESSELING, H. 1991. Water resources of the Wadi Surdud area: Pilot study of water resources management. Report WRAY-22. Sana'a/Delft: GDWRS/TNO.

VAN DER GUN, J.A.M. & ABDUL AZIZ, A. 1995. The water resources of the Yemen: A summary and digest of available information. Report WRAY-35. Sana'a/Delft: GDH/TNO.

VAN GEER, F.C., & DEFIZE, P.R. 1987. The detection of natural and artificial causes of ground water fluctuation. In *Proceedings of the International IAHS Symposium at Vancouver, August 1987, on The Influence of Climate and Climatic Variability on the Hydrologic Regime and Water Resources*. IAHS Publication 168.

Chapter 16

Hydrological Planning Aspects of Groundwater Allocation

Yoav Harpaz
Water Resource Planning, Ramat Hasharon, Israel

1. INTRODUCTION

The paper addresses some specific problems of groundwater allocation from a resource located in an arid or semi-arid region, and the role of hydrological factors in the process of planning the joint exploitation of transboundary aquifers. The concepts of safe yields and exploitation potential are dealt with and considered inadequate for designing management systems. A different approach is advanced that might be useful in devising procedure for setting water allocation arrangements.

2. GROUNDWATER PROPERTIES

Groundwater systems are much more complex than surface water basins, so that the division of water in the aquifer, according to strictly administrative or political criteria, as was contemplated in a few past disputes, does not seem to produce practical solutions. The hydrological factors have far-reaching effects on the planning of aquifer management, in general, and on the formulating of water allocation schemes, in particular.

The reason is that a groundwater aquifer is mostly an irregular and heterogeneous system, and is generally defined by many more hydrologic parameters and components, namely:

–Physical – hydrological characteristics, such as geometry, hydraulic coefficients (conductivity, storage capacity, flow gradients);
–various boundary conditions;
–state variables: water levels, gradients, volume of water stored in the aquifer, etc.;
–natural inflows and outflows (replenishment, discharge);
–quality distribution;
–locations and rates of water extraction facilities;
–inputs of polluting elements (their sources, location and fluxes).

Several characteristics are constants, while others may change in time, and many are interdependent. Most of them also interact with the hydrologic environment, that is, with surface waters, precipitation, etc. Aquifer types are distinguished by a set of properties and their combination.

Since those hydrologic properties actually determine the availability of water and the productivity of an aquifer, distinct from stream flows, they cannot be directly gauged and recorded, the aquifer management planning could not proceed along the same planning guidelines as in the case of surface-water disputes.

3. TYPES OF AQUIFERS

Various types of aquifers behave differently in response to exploitation, and therefore cannot be subject to the same allocative rules. We may distinguish between aquifers according to the following properties:
–large or small aquifers;
–shallow to deep;
–in humid or arid environment;
–phreatic or confined; or maybe a combination of both pressure types;
–isolated or in contact with saline water bodies;
–highly productive or poorly conductive;
–intensively developed or still intact;
–extent of anthropogenic pollution;
–degree of remedial action, etc.

It is obvious that a rational program of groundwater production and distribution would be different in each of these cases. Therefore, planning an allocation arrangement based on administrative criteria would be impossible, unless the hydrology of the shared aquifer system is well understood. Contrary to stream flow, the concept of fixed, finite, water volumes to be divided between partners is rather meaningless, because the availability of water and its quality depend on so many factor, and would also change with time.

4. GROUNDWATER ASSESSMENT

4.1 Safe Yield

The concept commonly used in the past to assess the water quantities available for production from an aquifer was the *basin yield* ("safe yield" or "sustained yield"), which was defined as an overall quantitative limit set on the total extraction from the aquifer, in order to avoid undesired results; but those results are only vaguely defined.

Actually, those Basin Yields estimates cannot be constant, definite values, because they depend on many complexly interrelated factors, and may often change according to:

1. hydrologic management decisions, present and future;
2. the agreed-upon definitions of desired effects (hydraulic, water quality, economic, environmental);
3. the amount of residual discharge (to springs, streams, sea or lakes) to be salvaged;
4. the water quantities to be mined from storage.

4.2 Exploitation Potential

Moreover, because the time dimension was not included in the *basin yield* concept, another concept was later introduced for groundwater assessment: *hydrologic exploitation potential.* Because of its dynamic property, the potential is regarded as more adequate and better applicable to planning the rational exploitation of an aquifer, on a short- and long-term range.

The *hydrologic potential* is defined as the average amount of groundwater available for extraction, perennially, of various quality categories, and along the time axis. That amount is the sum of natural flows (or uncontrolled flows) into the aquifer, minus pre-planned residual outflows (or uncontrolled natural outflows), plus or minus change of storage (depletion or build-up of water volume in the aquifer); and all under constraints set by pre-determined policy of exploitation and conservation.

The controlled water-balance equation is:

HP = NI - PPRO -/+ CS

Where HP = hydrological potential; NI = natural inflows (or uncorntorlled flows); PPRO = pre-planned residual flows (or uncontrolled natural outflows); and CS = change of storage.

Some **common constraints** to the hydrological exploittaion potential are:
–intrusion of saline waters,
–minimum residual outflow at the natural outlets,
–unacceptable salinity levels in the pumped water,
–feasible pumping depth,
–volumes of minable reserves,
–prevention of pollution, etc.

Estimates of the aquifer's *exploitation potential* actually depend on knowing the hydrological characteristics and factors that cannot be measured directly in this invisible underground system.

Although the potential concept also considers the changes occurring in the natural processes, other factors, such as evolution of exploitation and management decisions and their impacts, are not taken into account. Such factors are, for example:

- Replenishment, which varies as a function of climate fluctuations and artificial recharge operations.
- Water levels – also follow patterns of water abstraction (locations and pumping rates) from the aquifer, in the past as well as in the future; sharp declines occur under severe drought conditions.
- Salinization is also the result of exploitation development.
- Continuous over-pumping may lead, over time, to depletion of the source.
- Accumulating anthropogenic pollution inputs may also affect the yields and potential of the aquifer.

5. AQUIFER MANAGEMENT

Recently, a more comprehensive approach has evolved which includes the time dimension and also considers the above factors: *hydrological management of aquifers*. The principal objectives of that aquifer management are:
–extending water availability;
–extracting water of lesser quality, otherwise unusable;
–manipulating with facilities and measures (e.g., withdrawal and recharging) in order to draw maximum water, complying with constraints of quality, engineering or economic nature;

–providing regulating storage capacity underground, in order to mitigate the effects of droughts;
–utilizing the decontamination capability of the geologic medium;
–applying good housekeeping measures.

The planning of management comprises mainly the programming of exploitation development, the spacing of wells and the regime of pumping, artificial recharge measures, and ways and means to protect the quality of water. In complex groundwater systems, the hydrological management process is the only operative basis for designing water distribution and allocation schemes. Aquifer management planning has become, recently, routine practice in most of the groundwater studies the world over.

5.1 Tools for Management Planning

An efficient methodology available today for designing hydrological management plans, in problematic multi-users aquifers, is the *mathematical modeling* technique. On the models one can test various operational plans and predict their long-term effects, in quantitative and qualitative terms. Two and three-dimensional computer models are at service for that purpose.

The relevant modeling process comprises the following steps:

1. Obtaining adequate data on the properties of the aquifer.
2. Constructing the computerized hydrological management model.
3. Running simulations of development and management programs, including alternative allocation arrangements.
4. Checking and weighing the results against the management objectives and constraints.
5. Proposing hydrological management options to be considered in the process of selecting groundwater allocation schemes.
6. The results of these simulation studies are indispensable prerequisites to any formulation of administrative regulation agreements.

6. CONCLUSION

The search for solutions to the allocation problem should begin with the elaboration of technical-hydrological management options. The necessary tools and techniques are already available and proven, so that they could be readily employed by the planners of the joint management of shared aquifers.

Chapter 17

The Potential of GIS in Water Management and Conflict Resolution

Jad Isaac & Maher Owewi
Applied Research Institute (ARIJ), Bethlehem

1. INTRODUCTION

The Middle East is predominantly an arid to semi-arid region and located at a crossroads of climatic and botanical zones. Although diverse environments exist within the region, including alpine, tropical, coastal and desert, the countries of the area generally share common water resource problems and seek similar solutions to them.

Integrated joint water resources management for the Middle East has been gaining momentum in the past few years, but recently experienced a setback because of the stalling in the peace process. Being a truly interdisciplinary concept aimed at considering quality and quantity problems of both surface and groundwater, integrated joint water resources management requires the sustained cooperation of experts with different academic and technical experience in the region.

Hydrological and hydro-geological studies are being carried out at different levels and need data which is consistent and up-to-date. The amount of data involved in hydrological and hydro-geological studies requires a system which can store large amounts of information and process it for hydrological applications. The increasing complexity of hydro-geo-logical modeling requires the flexible manipulation of data input and considerable visualization functionality for model output. Also, there is an increasing need for up-to-date information on time-dependent variables, like ground water levels, quality, and abstraction rates.

The GIS or Geographic Information System, is an essential tool, necessary to deal with the problems and issues noted above. It is considered to be important for the collection, storage, analysis, modeling, and display of multi-disciplinary data from various sources, including remote-sensing imaging, digital maps, field sampling, and survey information. There are broad data categories for input into the system: (a) alphanumeric; (b) pictorial or graphic; and (c) remotely sensed data in digital form. Table 1 shows the different elements in an integrated Geographic Information System.

Table 1. Elements in the Geographic Information System

Data Processing Subsystem		**Data Analysis Subsystem**			**Information Use Subsystem**
Data Acquisition	Data Input	Data Storage	Retrieval and Analysis	Information Output	Users
Primary Data	Conversion to Machine Record	Basic Desegregate Data	Retrieval	Report Generation	Researchers
Secondary Data	Geocoding	Areal Unit Summaries	Statistical	Mapping	Planners
Survey Data	Image Processing			Graphic Display	
Image Data	Entity Transformation and Formatting	Time Period Summaries	Modeling	Derivative Machine Records	Managers

Source: Tomlinson, 1972, in Lo, 1986

The entry of alphanumeric data is straightforward because it is available in a computer readable form. The input of pictorial or graphic data, such as maps and photographs, requires the use of a digitizer which converts the features into strings of coordinate values. A usual approach is to represent polygonal boundaries as lines, and lines as a sequence of very short, straight-line segments which can be represented by an ordered sequence of points defining the segments (Marble and Penquet, 1983, in Lo, 1986).

Remotely sensed data generated by multi-spectral scanners or high resolution video cameras from space platforms are in raster format. However, this spectral data has to be restored, enhanced, filtered, or geometrically transformed by the techniques of image processing before they can be incorporated into the Geographic Information System.

While three-dimensional GIS, such as Digital Elevation Models (DEMs), is essential for the representation of surfaces such as landscape morphology, much can be accomplished with a two-dimensional GIS, particularly in surface hydrology. Since surface hydrology processes are related to groundwater processes, a two-dimensional GIS can significantly contribute to groundwater studies, too.

Table 2. Digital Hydrological and Hydro-geological Geographical Database Necessary for Integrated Water Management

Subject	**Object Type***	**Scale**
Precipitation	P, L	
Potential Evapotranspiration	P, L	
Land use	A, L	1:20.000
Land cover	A, L	1:20.000
Population distribution	A	
Urban areas	A, L	1:20.000
Industry	A, P	
Soil type	A	1:250.000
Temperature	P, L	
Topography	3D Line	1:20.000
Digital Elevation Model (DEM)	R	50 m pixel size
Slope Model	R	50 m pixel size
Aspect	R	50 m pixel size
Perspective view	L	Based on 50 m pixel size DEM
Drainage	L	1:20,000
Catchment area	A, L	1:250,000
Wells	P	
Springs	P	
Groundwater Basins	A, L	1:250,000
Geological features	A, L	1:250,000

* P = Point, L = Line; A = Area R = Raster

The two-dimensional GIS uses vector data consisting of points, lines and polygons and their associated attributes, and the three-dimensional one uses raster date where all information is represented as values on a grid. The vector data structure permits the representation of locations with a great deal of precision, however, its analytic capabilities are somewhat constrained by the complexity of the programming required to handle large numbers of x, y coordinates. The precision of raster data is limited by the size of the grid cell, but, the structure allows for easier analysis, primarily because of the implicit row and column indexing of locations. Therefore, raster GIS permits the complex analyses that are otherwise difficult to accomplish with vector data, and is particularly useful for hydrological modeling. The multi-disciplinary aspect of GIS means that data representing a variety of environmental factors which influence hydrological processes can be integrated. Data about various properties of soils, geology, terrain morphology, rainfall, hydrology, and vegetation cover available in digital map format can be tied in with remote sensing imagery and information collected from the field by their location. Depending on the precision and accuracy of the data, it is possible to have analyses on a variety of scales in order to provide a schematic low-resolution view of processes, or more detailed views of particular areas of interest. The low resolution studies can be verified by the collection of more data, and intensive and detailed studies, and the validity of various models at different scales can be analyzed. Finally, a variety of map and tabular products can be developed for analysis, engineering and planning purposes. Table 2 shows the needed digital, hydrological and hydro-geological geographic database for integrated water management.

2. THE USE OF GLS IN JOINT WATER MANAGEMENT

The water crisis in the Middle East is not simply due to insufficient supplies, but to an uneven distribution of the resource, which is further aggravated by inappropriate consumption practices. The source of the water crisis in the Middle East is its unequal allocation and usage among the countries of the region, threatening its political stability. For example, Palestinians are allowed to utilize about 19% of their water resources as a result of Israel's practices (Figure 1). Most of the water resources are shared between more than one riparian system. However, the current pattern of water resources use in the region did not come about as a result of negotiations but in most cases was imposed by force. The joint management of shared rivers and aquifers in the region is still far from becoming a reality.

It is unfortunate that the ongoing Middle East peace process, in both its bilateral and multilateral tracks, has so far failed to address the issues that are at the heart of the water disputes of the region. While some progress was achieved between Israel and Jordan on the subject of water, little was between the Israelis and Palestinians. According to the Oslo B agreement, the Israeli government recognized the Palestinian water rights, but these are to be determined in the final status negotiations. The gap between the positions of the two parties on the issue of water rights was so wide during the last rounds of negotiations that it almost caused a collapse of the interim agreement phase. The compromise that was finally reached will only serve to load the agenda of the final status negotiations. The bilateral talks between Israel on the one hand, and Lebanon and Syria on the other, are dragging behind, and caused the latter two countries to boycott the multilateral talks. Hence, the multilateral talks have not promoted genuine regional cooperation as they were intended to, thereby conflicting them to a few limited activities.

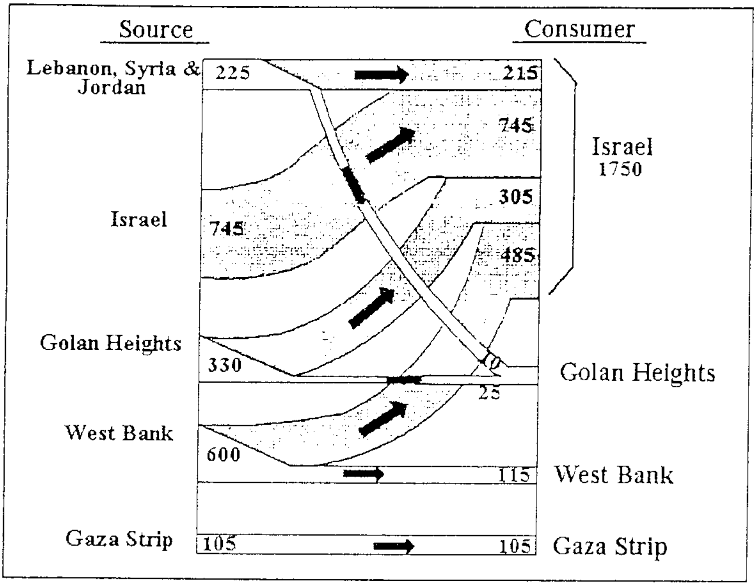


Figure 1. Water Resources and Consumers in the Occupied Arab Territories and Israel
Source: Modified from USIS

Regional cooperation to protect the water resources of the Middle East is a responsibility shared by a number of countries, regardless of their political differences. Throughout the region, the natural facts of water supply and those of socio-politics regarding water control, consumption and demand interact to form a complex hydro-political situation. The water allocation of the region's three major river basins, the Nile, the Euphrates-Tigris, and the Jordan, are sources of tension and potential conflict. The need to preserve the region's water resources and the recognition of this need have already led to the successful creation of a framework for regional water resources cooperation in the Middle East.

Since all the rivers in the region cross international borders and many of the groundwater aquifers are shared, an essential step for initiating a joint water management structure concerns the issue of water allocation. Central to the riparian dispute between Israel and the Palestinians is the Jordan drainage basin, which constitutes the region's chief water resource. The headwaters of the Jordan River, located in northern Israel, the occupied

Golan Heights and southern Lebanon (including Israel's self-proclaimed 'security zone'), feed Lake Tiberias (the Kinneret, or Sea of Galilee) and the Syrian and Jordanian waters (most importantly, the Yarmuk River); while West Bank and Israeli springs feed the Jordan River that runs below Lake Tiberias. As a whole, these systems make up the Jordan international drainage basin, a naturally defined area that cannot be artificially subsectioned. A second area of dispute is the control of aquifers which flow west from the heights of the West Bank towards the Mediterranean, Underground water resources are the most important in this second area of dispute, as surface waters contribute only 30 per cent of the total supply in Israel and the West Bank.

Following the 1967 occupation of the West Bank, Israel applied stringent policies that prevented the Palestinians from fully exploiting the area's groundwater. These included the expropriation of wells belonging to absentee owners, the denial of permits to sink new wells, and the imposition of rigorous water quotas. Groundwater in Gaza, which is estimated as having a 65 mcm per annum potential is the only source of freshwater. At present, over 100 mcm are pumped from these shallow aquifers, resulting in the gradual invasion of the Gaza aquifers by sea water.

The current situation cannot be sustained. The problem of the allocation of water between the Israelis and Palestinians must be resolved. The issue almost caused a breakdown in the negotiations on the interim agreement. Palestinian water rights can be summarized as follows:

1. Absolute sovereignty over all of the Eastern Aquifer Systems since the recharge and storage of this aquifer are entirely in the West Bank, thereby making it an unshared water resource.
2. Equitable water rights in the western and north-eastern aquifer systems. Although these aquifers are recharged almost entirely from the West Bank, Israel uses over 85 per cent of the waters in these aquifers as shown in Figure 2.
3. Equitable water rights in the Jordan River system, since the Palestinian Authority area is downstream riparian in this international basin.
4. Lake Tiberias storage and fishing rights since this natural reservoir is an integral part of the Jordan River system, in which the Palestinian Authority area is a legal riparian entity, allotted the privileges to use equitably all of its available resources.

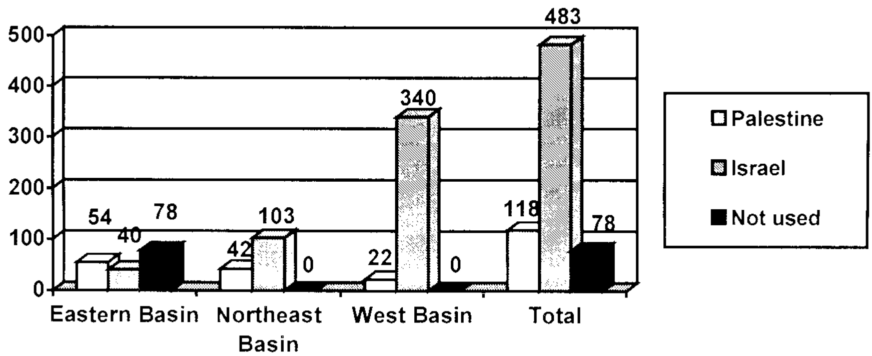


Figure 2. Extractions from Groundwater Basins in the West Bank

The resolution of the Palestinian-Israeli allocation and water rights disputes will of necessity be governed by the principles of international law. Two legal aspects of the conflict concern us here. First, Palestinians and Israelis must reach a consensus on sovereignty over water resources in the West Bank and Gaza. And second, Palestinians and Israelis must reach an agreement on the rightful allocation of shared water resources to each party.

The Helsinki Rules of 1966 provide the most comprehensive codification of international water laws, listing a total of 11 factors to be considered in the resolution of riparian conflicts. These include, but are not limited to:

1. The geography of the basin, especially including the extent of the drainage area in the territory of each basin-state.
2. The hydrology of the basin, especially including the contribution of water by each basin-state.
3. The climate affecting the basin.
4. The history of the past use of the basin's waters, especially including existing use.
5. The economic and social needs of each basin-state.
6. The population dependent on the basin's waters in each basin-state.
7. The comparative costs of alternative means of satisfying the economic and social needs of each basin-state.
8. The availability of other resources.
9. Avoiding the unnecessary exploitation of the basin's waters.
10. The practicability of compensating one or more of the co-basin states as a means of settling disputes among the users.
11. The degree to which the needs of a basin-state can be satisfied, without notably damaging the supplies of a co-basin state.

GIS may yet prove an extremely powerful tool which can be used to get the parties to agree on water allocations based on the catchment area, storage, modeling, and other related factors. The system can also help determine the apportionment of water among the regional parties to deal with yearly variations in rainfall, recharge, well and spring discharges, water consumption, and so on.

For example, suppose the stream types within a particular catchment area have to be identified. One quick way to do this is to manually overlay a stream map and a catchment map. This is an easy operation if the streams of only a small catchment area are concerned. But, what if the stream types for all of the catchment areas in the West Bank have to be known, and that some catchment areas contain more than one stream type, permanent or intermittent, with some of the streams extending into Israel? These questions are more difficult to answer, but such an operation is one of many spatial operations which can be carried out with a GIS to create new spatial relationships. Figure 3 shows the catchment areas of the West Bank with the distribution of different stream types, permanent or intermittent.

According to the Oslo B agreement, water data will be exchanged between the Palestinian Authority and Israel, but so far little has been done in this field. We propose that a Water Information Network (WINET) be established and that a web site for all water experts to provide and exchange data. The establishment of such a network should not be delayed and can be initiated immediately by interested academics and experts.

3. DESIGN OF THE WATER INFORMATION NET SYSTEM (WINET)

When designing the WINET, an integrated database and GIS software should be used.

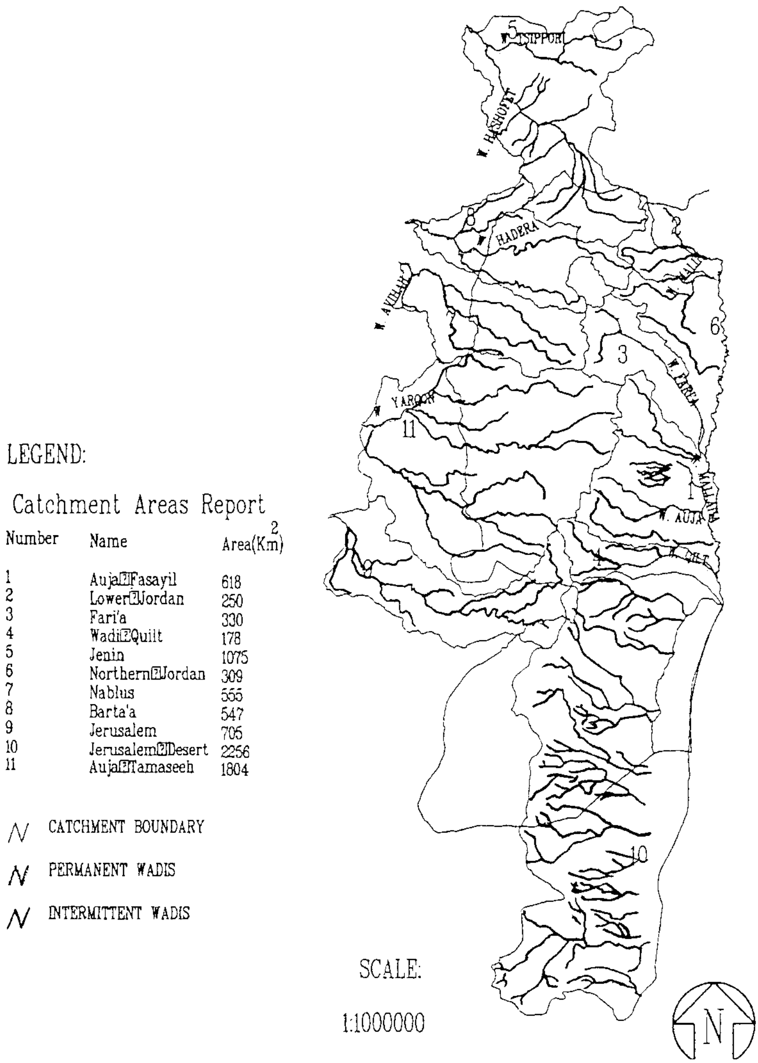


Figure 3. West Bank Catchment Areas

3.1 GIS Software

A GIS based on ARC/Info or PAMAP software can be used to create, protect, analyze and model the different layers. Each layer is a map containing relevant information on one hydrological and hydro-geological issue.

3.2 Linkage of Database to the GIS

One of the most valuable features of the GIS technology is the possibility to connect its proper internal data to any other external database. The information in the developed database can be located, analyzed and manipulated in an integrated manner to provide real assessments and projections. Such a procedure will facilitate the assessment of the impact of the environment for any specific plan or project on the natural resources of Palestine, in addition to proposing solutions and measures for the hydrological and hydro-geological protection in a particular defined zoned or in the whole area in general. Database linkage with the GIS presents a powerful tool which can help Palestinian National Authority planners and decision-makers on matters concerning water issues.

The linkages occur when there is information in one file, for example on wells, and different information in another file. By using a key common to both files in this case, the well number, the linkage can be made. Hence, the record in each file with the same well number is extracted, and the two are joined together and stored in another file.

WINET should comprise of GIS ARC/Info, compiled with an Oracle database as tools to make up the necessary maps and models. Figure 4 outlines the strategy to be used during the compilation of information: primary borehole data, stored in the Oracle database, is integrated with secondary data, such as surface geology, topography and drainage. Integration, interpretation and analysis of different interpreted parameters are done within the GIS environment. The final output would be maps, reports and models which can be used for various reasons.

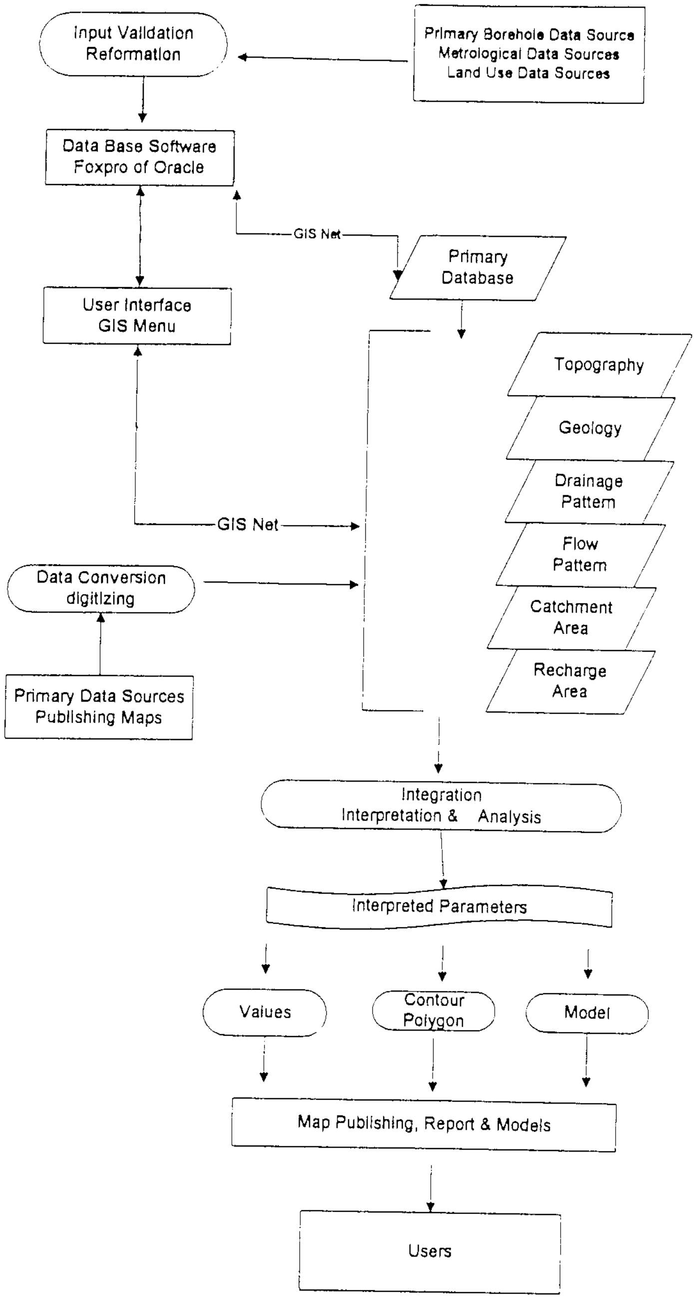


Figure 4. Compilation of Parameters for Hydrological and Hydro-geological Modeling

4. OTHER APPLICATIONS OF THE WATER INFORMATION NET SYSTEM (WINET)

4.1 Database (Maher et al., 1995)

In order to create a Middle East information system, data on location, address, wells, well_IDs, owners, chemistry, geology, catchment areas, pipe-water networks, and other such factors must be collected. Any record of this nature is a candidate for inclusion in the GIS. It is important that the extent of these records be established at the design phase. ARIJ Water Unit has its own water database bank installed on GWW software. The table below shows an example of the wells database installed on ARIJ GIS computers. Data from the GWW and GIS systems can quite easily be exchanged.

$Record	*Well*	*Well_ID*	*Well #*	*Owner*	*X(UTM)*	*Y(UTM)*
1	2	20	W5022	Sabri Khalaf	734324	3527041
2	3	21	W5023	Moh'd Abu Shushah	732944	3528831
3	1	22	W5024	Sulaiman All Barham	734268	3526842
4	4	23	W5025	Jawad All Masri	735230	3526013
5	5	24	W6026	Joudeh Abdullah	734227	3528003

Source: Maher et al., 1995

Pollution and monitoring systems of wells, springs and even of the groundwater can be done through the GIS. As a simple example, consider the table below:

Well_ID	*Well #*	*X(UTM)*	*Y(UTM)*	*Depth to GW table (m)*	*SAR*
1	W5029	73820	3527447	8.30	9.6
2	W5030	736903	3527714	7.88	5.1
3	W5033	736231	3526188	18.44	8.3

'What is the sar value for each location?' is a spatial query, and 'Which wells have a sar value of (7.88)?' is a spatial query that can only be answered using latitude and longitude data, as well as other information.

GIS links up different sets of data. As previously mentioned, the linkage occurs when there are two different files with items in common. Some kinds of information are collected with more details attached, or less frequently than others. For example, the depth to water-table factor is measured quite frequently. On the other hand, pollution data is collected at less regular intervals. If the two types of data are for the same well, then the solution to making the date match the same well is to create two separate files and then match them using the common item (well #).

In this manner, the quality of water resources can be analyzed on the basis of the GIS system.

4.2 Drainage Pattern Delineation, Gully and Channel Development and Erosion

The GIS enables the collection of a flow accumulation data set which can then be used in predicting flow-water and delineating potential drainage patterns. This is particularly true in areas of high relief such as the West Bank. The ARIJ GIS unit is working to build a model for drainage patterns in the West Bank, and for that, a Digital Elevation Model (DEM) with Z-value and a pixel of 50 was especially developed for the West Bank. The model was built using the finite difference techniques of the Topographer Model of the PAMAP GIS software version 4.2. This finite difference technique is considered to be suitable for using trend data as the input data. Trend data represents the overall shape of the terrain being analyzed. It is usually made up of contour lines. Figure 5 shows the DEM produced.

A three-dimensional perspective view showing the drainage pattern of the West Bank was constructed using the above-mentioned DEM (Figure 6). This view was also built up using the perspective view model of the Topographer Model of the PAMAP GIS software version 4.2.

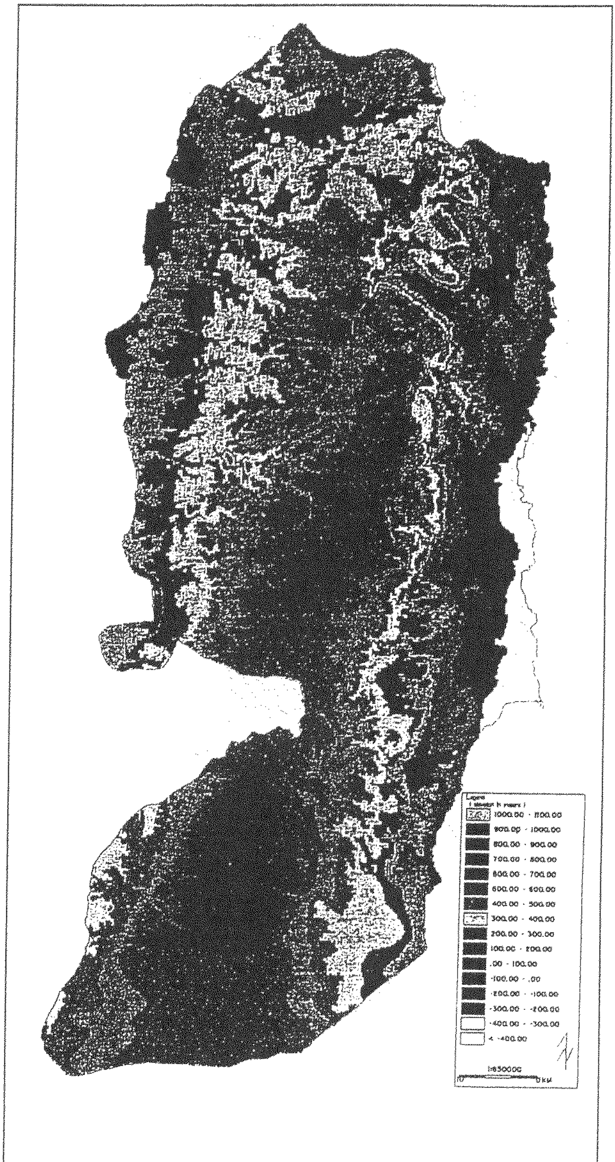


Figure 5. DEM of the West Bank

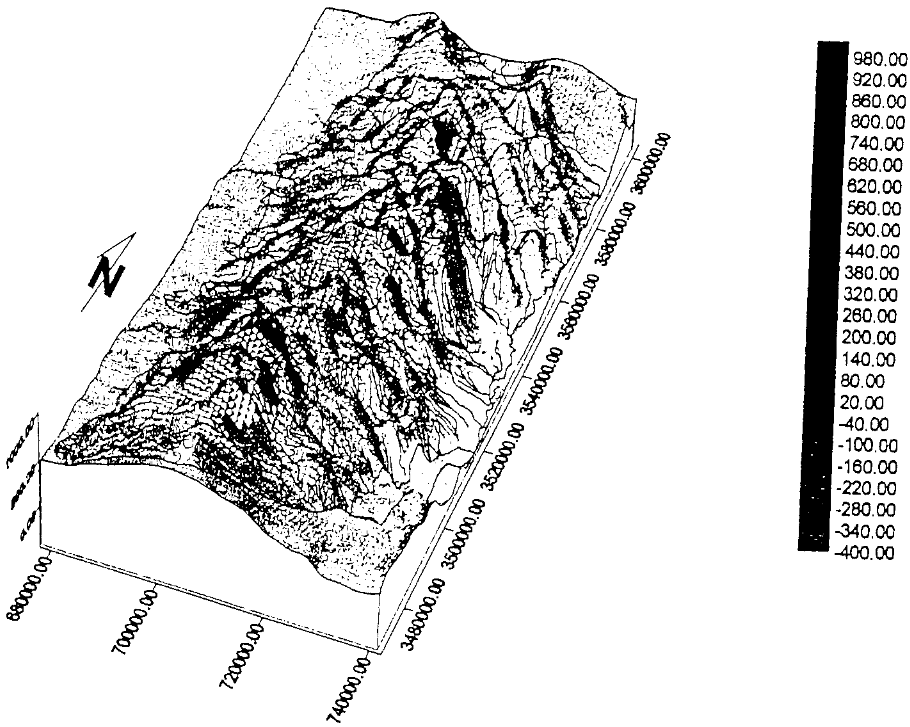


Figure 6. A Three-Dimentional Drainage Model of the West Bank

It is important to note that drainage-pattern data is essential for the GIS, as too is data on soil, vegetation, geological and precipitation parameters: The potential exists for predicting gully and channel formation and estimating the attendant erosion.

4.3 Stream flow Modeling

The same flow accumulation data set, if used in conjunction with rainfall, runoff and channel slope, can potentially be useful in modeling stream flow and carrying capacity for separate time intervals.

4.4 Locating Sediment Sinks and Potential Aquifer Recharge Areas

The GIS can help in the location of topographic depressions on the modulated surface. In conjunction with data on other environmental parameters, this information can be used to find the areas of sedimentary deposition and of aquifer recharging.

4.5 Planning and Placing Man-made Erosion-control Structures and Reservoirs

Knowledge of flow patterns, natural sediment sinks, and watershed boundaries can be of direct help in determining the best location for man-made sediment control structures. Although the GIS permits watershed modeling for potential dams, and the areal insertion of information on the elevation of spillways into DEMS, it is possible the areal extent and volume of reservoirs created by the dam.

4.6 Riparian Area Modeling (Dead Sea area)

Models of sediment yield and stream flow can be useful in determining the influx of sediments and pollution into streams from a non-point source. The GIS program that delineate the steepest overland flow paths have the potential for modeling pollution from point sources. Areas of potential pounding and deposition of sediment can be identified by the GIS because it has the capability to detect surface depressions.

5. CONCLUSIONS

So far, a number of potential uses of GIS in water management have been outlined. Many other applications for water management are also possible. Various hydrological models may be explored for potential interfacing with spatial data processing. Once the design of a particular model that forms part of a tool-set is completed, the model may be tested and verified against actual data collected in the field. If successful, it could provide whole sets of methods for field offices to use in watershed planning and management. These methods should facilitate and improve both the utilization of the GIS'S capabilities and informed planning and decision-making related to watershed management. The time has come for water experts in the Middle East to use the GIS in data exchange and water management and to address the sensitive issue of water allocation.

REFERENCES

ANDERSON, L. 1993. The Use of GIS Linked to Hydrological Models in the Nordic Countries. Paper presented at the International Conference on the Application of Geographic Information Systems in Hydrology and Water Resources Management. Vienna. Austria. 19-22 April.

APPLIED RESEARCH INSTITUTE. 1995. *Geographic Information System*. Jerusalem: Applied Research Institute.

1995. *Ground Water Database*. Jerusalem: Applied Research Institute.

BLASCZYNSKI, J. 1993. GIS Modeling Tool-Sets for Watershed Analysis and Management. Paper presented at the International Conference on the Application of Geographic Information Systems in Hydrology and Water Resources Management. Vienna. Austria. 19-22 April.

BOGARDI, J.J. 1994. The Concept of Integrated Water Resources Management as a Decision-Making Problem: Multi-Criteria Decision Analysis in Water Resources Management. Paris: UNESCO.

BRODIE, B. 1993. Compilation of Hydro-Geological Parameters Using a GIS: An Australian Information Paper presented at the International Conference on the Application of Geographic Information Systems in Hydrology and Water Resources Management. Vienna. Austria. 19-22 April.

ECONOMIC AND SOCIAL COMPARISONS FOR WESTERN ASIA (ESCAWA). 1992. *The Role of Geographic Information Systems in Planning*.

ESP. 1995. Reference Guide, Version 4.2.

ESRI. 1990. Understanding GIS: *The ARC/INFO Method*.

ISAAC, J. and SELBY, J. 1996. The Palestinian Water Crisis. *Natural Resources Forum 20 (1): 17-26.*

KIRCHOFF, C., BUSCHER, K., HINRICHS, G. & STREIT, U. 1993. Approach to an Integrated Application of GIS as Part of a Hydrological Information Systems in Hydrology and Water Resources Management, Vienna, Austria, 19-22 April.

LO, C.P. 1986. *Applied Remote Sensing*. New York: Longman Scientific and Technical.

OWEWI, M., ISAAC, J. & SABBAH, W. 1995. Application of GIS in Water Resource Management. Paper presented at the International Symposium on a Strategy for Water Sector Capacity Building in Palestine. Birzeit, Palestinian Authority. 6-7 September.

QUMSHIEH, V., OWEWI, M. & ISAAC, J. 1996. Establishing an Environmental Protection is a Must. Alexandria. Egypt. 21-23 May.

SHUVAL, H. 1993. Estimate of the water resource and water demands of Syria, Lebanon, Jordan, Palestine and Israel up to the year 2025. Harvard Middle East Project.

WOLF, A. 1993. Principles for confidence-building measures in the Jordan River watershed. Paper presented at the International Symposium on Water Resources in the Middle East: Policy and Institutional Aspects. University of Illinois.

V

ISSUES AND INNOVATIVE OPTIONS FOR GROUNDWATER MANAGEMENT AND ALLOCATION

Chapter 18

The Use of Economic Instruments for Efficient Water Use

Possibilities for Joint Groundwater Management in the West Bank and Gaza

Steve Lonergan
Centre for Sustainable Regional Development, University of Victoria

"The perception of water as a symbol of ritual purity exempts it to a certain extent from the dirty rationalities of the market."

Kenneth Boulding (1964)

1. INTRODUCTION

The importance of demand management as a key component to any joint water management effort between Israelis and Palestinians regarding the use of underground water has been discussed previously (Lonergan and Brooks, 1994).[1] The conclusion in these studies was clear: there is a pressing need to focus on demand-side approaches for dealing with water resource problems. Demand management must be a key aspect of any joint groundwater management institution involving Israel and the Palestinians. One essential component of such a policy relates to the establishment of an appropriate price structure for water. Ideally, water users should be charged a rate which is equal to the marginal cost of supplying the water. Although most political jurisdictions have developed water pricing structures, generally they are based on principles of cost recovery rather than demand management. Although there has been considerable debate over this issue, the demand for

1 See also Brooks in this volume.

water *is* elastic in most cases, and marginal cost pricing *will* affect the demand for water. However, to be effective any pricing measures must also be accompanied by conservation policies.

While appropriate pricing policies are one component of an overall demand management strategy, they are also closely linked to a broader set of economic instruments which are being promoted to achieve optimal levels of pollution as well as the most efficient pattern of resource use. Such instruments include water banking, water markets, tradeable permit systems and water auctions. The purpose of this paper is to briefly outline a set of economic incentives relating to water use which are being used in other regions of the world and to assess their potential to contribute to the joint management of underground water supplies in Israel and the Occupied Territories. The paper contains three main sections: (1) a brief discussion of markets and their role in resource management; (2) an overview of economic instruments pertaining to water supply and use, and examples of regions where such instruments have been applied; and (3) an assessment of their utility to contribute to effective joint management of groundwater resources between the Israelis and the Palestinians.

2. COMPETITIVE MARKETS AND RESOURCE USE: A BRIEF OVERVIEW

When economists refer to "markets" or "market-oriented instruments," they are simply referring to a situation where the forces of supply and demand determine the prices for certain goods. There are certain basic requirements for markets to function perfectly, and these will be discussed below. Basically, for any scarce resource - including water - under a "free" or unfettered market, individuals will bid for the resource until the price is determined by how much people are willing to buy and what they are willing to spend. While water poses certain unique problems because it is often seen as a "symbol of ritual purity" and therefore has symbolic as well as instrumental value,[2] for the moment we will assume that it should be treated like any other resource or commodity. If there is more water available than people are willing to buy at a certain price, the price will fall. Viewing water as a commodity that is freely bought and sold should result in an "efficient allocation" of resources. That is, water will be allocated to its "highest valued use." The value of the resource - actually, the minimum value - therefore, is represented by the price paid for the resource. The purpose of

[2] These terms can be attributed to Habermas. Instrumental value includes, but is not confined to, economic value.

any market-oriented policy is simply to produce the most efficient resource allocation possible.

However, the strength of the concept of efficient resource allocation is tempered by a number of criticisms (see Baumol and Oates, 1975; or Brajer, 1989, for a more detailed discussion). These include:

1. The focus on efficiency of use ignores principles of equity. The market simply assumes that all potential buyers are equally well-off.
2. The market does not, necessarily, reflect needs as much as it does wants.
3. Efficiency criteria also ignore future generations. The efficient allocation of resources is efficient only for today's generation; future generations have no influence in decisions, and must be looked after by the State (which, in turn, must affect the operation of the market).
4. Externalities - or external factors of production, which may be positive or negative - are not included in the search for efficient resource allocations. These externalities can include the social costs of pumping an aquifer or discharging wastes into a stream, for example.
5. For a market to work effectively, property rights must be well-defined. The extreme example of this is the difficulty in valuing collective or "public" goods.

Therefore, despite the importance of efficient resource allocation which can be furthered by a market system, there are distributional issues, externalities and problems with public goods which affect the functioning of a market. These also affect the utility of using market instruments for certain resources, such as water. More importantly, in terms of designing policies and joint management institutions which would promote economic incentives for greater efficiency in resource use, there a four important requirements of a market (see more detailed discussions in Tietenberg, 1988; Brajer, et al, 1989). While some of these were covered in my earlier paper in the discussion on appropriate water pricing, they bear repeating (adapted from Brajer et al, 1989).

2.1 Property Rights Must Be Well-Defined

Property rights, which define a resource owner's rights, privileges and limitations with respect to a given resource, have four primary characteristics: ownership; specification of rights; transferability; and enforcement. *Ownership* simply assigns the right to use a resource to a specific party (subject to possible restrictions). *Specification of rights* then specifies what rights an owner has over the use of her/his resource. *Transferability* is crucial for markets since individuals must be able to buy, and sell, the resource. And *rights must be enforced* or others can simply take them away (in which case there are no "rights"). These four characteristics are necessary for transactions to take place. How water rights are specified in the region will affect how well economic incentives are able to work.

2.2 Multiple Buyers and Sellers

For a market to work effectively, there must be competition between sellers and between buyers. No one group should have the power to fix prices or to even influence prices.

2.3 Resources Must Be Mobile

Water must be very mobile to ensure a well-functioning market. If water is not mobile, it effectively reduces the number of buyers and sellers. An example of such a situation is Jordan. Irrigation water in the Jordan Valley has historically been priced very low, less than $0.01/cu.m. (recent policy changes have increased the price of water to farmers, however). Water in the Highlands which is pumped from individual wells is priced at the cost of recovery, since owners pay the capital, operation and maintenance costs. And in the south, water from the Disi aquifer is heavily subsidized for use in agriculture. This results in spatial discrepancies in resource availability - related to the mobility of water - which affect the operation of a market. This is, quite obviously, important for water, since its mobility is a function of the distribution system in place at a given point in time. Some communities in the West Bank are still not serviced with piped water.

2.4 Information Must Be Readily Available

Complete information about the availability of both buyers and sellers must be accessible to all. It must also be costless.

I will return to these four requirements during the assessment of the potential for economic instruments for any joint Israeli-Palestinian groundwater management institution. Suffice it to say that markets do operate even when all these characteristics are not completely satisfied. The next section of the paper reviews three economic instruments to promote efficient water use; water markets, water banking and water auctions.

3. ALTERNATIVE ECONOMIC INSTRUMENTS FOR EFFICIENT WATER USE

To promote the efficient use of water, two types of economic instruments- or so-called market oriented approaches - can be applied. The first relates to raising the price of water to promote efficiency. An alternative to this is simply auctioning water to the highest bidder. The purpose of higher prices is not only to induce conservation of existing supplies, but to encourage a reallocation of water to higher valued uses. The issue of prices has been discussed elsewhere (Baumol & Oates, 1975; Winpenny, 1994) and will not be repeated here. Rather, I focus on the second type of instrument, one that is based on the formation of water markets.

3.1 Water Markets

The purpose of water markets is simply to provide an incentive for buyers to use water for activities where the returns are greater than the marginal value of water, and to sell the rest. Where water rights are well defined, water markets give the owners an opportunity to sell any or all of their water. This promotes efficiency in water use, since there is now an incentive for owners to sell water which is in low-valued uses. Water markets also help avoid unnecessary investment in new sources of supply (and the associated environmental and social costs, if any).

Water markets can also operate when water allocations are assigned to users by a regional authority (even though the individuals do not have ownership rights over the water). However, this can be problematic (from an equity perspective) when allocations are made at subsidized prices.

3.1.1 Examples

Groundwater markets have existed for almost a century in South Asia (Shah, 1989; Winpenny, 1994). Water owners - mostly farmers - sell their surpluses to other farmers, generally on a temporary basis. Sales are made via an extensive water distribution system, and sellers tend to be large farmers, while buyers tend to be smaller farmers (Winpenny, 1994). One of the major problems with these markets relates to the concern with externalities noted above. Sales of water encourage more rapid depletion of groundwater resources, and there is indication that groundwater mining is occurring in some regions, notably parts of Gujerat, India (Winpenny, 1994).

Surface water markets exist in the United States, particularly in the West and Southwest (e.g., Saliba and Bush, 1987; Thorson, 1989; Robinson and MacDonnell, 1990; Dudley, 1992; Griffin and Boadu, 1992). In most cases, surface water is allocated based on the prior appropriation doctrine, which requires that water users have a permit - which effectively assigns a property right - to divert water. Assuming the existence of well-defined property rights, a major constraint to the successful operation of water markets is the transaction costs associated with the transfer of water. These include legal and institutional costs of operation and enforcement. Various forms of marketing systems exist, including local marketing, regional marketing and marketing amongst industrial users. Local marketing is quite common in the western U.S., allowing water to be allocated to higher-valued uses within agriculture and between agriculture and other domestic/industrial uses. Although there has been some concerns expressed about the environmental and social costs associated with such transfers of water (see Saliba and Bush, 1987), in most cases these concerns are incorporated into decisions on transfers (Winpenny, 1994). There are also cases where individual companies have bought and sold water in regions where public supplies are scarce. Many of these measures involve firms in India which sell surplus water to other firms or develop recycling programs by providing tertiary treatment for municipal sewage (Bhatia, et al, 1993).

Regional marketing of water is also prevalent in the U.S., and generally involves a state or regional agency leasing water and then redistributing it for supplemental irrigation or for domestic/commercial use. Regional markets are quite active in Colorado, Montana, Texas and New Mexico.

Despite the concern over environmental and third-party (social) costs associated with water transfers, most of the experiences with water marketing have been positive. However, Saliba (1987) notes that we still have not been able to quantify the costs and benefits associated with water markets. In addition, high transaction costs are often blamed for inhibiting market transfers of water (Colby, 1990; Dudley, 1992). In these cases, only a large disparity in the value of the alternative uses precipitates transfer.

3.2 Water Auctions

One of the most direct ways of determining the value of any commodity - including water - is through an auction process. Water auctions, a form of water market, are documented in only two countries, Australia and Spain (Winpenny, 1994). Auctions generally require that legal entitlements to the water are held by a central agency, which is then free to distribute the water to the highest bidder. With a large number of competitive bidders, water auctions would result in an allocation to the highest valued use. In the case of Australia, water auctions were held by the Rural Water Commission in the State of Victoria in 1988 and 1989. The auctions were of limited success, since much of the available water remained unsold (buyers were not willing to bid higher than the reserve price) and the actual application of water was limited, since most buyers purchased the water for drought security rather than immediate use.

The auctions in Huerta, Spain, are well established, and operate in a region where the demand for water is high. Total water available is only one-quarter of that needed, and tickets are sold which allow buyers to take a fixed amount of water for a certain period of time. The government exerts little influence over the bid price, and the system works reasonably well, according to Winpenny (1994).

3.3 Water Banking

Water banking is simply the storage of water (usually during times of drought) for later use. In its simplest form, water banking includes the recharge of underground water supplies, either through surface reservoirs or artificial recharge mechanisms.

3.3.1 Examples

Water banking was formally established in the State of California in the U.S. in 1991, with the creation of a state water bank to reallocate water during extreme drought periods. The water bank was formalized after a number of large municipalities sought to buy water from individual sellers to supplement their dwindling supplies. The water bank was designed to meet four needs: municipal and industrial demand; agricultural demand; protection of fish and wildlife; and storage for later years (Loomis, 1992). The water bank paid sellers of water $125 per acre foot, and participation in the program was strictly voluntary. The water was supplied by leaving cropland fallow, substituting surface water with groundwater, and available storage. The selling price was set at $175 per acre foot, and was purchased primarily by municipal users (and water districts) such as the City of San Francisco and the Southern California Metropolitan Water District (which serves Los Angeles). In its first year, there were 351 sellers and 13 buyers.

As an emergency measure, the California water banking experience was a successful one, despite the inequity which was initially created between environmental uses of water and municipal uses. With the State acting as a broker, transaction costs were limited and negotiations proceeded quickly.

3.4 Transferable Permits

One other market instrument has been tried for promoting more efficient water use. This is a transferable permit system, which has operated in New South Wales, Australia since 1984. In this case, water allocations are made for agricultural, industrial, recreational and environmental purposes, and these allocations - or permits - can be traded (subject only to a veto by the State). A similar mechanism has been proposed by the U.S. Bureau of Reclamation (Moore, 1991). As a means of conserving water, or limiting pollution, tradeable permits can be effective in promoting efficiency, and meeting certain specified targets. In the absence of well developed individual property rights for water, tradeable permits may offer an appealing market mechanism which can accommodate both efficiency and equity concerns.

Most permit systems have been designed for emissions trading. Firms or regions have given permits to emit a certain amount of pollution (SO2 and NOx are the most common, but CO2 is also being traded). The permits can be traded or sold, for example, if one firm has a surplus and doesn't need part of their permits. A recent trade between two state utilities in the U.S. even involved trading permits for two different pollutants. There are five main advantages to a permit system when dealing with emissions. First, once total emissions have been decided on, the permit systems allow firms and organizations to decide on the most appropriate way of achieving these emissions. The same would hold true with water. Second, there is a continued incentive for firms to invest in improvements in technological efficiency. Third, permits avoid the problems of inflation and adjustment costs that occur with tax and subsidy systems. And fourth, this procedure promotes efficient water use and equity. There are also many other provisions which could be included - such as 20% of the permits get retired in any trade, guaranteeing that pollution - or water consumption - decreases over time. However, as with all resources, the allocation of the permits is a sticky issue.

In the case of groundwater in the West Bank/Gaza, the permits could be allocated with a lease provision as part of the deal. This might offer enough to allow for a discussion of the controversial water rights issue. There is concern on the part of many Israelis - and justifiably so - about the impacts on their economy if they suddenly reliquish large amounts of water. But they are also aware of the economic benefits of development in the Territories. A permit system might help allay these fears and work towards efficiency and equity. For example, for every 100 units of water allocated to the Palestinians, one-quarter might be leased back to the Israelis in short-term leases (e.g., 5 yrs.), one-quarter in medium term leases, and one quarter in long-term leases. As the Palestinian community needs more water, the leases can be retired (or, if warranted, renewed). This type of arrangement has two implications. First, it gives the Israelis some flexibility in developing alternative sources of water, in restructuring agriculture, or in coming up with alternative arrangements to minimize the potential economic shock. In terms of economic security, this is an important, if not vital, consideration. Second, the leases will bring income to the Palestinians to assist in development and, as more water is required, it becomes available. If the income from the lease of water is more valuable than the water itself, there remains the option to renew the leases. This is, of course, a form of water market, with the addition of the guaranteed lease in the first instance. The transfer of water would initially take place through Mekorot's system, and then later through whatever system the Palestinians choose.

4. CAN MARKET-ORIENTED INSTRUMENTS CONTRIBUTE TO EFFECTIVE JOINT MANAGEMENT OF GROUNDWATER IN ISRAEL, THE OCCUPIED TERRITORIES AND GAZA/JERICHO?

In the first section of this paper I outlined four important requirements of a market in order for it to function effectively. These were: property rights over water must be well-defined; there must be many buyers and sellers; water must be mobile; and information must be readily available and costless. How well are these conditions met at present in the region, and can a joint groundwater management institution ensure that these requirements are met in the future?

It is the case in most jurisdictions that property rights for water are either poorly defined or are mixed among individuals, the state, or the public. At present, "rights" over groundwater throughout Israel, the West Bank, and Gaza lie primarily with the State of Israel, although there are some privately owned wells and municipal wells in the West Bank and Gaza. Immediately, this poses a problem for the operation of water markets. In addition, it affects the second requirement as well, that there be many buyers and sellers. However, markets can still work well when water can be allocated to individuals. Wishart (1993) has called for the establishment of a water bank in Israel, and feels that the water distribution system in the country, as well as the ability of the State to allocate water to individuals, would ensure a strong market for water. The situation is less clear for the interjurisdictional situation with groundwater, however, as the issue of property rights remains muddled.

The second requirement pertains to the existence of a large number of buyers and sellers. At present, there is not the number of buyers or sellers to warrant the establishment of a market. This would only occur once a system of water rights was put into effect or a system of water allocations. There still remains a concern over the distribution of income between buyers and sellers, however. Even if there are a large number of buyers and sellers, they can be classified into two groups; domestic, commercial and industrial users, and agricultural (see Chan, 1989). The activity in any water market will be dominated by the first group, since they are able to pay a higher price for water. While this may promote more efficient use of water (indeed, many have advocated a move away from water use in agriculture to less water intensive economic activities), it must be accepted that this mechanism would have similar results as would reallocating water from agricultural to industrial uses.

The third requirement relates to the mobility of water. There is a political as well as a physical aspect to water mobility in the region. While Mekorot has a well developed water supply system, it is unclear whether the distribution of water to the Palestinians by Mekorot is an acceptable situation. At least the physical infrastructure needed to promote water trading is available; this may be appropriate in the short term until a Palestinian operated system becomes available.

Last, information must be readily available. While this has not been the case over the past thiirty years (indeed, it has been a major source of concern expressed throughout the multi-lateral peace negotiations), the situation is changing. I expect that the data issue will be resolved in the near future and that information will be accessible to all.

So, are the conditions appropriate for the development of water markets between the Israelis and the Palestinians? The lack of well-defined property rights for water in the region poses an almost insurmountable barrier to the development of water markets. Until water allocations, a division of water, or water rights have been decided on, it would be difficult to imagine a smoothly operating market for water. The other three conditions - many buyers and sellers, water mobililty, and availability of information - appear less a problem and could be accomodated once property rights are set. One possible option would be to develop a system of water permits. While still requiring an allocation of water amongst the parties, a lease system could be included to minimize the concern over economic security for Israel. Despite the fact that many water markets operate without all of the four requirements being completely satisfied, meeting the condition of water rights is necessary for any market to operate effectively.

5. CONCLUSION

The discussion above was an attempt to briefly review a series of economic instruments which have been used to promote greater efficiency of water use and to assess these instruments relative to their potential for joint groundwater management between Israelis and Palestinians. It must be noted, however, that the use of market-oriented instruments for promoting greater efficiency of water use has numerous critics. As Okun (1975; as quoted in Chan, 1989) notes, "The imperialism of the market's valuation accounts for its contribution, and for its threat to other institutions... Given the chance, it would sweep away all other values, and establish a vending-machine society." And Polanyi (1957; also cited in Chan, 1989) states that, "a self-regulating market demands nothing less than the institutional separation of society into an economic and political sphere..."

The concerns with distributional issues - relating to unequal economic power between institutions or regions and between generations - the pervasiveness of externalities, and the problem of public goods, mandate that some measure of government interference is necessary in dealing with water management in Israel, the West Bank and Gaza. Water is not simply an economic good; it is also essential for human survival and for the maintenance of social structure. And it has important symbolic value as well. Accordingly, the role of market-oriented instruments in promoting efficient water use must be tempered by other concerns. In particular, the issue of equity must be considered at least as important as the issue of economic efficiency when managing this scarce resource.

In addition, many of the characteristics of markets are lacking at present with respect to water in Israel, the West Bank and Gaza. While water rights are well defined in most cases (they lie with the State), the lack of private ownership of water poses problems for the successful operation of a water market. At this point in time, there are also very few buyers and sellers, although a system of water allocations (which would include rights to, but not necessarily ownership of, water supplies) could alleviate this problem. The distribution system operated by Mekorot has made water reasonably mobile, but there remain communities in the West Bank which do not have piped water, and others which are not connected to the Mekorot system. Last, there has been a problem in the past with the availability of information. While this situation is slowly being remedied, until information is readily available, there is little possibility that a market will operate effectively.

Ultimately, the doctrine of "equitable apportionment," consistent with the provisions embodied in the Bellagio Draft Treaty (see Hayton and Utton, 1989) must be incorporated into any joint management exercise. Within that context, market instruments may still be useful tools to promote efficiency of use. They can also be used to address some of the equity problems inherent in the adoption of market solutions. As an example, there has been a loud clamor for a tradeable permit system to deal with transboundary pollutants. One option for reducing carbon dioxide emissions involves allocating permits for CO_2 emissions to countries based on an agreed upon allocation of quotas (which could be a function of population or other variables). These allocations could also be leased to other countries, since some countries will have permits for emissions greater than their present emissions and some countries will receive a lower allocation than existing levels. The result of the leasing process would be to transfer income among countries. A similar process could work with the assignment of groundwater allocations within Israel, the West Bank and Gaza. Part of any agreement on the equitable apportionment of groundwater in the West Bank/Gaza would be the provision of long-term leases to ensure that one party is not irreparably harmed through a cut-off of existing supplies. In turn, equity provisions are addressed through the transfer of income - to pay for the leases - to the other party. Such an agreement could be mutually beneficial, and ensure that existing water supplies would not be curtailed until alternative sources (whether the result of conservation or supply augmentation) became available.

The purposes of this paper were to review a number of economic instruments which have been applied to promoting greater efficiency of water use in various parts of the world and to assess whether these options may be appropriate for joint management of groundwater resources in Israel, the West Bank and Gaza. Two points should be clear from this discussion. First, it is not always appropriate to treat water simply as another commodity; water has symbolic as well as instrumental value, and this must be taken into account when trying to promote greater efficiency of water use. Second, the key characteristics of a market for water do not presently exist in a form that would allow for the successful operation of a market in the region. However, some of these characteristics could be embodied in a joint water management institution that is developed. One of the more interesting options to be pursued might be the development of a tradeable permit system, which has both efficiency and equity components. The successful experiences with water markets and water banking notwithstanding, the development of these instruments with respect to groundwater resources in Israel, the West Bank and Gaza/Jericho must proceed slowly, and with due consideration of the social and environmental costs associated with such instruments.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the support of the Social Sciences and Humanities Research Council of Canada in the preparation of this manuscript.

REFERENCES

Baumol, W. and W. Oates, 1975. *The Theory of Environmental Policy.* Englewood Cliffs, NJ: Prentice Hall.

Boulding, K., 1964. The economist and the engineer. In: S. Smith and E. Castle (eds.), *Economics and Public Policy in Water Resources Development.* Ames, Iowa: Iowa State Univ. Press.

Brajer, V., A. Church, R. Cummings and P. Farah, 1989. The strengths and weaknesses of water markets as they affect water scarcity and sovereignty interests in the West. *Natural Resources Journal*, 29: 489-509.

Chan, A., 1989. To market or not to market: allocation of interstate waters. *Natural Resources Journal*, 29: 529-547.

Colby, B., Transactions costs and efficiency in western water allocation. *American Journal of Agricultural Economics*, 72: 1184.

Dudley, N., 1992. Water allocations by markets, common property and capacity sharing: companions or competitors? *Natural Resources Journal*, 32: 757-778.

Griffin, R., and F. Boadu, 1992. Water marketing in Texas: opportunities for reform. *Natural Resources Journal*, 32: 265-288.

Hayton, R. and A. Utton, 1989. Transboundary groundwaters: the Bellagio Draft Treaty. *Natural Resources Journal*, 29: 663-721.

Lonergan, S.C. and D. Brooks, 1994. *Watershed: The Role of Freshwater in the Israeli-Palestinian Conflict.* Ottawa: IDRC Books.

Moore, M., 1991. The Bureau of Reclamation's new mandate for irrigation water conservation purposes and policy alternatives. *Water Resources Research*, 27(2): 116-132.

Okun, A., 1975. *Equality and Efficiency: The Big Tradeoff.*

Saliba, B., 987. Do water markets work? Market transfers and trade-offs in the Southwestern States. *Water Resources Res.*, 23: 1113.

Thorson, J., 1989. Water marketing in Big Sky country: an interim assessment. *Natural Resources Journal*, 29: 479-488.

Tietenberg, T., 1988. *Environmental and Natural Resource Economics.* Glenview, Ill.: Scott, Foresman and Co.

Winpenny, J., 1994. *Managing Water as an Economic Resource.* London: Routledge.

Wishart, D., 1993. Shock therapy for Middle East water managers. *Proceedings of the International Symposium on Water Resources in the Middle East: Policy and Institutional Aspects.* Urbana, Illinois, October, 1993, pp. 69-75.

Chapter 19

Water Markets, Water Rights and Strategies for Decentralizing Water Management

K. William Easter & Robert Hearne
Professor in the Department of Applied Economics, University of Minnesota, St. Paul, MN, USA
Assistant Research Professor and Environmental Economist at CATIE, Turrialba, Costa Rica

1. MARKET AND GOVERNMENT FAILURES

To implement effective water management, institutional and organizational arrangements must be developed to deal with market and government failures. The major types of market failure are: the positive and negative externalities, which lead to non-optimal resource provision; nonexcludability and nonsubtractability, which contribute to the under-provision of goods or services; and natural monopolies, which result in non-competitive pricing. Nonexcludability refers to the difficulty involved in preventing a non-paying consumer from using a good or service, which then makes it unprofitable for private firms to supply. Village wells and large gravity-flow irrigation systems are, in many instances, faced with nonexcludability problems. Nonsubtractability occurs when the use of a good or service by one individual does not subtract from its value to another. Examples include capital equipment such as dams, water and sewer pipes, and irrigation canals that are not used to full capacity. If there is little or no cost from added utilization of these facilities then expanded use leads to an increase in society's total economic benefits. Goods and services that are both excludable and subtractable such as bottled water are easily rationed by price and provided by private firms. In contrast, goods that are characterized by nonexcludability and nonsubtractability in consumption are classified as public goods because they are difficult to allocate with market mechanisms and are likely to involve government provision. Flood control and instream uses of water are examples of water services that have required government intervention.

Because of economies of scale that result from large, lumpy investments, the delivery of water services has many of the characteristics of a natural monopoly. As a result of this market power, the organizations that supply water can prevent potential competitors from entering the market by charging low prices and then, after the competition is eliminated, charge much higher prices. Such market power can exist at different levels of a water system depending on who controls the water. A measure of this market power is contestability, which refers to the ability of competitors to enter into a market to gain a share of the clientele.

These market failures have led many governments to dominate the provision of water services and discourage private sector investment in water resources. Yet the sources of market failure are not the same in all parts of the water system (see Table 1). Many parts of the system can be organized to minimize market failure and make use of the private sector to improve the efficiency of service delivery. Separate organizations can be responsible for different parts of a water system (Kessides, 1992). Government can provide the capital and obtain the reservoir and canal right of ways and then contract out the construction of the irrigation infrastructure to private firms. After the water system is completed, water users associations, local communities, or financially autonomous utilities can operate much of the system and deliver the water. Such arrangements can help introduce appropriate incentives, improve accountability, increase efficiency, and lower the financial burden on governments. Similarly, water markets can be introduced at different points in the system to provide incentives for efficient water allocation.

Table 1. Public and Private Good Characteristics, Market Power, and Externalities in Water Systems

	Subtract-ability	Exclud-ability	Contest-ability	Externalities
I. <u>Water Supply</u>				
A. Piped				
1. Trunk System[1/]	H	H	L	PH, GD
2. Distribution System	L	M	L	PH
3. Terminal Equipment				
a. Common (i.e. handpump)	M	L	H	PH
b. Individual (i.e. home faucet)	M	H	H	PH
B. Village wells	M	L	H	PH
C. Vending (tanker trunks etc.)	H	H	H	PH

II. Irrigation				
A. Production				
1. Trunk System (dam, main canal)2/	M	M	L	WL, ND
2. Small dams and reservoirs2/	M	M	M	
3. Run of the River Systems2/	M	M	M	
4. Deep Tubewells1/	H	H	M	WL, GD
5. Shallow tubewells1/	H	H	H	WL, GD
B. Distribution System[2/]	M	M	M	WL, ND
C. Terminal system (on farm) gravity				
1. Field to field irrigation	H	L	H	WL, ND
2. Field channels	H	H	H	WL, ND

PH = Public health
WL = Water logging and salinity
ND = Introduction of new diseases
GD = Groundwater depletion
L= Low, M = Medium, H = High

[1/] The degree of subtractability associated with a given well actually depends on the nature of the aquifer from which the well is drawing. High water resource scarcity is assumed. Excludability refers to the tubewell, not the aquifer.

[2/] The degree of subtractability depends on the scarcity of water and the canal capacity.

Source: Adapted from World Bank, 1993.

2. INTERNATIONAL WATER POLICY CHANGES

In response to past weaknesses in water policies and problems of government failure, many countries, as well as international agencies such as the World Bank, have taken a critical look at their activities in the water resources sector. For the World Bank, it resulted in a new water resources management policy that was approved by the World Bank Board of Directors and published in September 1993. At the core of the new Bank policy are two key components. First is the adoption of a comprehensive management framework which calls for water to be treated as an economic good. Second is a greater decentralization of service delivery, greater reliance on pricing, and financial autonomous service entities, along with fuller participation of water users in the management of water resource systems. The policy encourages countries to develop national water strategies with coherent and consistent policies and regulations across sectors that involve stakeholders in a transparent process of water planning and management (World Bank, 1993).

Some progress has already been made as a number of countries are in the process or have adopted water policies that reflect many of the basic features of the Bank's policy. Countries such as Sri Lanka, the Philippines, Turkey, Indonesia, and some states in India have adopted the approach of promoting and expanding the role of water user associations (WUAs) in water management and system ownership (Gerards, et al., 1991, Uphoff, et al., 1990, and Easter, 1993). Other countries such as Chile and Mexico have taken the additional steps of specifying transferable water-use rights and supporting water markets as a mechanism to help decentralize and improve water management (Lee, 1990). These policy changes reflect two important characteristics of the water sector. First, water has many competing uses that are highly interdependent which gives rise to numerous externalities. What someone does upstream can have an unintended direct impact on downstream users. These interdependencies lead to a wide range of externalities in rivers, lakes, and groundwater use. Second, internalizing these interdependencies through effective government control over water management has proven to be beyond the capabilities of many governments, especially when more than one country is involved.

3. DECENTRALIZING WATER MANAGEMENT

The realization that government agencies do not have to manage all parts of the system and growing financial constraints have pushed governments to rely more heavily on WUAs, financial autonomous entities, and private firms to provide water services. For example, after the inefficient government attempts to develop groundwater in south Asia, most of the development of well irrigation was turned over to the private sector, resulting in rapid expansion of irrigation and food production (World Bank, 1984). Many of the smaller public irrigation systems in the Philippines and Indonesia have also been turned over to farmers (Small and Carruthers, 1991). In other countries, the farmers are taking over operations and maintenance and in some cases the irrigation agency is contracting with WUAs to collect water fees. In Argentina, small WUAs combined to form larger ones that could take advantage of economies of scale associated with water development and use professional management. As a consequence, administrative costs dropped and conveyance efficiency has increased by 10 percent. The twenty-one new autonomous water organizations raise their own budgets and use their own regulations based on the national water law. The direct hiring of professional management improved accountability and assurance concerning the "fair" operation of the irrigation system (Chambouleyon, 1989).

Another mechanism that can improve decentralized water management is the use of water markets. Because of the previously mentioned market failures, it is not surprising that water markets have not been supported by governments. Yet with the growing water scarcity and the large differences in water values among uses, markets are being considered more widely as a means to improve water allocation and to reduce the economic impact of water scarcity. In contrast to water allocation by administrative decision, market allocation guarantees compensation for users who relinquish water. Market decisions are based on individual assessments of the value of water. These assessments are made with information that is available to individual water users but expensive for water agencies to collect. Thus, markets reduce the cost of providing the necessary information for efficient water allocation. Furthermore, the incentive to withhold information from central agencies responsible for water allocation is removed.

Water markets are possible when individuals and institutions have a secure claim to water that is transferable and separate from land – either through a right, a permit, or an entitlement. Because of the compensation received by sellers, tradable water-use rights provide incentives for the transfer of water from low valued to high valued uses and for the improvement in water use efficiency through the introduction of an opportunity cost. Furthermore, a secure supply of water increases producer incentives to make long-term investments in production technology.

For an efficient water allocation that minimizes transaction costs, the water market can work at two levels. The first level is among farmers and other water users within a given water or irrigation district. Second is transactions among water users or WUAs in different districts. Markets at these two levels reallocate water so that water prices minus transaction costs are equalized across and within districts. Gains from such water trades can be substantial. For example, Chang and Griffin, 1992, estimated gains in trade from water sales in Texas to be from \$3,000 and \$16,000 per $1000m^3$. In California, Vaux, 1986, estimated that trades within the agricultural sector would move water from the northern to the southern part of the Central Valley and produce gains of \$10 million annually based on 1980 figures.

For Morocco, Diao and Roe estimate that water reallocation through the sale of water-use rights among farmers would increase Gross Domestic Product by .22 percent and social welfare by .25 percent. Water is reallocated from low values crops to higher value crops and producers of low valued crops maintain income by selling their water. This is quite different from the case where water prices are raised but water is not marketed. In the latter case, all irrigated farmers lose since they have to pay higher water prices but cannot benefit from being able to buy or sell water (Diao, and Roe, 1998).

Several institutional and organizational arrangements are required if water markets are to operate effectively. First, transferable water rights or use rights should be established based on the volume of water, or on the share (percent) of water from a stream or canal flow. These rights should be recorded, tradable, enforceable, and separate from the land ownership. Where volumetric rights are established in rivers with variable flows, as in the western U.S.A., certain rights may have priority for water withdrawal relative to other more junior water rights. Emergency measures may be needed to ensure potable water supply during droughts, but the use of these measures should be limited to preserve the validity of the water rights. In large river valleys where downstream users are dependent on the return flows of upstream users, these return flows should be accounted for in the water right. The return flows can be accounted for by restricting water transfers outside a region to only the portion of the water right that is actually consumed. In irrigation this is, on average, less than half of the water released from the source of supply. In order to guarantee the advantages of economic incentives in water-use, these rights should not specify either location or type of use. To protect the rights of other water users, these rights should have some specification of the quantity and quality of water returned to rivers and canals after use. In addition, some highly polluting uses of water could be banned.

A second important consideration in establishing water rights involves groundwater. Where surface and groundwater are interconnected, problems are likely to occur if rights for surface water are established without doing the same for groundwater. Surface water rights are not secure if someone can install a well next to the canal or river and draw out "your" surface water. The lack of compatible surface and groundwater rights has caused serious water management problems in a number of areas such as Arizona (Charney and Woodard, 1990).

Third, because of the different externalities and interdependencies in water use, a system of enforcement and conflict resolution will be needed. Guidelines should be established for dealing with water rights disputes, third party effects, and discharges into water sources. Also, guidelines for the regulation of natural monopolies should be established. In the western U.S.A., both water courts and a State Engineer's office perform this function. Water or river basin commissions such as those in France could provide the same service.

Fourth, if there are important societal water uses (uses with strong public good characteristics) that cannot compete in the market for water, the public sector can either purchase these rights or reserve them in the initial allocation of water rights. This might involve water for instream water uses such as the preservation of fisheries. Water quality also needs to be included in the rights or defined by effective government water quality standards. If this is not done, water may be supplied in the quantity established by the water right but the quality may make it unusable for the purpose desired. For example, farmers near some major cities have had problems growing vegetables because the irrigated water they receive has been contaminated by sewage discharges that can cause serious health problems when used to irrigate vegetables (Easter, et al., 1998, Ch. 9).

Finally, the initial distribution of water rights is likely to be a contentious issue unless defacto water rights already exist and the primary task is to have them formalized. Where defacto rights do not exist, many countries have avoided conflicts and maintained political support by allocating water rights based on existing land rights in the irrigated area. This works fairly well if the distribution of land is reasonably equitable, as was the case in Chile when water was made tradable. If land ownership is highly concentrated, such as in the Central Valley of California, where large scale farmers captured many of the direct benefits from the subsidized public irrigation projects, then an alternative water allocation criteria or land reform is needed. One alternative is to allocate the water rights to all families (landowners and landless) in the irrigated area, as was done with a small village irrigation project in northern India (Joshi and Seckler, 1982). In this case, the water market was a means to reallocate water rights since some water rights owners had surplus water. The end result was that even landless families benefitted since they could sell their water rights. Thus all families shared directly in the economic surplus (rents) created by the irrigation project. A complementary alternative would be to allocate some of the rights to the WUAs or a river basin authority and use the revenue from the sale of these rights to fund the operation and maintenance of the water system.

4. COUNTRY EXPERIENCE WITH WATER MARKETS

Water markets usually involve either the exchange of a finite amount of water during a specified period of time, or a permanent transfer of water-use rights. The former – sometimes referred to as a spot market–occurs when the owner of a legal or prescriptive right to a certain volume or flow of water sells a portion of that water, sometimes outside of legal sanction, to a neighbor in a simple transaction. These exchanges are for a specified period of time – sometimes for only a few hours of irrigation. Although the unit of sales may not be metered volumetrically, both buyer and seller have good information on the volume involved. A more permanent transaction involves the exchange of the water-use right itself. This generally requires legal sanction to assure the security of the right after the transfer. With permanent transfers, the burden of uncertain supply falls on the purchaser of the right.

4.1 South Asia

Transfers of water between farmers are common, especially in the Indian subcontinent where neighboring farmers trade hours of canal water or of pumping time, often without legal authorization. Informal markets have developed in the large surface water systems of Pakistan and northern India among farmers along a given water course or canal (Easter et al., 1998; Easter, 1986). Farmers have a use right for a certain time period to irrigate from the watercourse that serves their area. The actual volume of water received will vary depending on the water flow but whatever the flow is during farmers' allotted time for irrigation is theirs to use. The trades arc made of all or part of an individual irrigation time allotment. Yet, even on an individual watercourse, the coordination required among farmers can make it difficult to initiate trades. If there are other farmers on the watercourse in between the two farmers who want to trade, then the intervening farmers must also agree to the change in irrigation time. The fact that such water trades are illegal makes it difficult if not impossible for the government officials to help in the coordination of trades. Still numerous trades occur, indicating that both buyers and sellers receive significant benefits from these trades (Easter et al., 1998, Ch. 13; Easter, 1986).

Also in India, where private well development has proven to be the most productive form of irrigation, groundwater markets have made irrigation water available to even the poorest farmers. "Up to half or more of the land served by private modern well extraction mechanisms in many parts of India is likely to be owned and operated by the buyers of water" (Shah, 1993, pp. 48-49). This practice is encouraged by the pricing policies of State Electric Boards, which collect flat fees for each pump instead of a charge for the power used. With a marginal pumping cost that is close to zero, the pump owners' selling price is driven down through competition, and water charges remain low, and near the cost of pumping in many areas (Palanisami and Easter, 1991; Shah, 1993). In areas with limited groundwater stocks, water levels are falling and well owners must deepen their wells or stop irrigating. As would be expected, water prices are much higher in these cases, and above pumping costs because of the high scarcity value of the groundwater. In areas with salt water intrusion, rapidly declining groundwater tables, or aquifer compaction, market prices probably fail to reflect the externalities caused by excess pumping of groundwater and increase the rate at which the aquifer is damaged. But in the areas where canal irrigation causes waterlogging, or where groundwater recharged from monsoon floods is good, increased groundwater pumping has produced major economic benefits for India (Shah, 1993).

4.2 Spain

A very different community-based water market developed several centuries ago in Alicante, Spain, just south of Valencia. The market evolved in irrigation systems of 3,700 ha. which included the Tibi dam built in the late sixteenth century. A system of water rights developed that was partly separated from the land irrigated. Although the water rights were based on allotted irrigation time from a canal, the rights were translated into volumetric units. This was possible because of the control that existed in the system. In contrast to the uncertain flows in the large Pakistan and Indian systems, the Alicante system maintained a constant flow in the canals of 150 l/sec., except in drought years. This, multiplied by the allotted irrigation time, provided a volumetric measure of the water right (Maass and Anderson 1978).

The water market was based on an auction every Sunday morning in the village of San Juan. Buyers purchased tickets for a particular irrigation time during a particular cycle of canal flows. Both irrigators and non-irrigators owned these rights. An analysis of the market exchanges and water allocation by Maass and Anderson (1978) found it to produce higher net returns than two alternate rotation systems used elsewhere in Spain.

4.3 The United States

Permanent transfers of water-use rights are common in the western U.S.A., where water is allocated through priority rights based on seniority (Colby, 1990). Much has been written about water markets in this area, where water scarcity and an evolving economy have encouraged the development of physical and institutional infrastructure for water management. Transfers are well regulated and although the legal system and other mechanisms for conflict resolution are utilized, conflicts continue to occur, especially as environmentalists push for the protection of instream flows and Native-Americans press for traditional water rights (Easter et al., 1998, Ch. 6).

A centralized system of transferring finite quantities of water was established in California. This "Water Bank", started in 1991, takes advantage of the state's extensive system of canals, and allows entities with high valued uses of water to buy finite quantities of water that would otherwise be employed in low valued uses. Despite the fact that actual purchases were limited, municipal areas were able to ensure future supplies of water during the last part of a severe drought. Because transfers of water are volumetric and temporal, sellers are not threatened with forfeiting their permanent water rights. Thus the political difficulties of permanent water transfers were minimized while the economic incentives of water markets were introduced.

Another creative method of transferring water from low valued irrigation uses to high valued urban water uses is through water conservation investments by the Municipal Water District of Southern California (MWD) in the Imperial Irrigation District (IID) in exchange for the conserved water. As part of this accord the MWD agreed to invest $125 million in canal lining, management systems, and tail-water recovery for the IID system (Peabody 1991). Expected savings of 125.8 million m^3 of water per year will be transferred to the MWD for a period of 35 years.

In Texas, three types of water market transfers are found (Chang and Griffin, 1992). One type of transfer is groundwater ranching, where cities buy land and extract the underlain groundwater. Another type is internal transfers of water owned by the states' autonomous river management authorities. The third type is transfers of permanent water-use rights defined under the Texas Water Rights Adjudication Act of 1967. Two types of rights have been established based on Texas' reconciliation of the riparian and prior appropriation doctrines. Under this reconciliation process, termed "adjudication," water-use rights are defined on the basis of the type of right and not on the seniority of the claim. Thus, the effects of water shortages are shared by all rights holders.

In the lower Río Grande Valley, where groundwater is practically nonexistent, permanent water-use rights are traded. This area is experiencing rapid growth, and 70% of the population lives in urban areas, but agriculture is still an important economic activity. All of the state's citrus and sugarcane production is in this valley. In the twenty years prior to 1990, water-use rights to over 94 million m^3 per year have been transferred from agricultural uses to municipal uses. This accounts for 94% of total water transferred in the valley. Because all water-use rights are adjudicated and there are only two types of these rights, the administrative procedures involved in these transfers are relatively expeditious. Also, the interested buyers are well known and the transactions costs are low (Chang and Griffin, 1992).

4.4 Australia

As part of its water reforms, Australia has also encouraged the development of both permanent and temporary water trading among farmers. The large Murray Darling Basin in southeastern Australia has been the focal point of water reform and water market development. This basin, which accounts for about 40 percent of the value of Australia's agricultural production, is heavily dependent on irrigation. Thus, it is not surprising that this was the focus of Australia's water reforms. These reforms included: water pricing to reflect all costs, specification of water rights, allowing and facilitating water trading, reform of water utilities and regulatory agencies, and involving water users in the water reform process and in water management. Thus, Australia was clearly trying to improve water use by decentralizing allocation and other management decisions.

The establishment of water rights and trading has only occurred in some areas. In addition, temporary water trades have been more extensive than permanent trades. For example, in the Goulburn-Murray sub-basin, between 1994 and 1997, the annual number of temporary trades ranged from about 1,400 to 2,600, while permanent trades average around 200. The number of trades has been limited by the lack of canal capacity and other infrastructure to deliver the water, particularly during periods of peak demand. In addition, the uncertainty concerning seasonal conditions and future water policy have lowered the number of permanent trades relative to temporary ones. (Bearne, et al., 1998). Another constraint to water trading in the Murray-Darling Basin has been the complex institutional arrangements. Only a subset of water users have water rights that can be exchanged freely among users. Thus, although water markets have been used to reallocate some water in Australia, there is still scope to expand the use of water markets.

4.5 Chile

Chile is one of the few developing countries that has encouraged the use of markets in water resource management. Market allocation in Chile is feasible because a system of transferable water-use rights was established with the National Water Code of 1981. This law states that water is a national resource for public use but that permanent and transferable rights to utilize water can be granted to individuals in accordance with the law. Although the law stipulates that rights are to be specified by volume of flow per unit of time, in reality rights are defined as a share of stream flow. This use of shares follows a traditional practice used since the development of canal irrigation by Spanish colonists.

Water-use rights are specified for consumptive and non-consumptive use. Non-consumptive rights oblige users to return the water in a form specified by the right which does not damage the rights of other users. Consumptive use rights are granted for the full use of all the water stipulated in the right. Thus, downstream users do not have rights to return flows generated from upstream users. Water users in downstream sections of a river have rights to the water that enters rivers through springs, rainfall, and return flows from upstream sections of the river. These rights holders are not protected by the law from any change in upstream water use that significantly reduces the water that they receive through return flows or springs. There is also no restriction on the transfer of water to another basin.

Water-use rights are also required for groundwater exploitation. Individuals can request from the General Directorate of Waters (DGA) a right to groundwater, once they have confirmed the existence of a certain well yield at a certain depth. A groundwater use right establishes a specified protective area where other wells are prohibited.

Most water-user rights have been retained from the private development of canals and later redistributed, along with land, during the land reforms of the 1960s and 1970s. The Water Code stipulates that individuals can petition the DGA for water-use rights. However, most rivers in the arid north and fertile central valley of Chile were completely claimed and divided before the 1981 law. The government did, however, grant large quantities of non-consumptive rights, mostly to developers of hydroelectric projects in southern Chile. Although these non-consumptive rights were not supposed to interfere with established consumptive rights, conflicts have occurred (Bauer, 1993).

Conflicts between water users are generally resolved within water user associations. The DGA does have limited powers to regulate natural channels, and can intervene in disputes when water user associations misuse their power. During times of drought the DGA can impound water, with compensation to water rights holders. The ultimate arbiter in water conflicts is the judiciary. Yet the effectiveness of the courts in conflict management has been limited by judicial restraint and formalism (Bauer, 1993).

The market exchange of water-use rights is common in several valleys in the northern and central regions of Chile. All titles and exchanges are recorded in the local real estate registry. Since water flows are controlled by water users associations, these institutions play a key role in all water transfers. Many water-user rights are not formal titles and these are recorded only with the water user associations.

In order to assess water markets in Chile, four river valleys, the upper Maipo Valley in Chile's central valley, the Elqui and Limarí Valleys in north-central Chile, and the Azapa Valley in the far north of Chile were chosen for case studies (Hearne and Easter, 1995). These valleys were identified because of prior information which suggested that there was – or should be – active water trading occurring there. In the survey of these areas, only a few transactions were identified in the upper Maipo Valley – except where water-use rights were ceded to municipal water companies by developers of urbanized land. Similarly, in the Azapa Valley, only a few transactions were found. In the Elqui Valley, transactions were infrequent, but there was significant intersectoral exchange of water as well as a slow transfer of water-use rights within agriculture. In the Limarí Valley, with its well developed system of irrigation infrastructure and well organized WUAs, transactions were frequent.

The Elqui Valley in Chile's IV Region supplies water for 18,700 ha of farmland as well as potable water for the medium sized urban area of La Serena/Coquimbo (250,000 inhabitants) with a very large summer population. Major crops include table grapes, pisco grapes, other fruit crops, potatoes, and pasture. Rainfall is scarce in this region with an average yearly precipitation of less than 120 mm. There are 25,000 total shares of water in the Rio Elqui, each share is supposed to deliver 1 liter/second in a good year, although 0.5 liters/second is generally considered closer to the average.[1]

In the Elqui Valley, a limited set of 47 permanent transactions for the period of 1986-1993 were identified. Included in these transactions were purchases made by the local municipal water supply company which bought 292 shares of the river amounting to 28% of its 1992-93 water-use rights. Ninety percent of the shares sold in this valley have not been used by their sellers in recent years. Some of these sellers had surplus water, others had rights to water along canals with high water losses, others no longer farmed, and still other sellers owned rights to water but did not own land.[2]

The purchase price of shares from the Elqui River is quite variable, reflecting transaction costs and in many cases, the particular conditions of buyers and sellers. The water supply company's average purchase price in 1992-93 was near US $1,100 per share. During the same period, small plot developers in the lower Elqui Valley were paying US $2,500 per share for water in a conveniently located canal. The price per share for sales between individual irrigators ranged from US $250 to US $1,000. Often the differences in prices reflect the individual circumstance of the seller. Transaction costs for most transfers are relatively low because this is a narrow valley with many short canals flowing directly from the Elqui River and its tributaries. However, some water buyers, especially the municipal water supply company, did need to investigate title claims and had transactions costs equaling 21 percent of purchase price. Gains-from-trade were estimated to be close to the transactions price of $1,000 (Hearne and Easter, 1997). Both buyers and sellers benefitted from these trades, with buyers, especially those using water for potable supplies, receiving, on average, three times the benefits of the sellers.

1 At 0.5 liters/second per share, one share delivers 15.736 m^3/year.

2 All water that is not used by its owner is generally used by neighboring farmers in the same canal or section of the river, except in years of surplus water.

South of the Elqui Valley in the IV Region is the productive Limarí Valley. This valley has 50,000 ha of irrigated farmland producing table grapes, pisco grapes, horticultural products, basic grains, and pasture. A central feature of this valley is the presence of a large interconnected system of three interseasonal storage reservoirs with a total storage capacity of 1 billion m3. Also, flexible gates and well organized WUAs allow for volumetric specification of water-use rights. This is a dry area with a mean annual precipitation of 140 mm. There is one small city, Ovalle, with a population of 80,000 that draws water from the Limarí River.

Many of the permanent transfers of water-use rights in this area involve large acquisitions of both land and water by a few large table grape exporters. Some of these transactions entail a shift away from traditional crops to higher valued fruit corps. Also, in the last few years, many small and medium sized farmers have forfeited land and water rights to fruit exporting companies in lieu of debts owed to the companies.

Prices range from US $3,000 for a right with an average volume of 4,500m3/year in the table grape producing area above the Paloma Reservoir, to US $500 for a share with the same volume below the Paloma Reservoir. This difference in price reflects both the premium placed on water in the hot, dry sunny uplands, and the prohibition on transferring water-use right from below Paloma Reservoir to canals above the dam. The value of reservoir storage is demonstrated by the fact that a water-use right in the Limarí Valley is generally worth more than a water-use right in the Elqui Valley that delivers five times as much water.

Gains-from-trade per share in the Limarí Valley were estimated to be about 3.4 times the 1994 transaction price of $3,000. Financial gains from these transactions were captured by the buyers, especially by large table grape producers. The financial gains to many of the sellers, mostly small farmers, were negligible.

The upper section of the Maipo River supplies water to 4.5 million people in the Santiago area while irrigating nearly 100,000 ha of urban, suburban, and agricultural land. The river is divided into 8,133 shares, each representing 8 liters/second, 85% of the time. In this valley, there have been very few transactions of water-use rights in the past eight years before 1993. The Metropolitan Sanitation Works Company had contracted a team of lawyers to purchase rights but only 33 shares of the Maipo were purchased in the eight years before 1993, with prices averaging US $10,000 per share. The only industrial concern to purchase water rights was a paper mill which made two purchases totaling 4.5 shares. There are also very few permanent trades between farmers. In the large canal systems of five WUAs, which distribute 65% of the irrigation water in this section of the river, there were only a handful of trades between farmers. All of the canals in the five

WUAs have fixed flow dividers to distribute water which raises the transaction costs of trading.

The Azapa Valley, which is located in the downstream section of the San Jose River Basin in Chile's far north supports 3,280 hectares of irrigated farmland and supplies water to the city of Arica (population 160,000). This valley, bordering the extremely arid Atacama Desert, is very dry and rainfall in the lower reaches is negligible. The municipal water supply company which supplies water to Arica, has been able to use rental agreements to meet the short-term crude water needs for the city of Arica. This company is renting wells from owners of groundwater rights, and has increased groundwater pumping in the Azapa Valley, despite recent indications that the Azapa aquifer is being drained at an alarming rate.

Various government agencies, responding to a presidential mandate to give Arica's water supply a priority in government action, have assisted in the transfer of water to the city. In the negotiations with farmers, the water supply company was able to both invoke the government's appeal to farmers to release water for Arica and the possibility that the state could impound water during severe water shortages. Given these groundwater supplies, the water supply company has not needed to purchase water from surface water users in the Azapa Valley. Thus the recent additions to Arica's water supply is essentially the result of government action rather than of free market activity.

In summary, probably the most important benefit of Chile's system of transferable water-use rights is the security brought to rights holders that does not exist in a system of government control over water allocation. Chilean farmers have invested heavily in irrigated fruit crops and taken advantage of their favorable growing season to receive high inter-national market prices for their crops. As the value of water in agricultural production has increased, individuals have also increased their investment in more efficient irrigation technology.

4.6 Mexico

In Mexico, leases and sales of water among farmers for seasonal water use have existed for many years, even when such sales were not encouraged or were illegal. However, this situation changed in 1992 when a new water law was promulgated. Many of the ideas that went into developing the new law evolved over the twenty year period when Mexico was engaged in a process of trying to improve its water resources management. The new water law coincided with a series of policy reforms which started in the late 1980s and included: i) private control of communal land holdings (*ejidos*); ii) the transfer of the operation of canal systems to water user associations (WUAs); iii) the revision of the role of the National Water Commission (CNA), and iv) liberalized trade. These reforms were expected to improve water resources management through greater user participation in irrigation management, as well as to increase irrigators incentives to improve water-use efficiency (Hearne and Trava, 1997).

Under the 1992 Mexican Federal Water Law, water remains national property. However, private transferable water-use concessions are granted to individuals, WUAs, and incorporated firms for a period of up to 50 years. Although concessions are renewable, CNA has to approve these renewals. According to the law, water-use concessions are volumetric and based on consumptive use[3]. Within the Irrigation Districts, CNA allocates concessions to WUAs organized at the level of irrigation units, or *módulos*, which in turn allocate water among the users according to their own procedures. The initial allocation of water-use concessions is based on historic levels of use. The federal government is further authorized to restrict water use in order to: ration water during drought; prevent the overexploitation of an aquifer; preserve water quality; restore an ecosystem; and protect sources of potable water.

The concession title is granted by CNA. The title contains the legal foundations for the grant, the location for the extraction of water, the concessed volume of water, the initial projected use, the place to discharge the return flow with the specifications concerning volume and quality, the duration of the concession, and the obligations and rights to which both the CNA and the users are committed.

In times of scarcity, there is no system to prioritize volumetric rights as is done in most of the western United States. However, the bylaws of each irrigation district and each *módulo* should specify a rationing system to distribute water when volumetric requirements cannot be met. When these bylaws are respected and enforced, growers have some security that a certain percentage of their water concession will be available. Most individual *módulos* do not have these bylaws, but instead rely on some form of proportional reduction.

The Water Law requires CNA to create a Public Registry of Water Rights (REPDA) listing all concession holders. This allows CNA to control the assigned volumes, as well as to record the information needed to grant future concessions. The registry also serves the task of certifying public and

[3] Article 23 of the Water Law states that the concession instrument must contain volumetric data. However, in actuality, the water available to individual modules within Irrigation Districts is decided by CNA in October or November of each year. In times of scarcity these allocations are, in general, reduced proportionally.

juridical acts of registration, extension, suspension, termination and transmission of water rights. This registration of water-use concessions allows any individual access to information on the allocation of water. Ideally, it guarantees and gives legal validity to registered concessions, it facilitates water resources planning and programming, and it is a readily available instrument for water users who may want to defend their rights during conflicts. However, given the delay and difficulties in registering concessions, it is uncertain how effective REPDA will be in reducing conflicts.

The Water Law also creates a system of water fees to be paid by the owner of the concession according to the intended use of the water. This water fee is assessed for both water extracted and for the quantity and quality of discharges. These water fees are designed to support the activities of CNA, however, the fee for irrigation water has been zero.[4] If water fees are not paid in three consecutive years, CNA can declare that the water is not being used and rescind the concession. Municipal and state government authorities responsible for potable water and sewage services are required to pay fees for water delivery and wastewater discharges.

Although the registration of water-use rights should increase the security of water delivery, individuals who register their rights are subject to the water-use fee. Given the difficulty of monitoring extraction of water, especially from groundwater sources, the registration of concessions has been slow. According to CNA's 1994 annual report, the total number of water users identified as having some "right" to water volumes was 206,500, while the number of registered users was only 26,375.

As long as the terms of the concession are not changed, transfers of water require the notification of the REPDA. In the event that a transfer of a concession affects a third party, authorization is required from CNA. Transfers of a concession outside the district require the approval of the WUA's general assembly, as well as authorization of CNA. The benefits of a transfer of water outside of the district are reserved for the district, not for the water user. Transfer of water between neighboring farmers is usually accomplished by notifying the ditch rider.

In many respects, the 1992 Mexican National Water Law provides an excellent basis for improved and more flexible allocation of water. By giving user groups the opportunity to manage their own canal systems, the law allows for greater accountability of irrigation services to the farmers. By

[4] With the transfer of canal management to WUAs, irrigators have been required to pay the WUAs a fee for management, operations, and maintenance. Part of this fee is allocated to CNA for the operation of headworks, main canals, and drainage networks.

giving individual users the freedom to buy, sell, or lease water-use concessions, the law provides a mechanism for water to move to more productive uses, while giving concession holders greater security. Also, the law tries to provide a balance between market forces and federal control. The federal government continues its role in water resources management through the CNA and the underlying federal ownership. Thus, a shift to decentralized water resources management and the use of market forces to determine the allocation of water may be constrained by a continuation of CNA's traditional preference for centralized control.

The Water Law gives CNA broad discretionary powers, to regulate transfers of concessions, restrict the use of water resources, renew concessions, and to determine the parameters for protecting water quality. The CNA also has considerable power to restrict water use, under Title Five of the Water Law, especially in times of emergency water shortages. Yet these discretionary powers need to be utilized with moderation and consistency to avoid undermining the benefits of secure water use concessions.

Two case studies, illustrate some of the potential problem associated with a top-down implementation of the 1992 Water Law (Hearne and Trava, 1997). In the first, Lagunera, an interior valley which lies on the border between Durango and Coahuila, the leasing of water and land rights was used as a mechanism to allow farmers to be compensated for the fact that in the third year of a drought, CNA chose to deliver water only to areas adjacent to main canals. The CNA did this to minimize conveyance losses in secondary canals and to limit irrigation to only a few *módulos* near the main canals. Cotton was selected as the only crop to be irrigated by the entire surface irrigation system. Owners of water rights in areas that did not receive water were able to lease their right to farmers on canals that were to be irrigated. Alternatively, these farmers could lease land in areas that were to be irrigated. The avoided productivity losses from conveyance losses may provide some compensation for the cost of forcing farmers to move from their own unirrigated land to the land that CNA chose to irrigate. But the hidden cost of lost opportunities to develop alternative crops and new arrangements for trading water may be quite high and not fully considered during the centralized decision making process.

In the Río San Juan Irrigation District, in the lower Rio Bravo/Rio Grande Valley, a water shortage combined with transfers of water to municipal and industrial uses, including a large transfer to the city of Monterrey, greatly reduced the availability of water for irrigation. The diversion of water from the Río San Juan Irrigation District to the city of Monterrey was initiated before the 1992 Water Law. This diversion was an important contribution to the growth of Monterrey and the economy of northern Mexico. But the reluctance of negotiators to fully compensate irrigators with either the same quantity of water as that diverted, or improvements in their irrigation infrastructure demonstrates that water- use concessions can be quite tentative. The precedent that water can be diverted away from irrigation systems without full compensation threatens the security of water supply to all irrigators in Mexico.

In order for water markets to effectively reallocate marginal amounts of water, concessions need to be secure and systems to properly measure and divide flows are required. In irrigation systems that rely on a strict rotation system transfers of water present a particular challenge. In Mexican systems, where irrigation turns are not strictly measured by periods of time, the simple trades of hours of irrigation as practiced in the South Asian *warabundi* systems cannot be easily implemented. Furthermore, in irrigation systems where conveyance losses require water managers to restrict the land area to be irrigated in times of drought, the free movement of water is severely restricted. In order to take advantage of water markets, Mexico may need additional investment in both the capacity of local water managers and the canal infrastructure.

Because the benefits from transfers of concessions from an irrigation district to an outside user are reserved for the district, the potential for intersectoral transfers of water are also limited. Such intersectoral transfers may be limited to the type of transfer that was made between the city of Los Angeles and the Imperial Irrigation District of California. In this trade, the city received water-use rights but compensated the irrigation district by agreeing to pay for improvements in the water delivery system. Although this type of transfer limits the incentives received by individual farmers, it does provide an opportunity for a mutually beneficial transfer (Easter and Hearne 1995, Rosin and Sexton 1993). In the two case study areas, transfers of irrigation water to municipal and industrial users, with compensation in the form of improved irrigation technology, could have been beneficial to all parties.

The key to an increased role for water markets in Mexico is the effective implementation of the 1992 water law. The water law makes it clear that the responsibility for water management is supposed to be decentralized to WUAs. The associations are supposed to take responsibility for maintaining the system and allocating the water locally. They are, therefore, critical to the effectiveness of the water market. In many cases, they will need to make infrastructure changes or change allocation rules so that the farmer who purchased the water can receive the additional supply. How easily a WUA can make such changes will affect the transaction costs of trades and the number of trades that are feasible to make. If the infrastructure gives the water user association only very limited control over the distributions of water then it will be more costly for them to implement the changes necessary to accommodate sales. It also is not clear who would pay for the changes that may be necessary to allow water sales. In the case of water sales in Chile, the buyer must pay for the changes in infrastructure.

5. LESSONS FOR THE MIDEAST

Although decentralization of water management, including the use of water markets, cannot solve all water problems, such decentralization efforts have improved the efficiency of water allocation in a number of countries. When given adequate responsibility and authority, WUAs have effectively taken over activities commonly performed by government agencies, at a savings to tax payers. Moreover, water markets offer the added potential benefit of improving water efficiency within a sector as well as providing a mechanism for reallocating water among sectors.

What can countries in the Mideast learn from other countries' attempts to decentralize water management and use water market mechanisms? Since water scarcity is a fact of life in the Mideast, one of the necessary conditions for incurring the expense of establishing water markets is clearly in place, i.e., scarcity. We also know that private arrangements for water trading already exist among farmers in similar regions, even where trading is illegal. In addition, it probably would not be too costly to establish private water use rights in the region, based on current water use patterns. The key question is whether or not governments would be willing to give up control over water transactions as the government of Chile has, and focus on oversight responsibilities including conflict resolution, regulation, and water quality improvement. In the short run, the answer is probably "no."

The Mexican law offers a possible compromise alternative, where markets are primarily allowed to operate freely within irrigation districts or water user associations. Intersectoral trades are subject to regulation by the Water Commission and approval of the irrigation districts. A similar strategy could be tried in the Mideast. This would allow governments to maintain a greater role in water planning and allocation while still encouraging market based improvement in water use at the sector level.

Markets might also be used to improve both intracountry and intercountry water allocation. For example, a system of annual or seasonal water sales similar to California's water market might by used by countries in the region to help modify the impacts of localized droughts. A water commission could be established to facilitate such trades. This would not involve permanent transfers of water, but would be limited to exchanges for a limited amount of time. These trades could offer large economic benefit to both the buyers and sellers.

The Mideast countries need to consider alternative ways they might use water markets to improve their water use allocation. If they take steps to reduce transaction costs, water markets can be an effective water allocation mechanism. Yet markets alone will not bring about a social optimal distribution of water. Governments will have to take an active role in protecting third party rights, in regulating monopolies, and in resolving water use conflicts.

ACKNOWLEDGMENTS

The authors would like to thank the World Bank and especially Gershon Feder and Ariel Dinar for their support of the work on water markets in Chile.

REFERENCES

Bauer, C.J. 1993. "Derechos de propiedad y el Mercado en una Institucionalidad Neoliberal: Effectos e Implcancias del Codigo Chileno de Aguas de 1981." Unpublished draft. Department of Jurisprudence and Political Science, University of California, Berkeley, CA.

Chambouleyon, J. 1989. "The Reorganization of Water Users' Associations in Mendoza, Argentina." *Irrigation and Drainage Systems*. 3:81-94.

Chang, C. and R. Griffin. 1992. "Water Marketing as a Reallocative Institution in Texas." Water Resources Research. 28:879-890.

Charney, A. and G. Woodard. 1990. "Socioeconomic Impacts of Water Farming on Rural Areas of Origin in Arizona." *American Journal of Agricultural Economics*. 72:1193-1199.

Colby, B. 1990. "Transactions Costs and Efficiency in Western Water Allocation." *American Journal of Agricultural Economics*, vol 72, no. 5:1184-1192.

Diao, Xinshen, and Terry Roe, 1998, "Trade Liberalization and Water-user Rights Markets: A Dynamic General Equilibrium Analysis of the Moroccan Case." World Bank Workshop on the Political Economy of Water Pricing Implementation, Washington, D.C.

Easter, K. William, M.W. Rosegrant, and Ariel Dinar, 1998. *Markets for Water: Potential and Performance*. Boston, MA, Kluwar Academic Press.

Easter, K. William and Robert Hearne. 1995. "Water Markets and Decentralized Water Resources Management: International Problems and Opportunities." *Water Resources Bulletin*. 31:9-20.

Easter, K. William. 1993. "Economic Failure Plagues Developing Countries' Public Irrigation: An Assurance Problem" *Water Resources Research*. vol. 29, no. 7:1913-1922.

Easter, K. William, ed. 1986. *Irrigation Investment, Technology, and Management Strategies for Development.* Studies in Water Policy and Management, No.9, Westview, Boulder, Co., Chapter 11.

Gerards, J., B. Tambunan, and B. Harun. 1991. "Experience with Introduction of Irrigation Service Fees in Indonesia." Paper prepared for the 8th Afro-Asian Region Conference, ICID, Bangkok, November 1991.

Hearne, R. and J. Trava. 1997. Water Markets in Mexico: Opportunities and Constraints. Discussion Paper 97-01. Environmental Economics Programme. IIED. London.

Hearne, Robert and K.William Easter. 1997. "The Economic and Financial Gains From Water Markets in Chile." *Agricultural Economics.* (15)187-199.

Hearne, Robert and K.William Easter. 1995. *Water Allocation and Water Markets: An Analysis of Gains-From-Trade in Chile.* World Bank Technical Paper Number 315. The World Bank.

Hearne, Robert R. 1995. "The Market Allocation of Natural Resources: Transactions of Water-Use Rights in Chile," unpublished Ph.D. Thesis. University of Minnesota, Department of Agricultural and Applied Economics.

Joshi, Deep and David Seckler. 1982. "Sukhomajri: Water Management in India," Bulletin of Atomic Scientists 38(3): 26-30.

Kessides, C. 1992. "Institutional Arrangements for the Provision and Production of Infrastructure." Unpublished Draft World Bank Paper.

Lee, T. R. 1990. *Water Resources Management in Latin America and the Caribbean.* Westview, Boulder, Co.

Maass, A. and R. Anderson. 1978. *And the Desert Shall Rejoice: Conflict, Growth and Justice in Arid Environments.* MIT Press. Cambridge, Ma..

Palanisami, K. and K. William Easter, 1991. "Hydro-Economic Interaction between Tank Storage and Groundwater Recharge," *Indian Journal of Agricultural Economics,* 46(2): 174-9.

Peabody, N. ed. 1991. Water Policy Innovations in California: Water Resource Management in a Closing Water System." Winrock International Institute for Agricultural Management. Discussion Paper No. 2. Arlington Va.

Rosen, M. and R. Sexton. 1993. "Irrigation Districts and Water Markets: An Application of Cooperative Decision-Making Theory." *Land Economics.* 69:39-53.

Shah, T., 1993. *Groundwater Markets and Irrigation Development (Political Economy and Practical Policy),* New York, Oxford University Press, 228 p.

Small, L., and Ian Carruthers. 1991. *Farmer-Financed Irrigation: The Economics of Reform.* Cambridge: Cambridge University Press.

Uphoff, N., M. L. Wickramasinghe, and C. M. Wijayaratna. 1990. "'Optimum' Participation in Irrigation Management: Issues and Evidence from Sri Lanka." *Human Organization,* 49(1): 26-40.

Vaux, H. 1986. "Water Scarcity and Gains from Trade in Kern County, California". in *Scarce Water and Institutional Changes.* K. Frederick, ed., Resources for the Future, Washington, DC.

World Bank. 1984. Pakistan: Sector Report, "Public and Private Tubewells Performance: Emerging Issues and Option," The World Bank, Washington, D.C.

World Bank, 1993. *Water Resources Management, A World Bank Policy Paper.* The World Bank, Washington, D.C.

Chapter 20

Water Demand Management

From Theoretical Concept to Policy Implementation

David B. Brooks
International Development Research Centre, Ottawa, Ontario, Canada

1. WATER DEMAND AND WATER MARKETS

For many years we believed that water supply was difficult, but water demand quite simple. What passed for demand analysis consisted of projecting growth curves of consumption forward in time as a function of some independent variable such as population (or, in more mathematically sophisticated models, several independent variables). At the risk of irritating many friends and colleagues, I would suggest that we got it backwards. In reality, supply is relatively simple – a matter of working with physical laws of hydrology and engineering principles – whereas demand, which depends on variables linked to human needs and behaviour, and which change over time and space, cannot be so easily constrained.

Even our terminology for demand is confusing. We refer on different occasions to needs (or basic needs), demands, wants, desires. Indeed, the amount of water needed to satisfy thirst is only a few litres per person-day; the amount needed to grow enough food for that person is 50 times larger; and the amount needed to run something close to a modern economy perhaps 100 times larger. How are we to define demand?

For most purposes, it is less important to be definitive about the exact definition of demand than to draw lessons from the range of terms. Most important, water is both a physical substance and an economic good, and it is the latter aspect that is most relevant to management and policy. (One can have as much water as desired provided you have the money and the energy to desalinate seawater and ship it to the point of consumption.) Another lesson is that the value of water depends not merely upon its quantity but on at least four other factors: quality (see below), reliability, time of availability and location.

Markets for water always exist, but are typically obscured by the fact that water is available free or grossly under-priced. Sometimes the markets are visible, as with water vendors in the poorer parts of many cities or with owners of bore holes in rural areas. Sometimes they are hidden, as when governments supply water at more or less subsidized rates, something that is universal in the Middle East. Typically, farmers receive the largest subsidies per unit and in total. In many cases, water is available "free," but a real cost is incurred (generally by women) in the time and effort to carry it from source to use. In addition, water must go some place after use, so there is commonly an even less visible price on (or cost) for wastewater as well.

Finally, water is characterized by a uniquely large gap between average price (what a consumer will pay for water in general), which is generally quite high, and marginal price (what that consumer will pay for a bit more water), which is generally not very much. In practical terms, we will pay a lot for a glass of drinking water but practically nothing for another cubic metre of irrigation water.

Only recently has demand management been recognized as an essential and effective policy tool for Middle Eastern nations. Indeed, in the absence of water demand management, it will be impossible to satisfy the three goals essential to continued human use of water (and disposal of our wastewater): economic efficiency, social equity and ecological sustainability.

2. PERSPECTIVES ON WATER DEMAND MANAGEMENT

Rather than pursuing a definition of water demand, it is more useful to look at three levels of water demand management. They range from the relatively mundane (if commonly ignored) level of the individual firm or household through the more important level of society as a whole to the truly radical level of questioning common notions of need and consumption.

2.1 Firm or Household

The water utility, industrial firm or household can be treated at the same time because they are all individual economic units, and, to one degree or another, they are all interested in savings. For any of them, water demand management (or demand side management, as it is typically termed by the utility; see Stiles, 1996) is simply a matter of cost effectiveness: Will investment (of time, money or effort) in saving water pay off in whatever terms are relevant to that economic unit? Of course, lots of things may get in the way of making an accurate balance, particularly when water is priced very low. Also, incentives can be misplaced (from an economic perspective) as when it is women who carry water but men who decide when to invest, or when buildings are charged for water but those rates are not applied to individual offices or apartments. In sum, calculations for the individual firm or household may be complex, but the principle is not.

2.2 Society

A much wider set of variables comes into play when we view water demand from the perspective of society as a whole. Concerns here arise because water, which is partially renewable and partially nonrenewable, moves around, crosses (or underlies) boundary lines, and has enormous absorptive capacity. However, the use of water by person/community/firm A affects the ability (or even the possibility) for person/community/firm B to use water. Therefore, we need social rules to define who can use water, how much water, and when. Because all human communities and livelihoods – human life itself – depends upon water, equity demands that we have special rules to ensure that everyone can satisfy basic needs for drinking and sanitation. And of course the withdrawal, use and disposal of water all have environmental effects. Calculations at the level of society are more complex and less definitive than those involving individual economic units. Concepts such as externalities, common property resources, and public goods all come into play, and an extensive literature has grown up to deal with them.

2.3 Soft Water Paths

Finally, there is the radical perspective that asks what the purpose of water use is anyway. Modelled on the highly successful approach to energy analysis dubbed soft energy paths (Brooks, 1995), the theory of soft water paths is still too nascent to discuss extensively at this time. However, we can already see lessons that are analogous to those we learned from energy:

One lesson is that, beyond the few litres needed to sustain life, there are many ways to satisfy demands for water. Most relevant to the Middle East, importation of food is an alternative to using water for irrigation (Allen, 1996). To be more careful, if the objective is to feed a given population, then use of water to irrigate or use of money to buy food are equivalent. Obviously, the two options are anything but equivalent in socio-economic and environmental effects.

A related lesson is to look beyond the immediate end-use to ask about demand management in a larger sense. Drip irrigation in Israel may get 90% or more of the water to the plants, but the larger question is whether the water should be used for irrigation at all. One can install low-flow toilets in an isolated Palestinian village, but the larger question is whether water-based sanitation should be used at all.

Another lesson is that it is almost as important to conserve the quality of water as to conserve quantity. High-quality water can be used for many purposes; low-quality water for only a few. On the other hand, the volume of use that requires high-quality water is rather small, whereas the volume of use that can accept low-quality water is very large. We need relatively small amounts of potable water for drinking but large quantities of more or less dirty water for growing food. The importance of quality may also change with technology; turbid water may be perfectly acceptable for flood irrigation but clog the holes in drip irrigation.

A final lesson is that lines between demand management and supply management get blurred. Is water harvesting a supply or a demand technology? Most analysts have found it convenient to include local sources of supply as part of demand management.

3. TOOLS FOR DEMAND MANAGEMENT

Tools and techniques to promote demand management can be classified in many ways but the following four categories are convenient (Rosegrant, 1997). None of the measures is as simple as will appear in the list below, even for surface water – and, in almost all cases, they are even more complex for underground water.

3.1 Institutions and Laws

Supply and demand systems for water always exist within a set of water rights, land rights, social and civil institutions, and legal regimes. Some are formal and others informal; some modern and others traditional; some international and others local. They all play a role – more accurately, as great a role as granted to them – as do both modern and traditional institutions for conflict resolution.

3.2 Market-based Measures

This is the world of water prices and tariffs, and of water subsidies, both of which appear in a variety of forms. Although pricing is currently touted widely, careful analysts see it as a necessary but insufficient incentive for achieving efficiency, equity and sustainability. Most would argue that subsidies should be explicitly justified; that water tariffs should be designed to encourage conservation, not just to recover costs (which implies that pricing should be high enough to move into the elastic portion of the demand curve); and that some form of lifeline pricing should be adopted to provide water for basic needs of even the poorest household. Of course, any of these measures depends upon the existence of a more or less sophisticated system for metering.

3.3 Non-market Measures

An enormous variety of non-financial measures can be considered to promote water demand management (Brooks & Peters, 1988). Information and consulting services can be provided; social pressure can be applied; regulations can limit the time or quantity of use; and so on. Although regulations have a bad name, they are often both appropriate and efficient for managing water demand. Exhortation is also more effective than generally believed, particularly in times of drought. The range of options is so wide as to preclude generalization, but one can say that they should be chosen so as to support and if possible reinforce the effects of market-based measures.

3.4 Direct Intervention

Governments and water suppliers can of course intervene directly by providing services, installing consuming or conserving equipment, fixing leaks, adjusting pressure, providing sewerage, and so on. Publicly funded water and sanitation utilities typically undertake many of these functions. More fundamentally, they can also affect, if not control, land use by their decisions on the location and quality of water and sanitation services, which is of course why these decisions are so politically sensitive.

Examples from each of the four categories of demand management measures can be found in Israel, which of course has a highly sophisticated set of institutions for managing water. Although the great bulk of people and budget are devoted to supply issues, recently announced moves to increase the price of water over time suggest that more attention will be paid to demand in the future. The Palestinian Water Authority is just now establishing a legal regime, and it remains to be seen how much emphasis it will place on demand management.

4. SOME THINGS TO DO AND NOT TO DO

There are lots of tasks in water demand management, so it may be of help to suggest a few things not to do, or at least to place well down in the priority list.

4.1 Don't Worry About

- *what will happen in the middle of the next century:* If one projects curves far enough, the world seems to run out of fresh water (Raskin et al., 1996). The relevant time period for water planning is, however, the next two to 20 years, and in that time frame water demand management has a lot to offer.
- *the advent of high-capital solutions:* Desalination, water pipelines and great canals are all on the horizon – which is exactly where they have been for the last 20 years! With the possible exception of some international transport by water and desal plants in petroleum-producing countries with a lot of residual oil, all of these techniques are too expensive for extensive use in most parts of the world.
- *water demand management in the North America or Europe:* The northern countries are no models of efficient, equitable or sustainable management of water. In effect, they have used their resources of capital and energy to overcome deplorably bad water management. You *can* learn something about process from North America, where requirements for freedom of information, public participation, and environmental assessment are more extensive than in Israel (Gouldman, 1996). Otherwise, conditions in the North are so different that you will have to rely on your own research to develop appropriate methods and measures.

4.2 But Do Think About

- *the in situ value of water: Energy* analysts are fond of saying that no one wants energy for itself, but only for the services it can provide. This is not the case with water. For one thing, water provides many services, including habitat for plants and animals, dilution of wastes, flood stabilization and so on. For another, lakes and rivers are beautiful;

springs and waterfalls are sometimes revered. Israel's current program to restore coastal rivers is evidence of the intrinsic value of water.

- *traditional water management systems:* Older systems, some of which still exist and some of which must be rediscovered, are worth studying. Qanats in Syria and elsewhere, for example, depended upon a high degree or organization for construction, maintenance and distribution of water; so too did the recovery of fresh water from submarine springs off Sidon and Tyre in Lebanon. The institutions on which such systems were based may have achieved a better balance among efficiency, equity and ecology than modern systems (as demonstrated, for example, in Agarwal & Narain, 1997).
- *how to allow for extreme events:* Except for fossil aquifers, our water supply is dependent on rainfall, and rainfall is notoriously variable from place to place, from summer to winter, and especially from year to year. As emphasized by other papers in this volume, demand management has an enormous role to play in multi-year droughts. That role ranges from forced cutbacks (mainly applied to irrigation unless the drought is prolonged) to exhortation (mainly effective with domestic use).

5. A NOTE ON THE COUNTER-REVOLUTION

Today's serious efforts at water demand management are almost revolutionary. Not surprisingly, therefore, these efforts have spawned a counter-revolution.

- The counter-revolution is led by the International Irrigation Management Institute (Keller et al., 1996; Seckler, 1996), and its main point is as follows: Water that is not used consumptively cycles back into a basin, and, therefore, what appears to be inefficient at a micro (individual end-use) scale may be efficient at a macro (water basin) scale. For example, irrigation water that runs off or sinks to the water table may return to the water course and then be used by farmers downstream. In effect, a water multiplier exists such that every drop of water that does not evaporate or evapo-transpire is used several times.
- The analysis put forward by IIMI has considerable merit. Moreover, it is not put forward naively; they allow for various kinds of losses of water quantity and of water quality in the flow back to the river or aquifer. Nevertheless, this analysis can be seriously misleading if used as an excuse not to improve micro-efficiency or to neglect water demand management. Among other things:
- Effective natural recycling must be proven; it cannot be assumed. It works very well along the Nile in Egypt, which is the source of many

case studies. For a variety of geographic and hydro-geological reasons, it works much less well in most other places.

- Over one-fifth of the world's population lives along a coast, so any water they use is lost directly to the sea. Moreover, this is merely a specific case of a more general effect of water flowing to an "economic sink" from which it is simply too expensive to recover (Rosegrant, 1997).
- Quality losses can be severe with each use of water, particularly in farming areas where fertilizer and pesticide residues are picked up by the water as it flows over the field.
- Water management costs are highly sensitive to the scale of the system. The less efficient is end-use consumption, the larger must be both supply and effluent facilities, which implies an inefficient use of capital.

In summary, even if basin efficiency is greater than farm efficiency in the use of water, this is only true in a physical sense. Thus, we end up where we started – water is at least as much an economic as a physical resource. Natural recycling is nothing on which Israel or Palestine can rely as an alternative to demand management. In most cases, it will save both dollars and the environment to conserve water; it may even allow for more equity as well.

6. CONCLUSION

By comparison with most other nations, Israelis and Palestinians are already very efficient in their use of water. The problem is that they are not nearly so efficient as they will have to be to cope with growing demands and limited supplies in the future. The potential gains are far from marginal, even for domestic uses (where leakage can be higher than end-use consumption). A number of authors have estimated that 25 to 35% of current water use could be saved with cost-effective measures (for example, Kahane, 1991). My own estimates suggest that, by promoting minor changes in lifestyles and in urban and industrial uses, plus some shift away from irrigated agriculture, Israel could save over half of the fresh water it currently uses. Palestinian savings would be much smaller, partly because it would be economically efficient to allow a modest expansion of irrigated agriculture and partly because the need for more water in the domestic, urban and industrial sectors will overwhelm use-by-use savings. Despite the differences in current patterns of use, and of prospects for change in the near future, it would be economic, social and ecological folly for either Israel or Palestine to ignore the huge potential of water demand management.

REFERENCES

Agarwal, A. & Sunita, N. (1997). *Dying Wisdom: The Rise, Fall and Potential of India's Traditional Water Harvesting Systems*. Centre for Science and Environment, New Delhi.

Allen, J.A. (1996). The Political Economy of Water: Reasons for Optimism but Long Term Caution. In: J.A. Allen (ed.), *Water, Peace and the Middle East: Negotiating Resources in the Jordan Basin*. Tauris Academic Studies, London.

Brooks, D.B. (1995). Planning for a Different Future: Soft Water Paths. In: M. Haddad & E. Feitelson (eds.), *Joint Management of Shared Aquifers: The Second* Workshop. Truman Institute of Hebrew University, Jerusalem; Palestine Consultancy Group, East Jerusalem.

Brooks, D.B. & Peters, R. (1988). *Water: The Potential for Demand Management in Canada*. Science Council of Canada, Ottawa.

Gouldman, M.D. (1996). *Water Resources Law and Administration: Can Israel Learn from Canada?*. Occasional Paper No. 19, The Halbert Center for Canadian Studies, The Hebrew University, Jerusalem.

Kahane, Y. (1991). *Water Conservation Measures in Israel, report prepared for UNEP – Mediterranean Action Plan*. Israel Center for Waterworks Equipment, Tel-Aviv.

Keller, A., Keller, J. & Seckler, D. (1996). *Integrated Water Resource Systems: Theory and Policy Implications*. International Irrigation Management Institute, Research Report 3, Colombo, Sri Lanka.

Raskin, P.D., Hansen, E. & Margolis, R.M. (1996). Water and Sustainability: Global Patterns and Long-Range Problems. *Natural Resources Forum*, 20:1-15.

Rosegrant, M.W. (1997). *Water Resources in the Twenty-First Century: Challenges and Implications for Action*. IFPRI, Washington DC.

Seckler, D. (1996). *The New Era of Water Resources Management: From "Dry" to "Wet" Water Savings*. International Irrigation Management Institute, Research Report 1, Colombo, Sri Lanka.

Stiles, G. (1996). Demand-side Management, Conservation and Efficiency in the use of Africa's Water Resources. In: R. Eglal, E. Rathgeber & D. Brooks (eds.), *Water Management in Africa and the Middle East: Challenges and Opportunities*. IDRC Books, Ottawa, Canada.

Chapter 21

Water Rights within a Water Cycle Framework

Eran Feitelson
Department of Geography, The Hebrew University of Jerusalem and the Harry S Truman Research Institute for the Advancement of Peace, Mount Scopus, Jerusalem

1. INTRODUCTION

Most discussions of water rights and allocations allude primarily to the withdrawal and use of fresh water. The main sources from which water is withdrawn, and thus rights determined, are rivers, lakes or aquifers. In riverine systems the importance of return flows, allowing the same water to be used several times, has now been recognized (Kolars, 1997). Yet, in most cases in the Middle East this recognition has not yet been institutionalized.

In this paper I argue that in the Israeli-Palestinian case discussions of rights over freshwater and their allocation for a single one-time use are insufficient. Rather, water can, and often is, used several times throughout the water cycle. Therefore, water rights or allocations have to be defined within the context of the complete water cycle, or at least half of it. From such a perspective some of the difficulties faced by negotiators may be resolved, as the water cycle view provides greater degrees of freedom in making allocations than the limited perspective that focuses only of freshwater withdrawal. To demonstrate this point one concrete suggestion is advanced for the Israeli-Palestinian case.

2. THE WATER CYCLE PERSPECTIVE

In Figure 1 the complete water cycle is presented, and the human interventions within it. From this Figure it is obvious that human intervention occurs in almost all parts of the cycle. In addition to damming surface flows and pumping groundwater, we affect recharge rates (both planned and unplanned – due to leakages from pipes and excessive irrigation), divert flows, and generate sewage which can be treated and re-used. Today a reversal of the natural cycle through desalination is also possible. Finally, we can even affect rainfall by cloud seeding, a technique used in Israel.

This view underscores the fact that water rights are defined for only a few points along the cycle, namely pumping and use of surface water. Most other human interventions are not addressed in water right doctrines. This misspecification may have adverse welfare effects. If resource enhancement due to cloud seeding or artificial recharge, for example, are not manifest in water rights or allocations the incentive to undertake such beneficial steps is reduced. This problem can be expected to be of consequence in cross-boundary circumstances, as the benefits are often likely to accrue, naturally, across the border. Cloud seeding may enhance rainfall, and artificial recharge may enhance groundwater supply, across a border. Disregard of these facets in definitions of water rights, or when determining water allocations, creates a free-rider problem, and hence under-investment in these activities.

Another point, which may be of greater importance, is that water re-use is not limited to riverine systems. Actually, in semi-arid regions recycling of wastewater can be the most readily available source of additional water. This is the case in Israel. Thus, while wastewater is usually viewed as a potential pollutant, and thus its treatment an obligation that has to be placed on the polluter, in semi-arid climates it should be viewed concurrently as a resource, over which rights have to be specified. When fresh water is scarce the importance of allotments of recycled wastewater increases. To understand the importance of this point in the Israeli-Palestinian context it is worthwhile to take a brief look at the changing water use patterns within Israel.

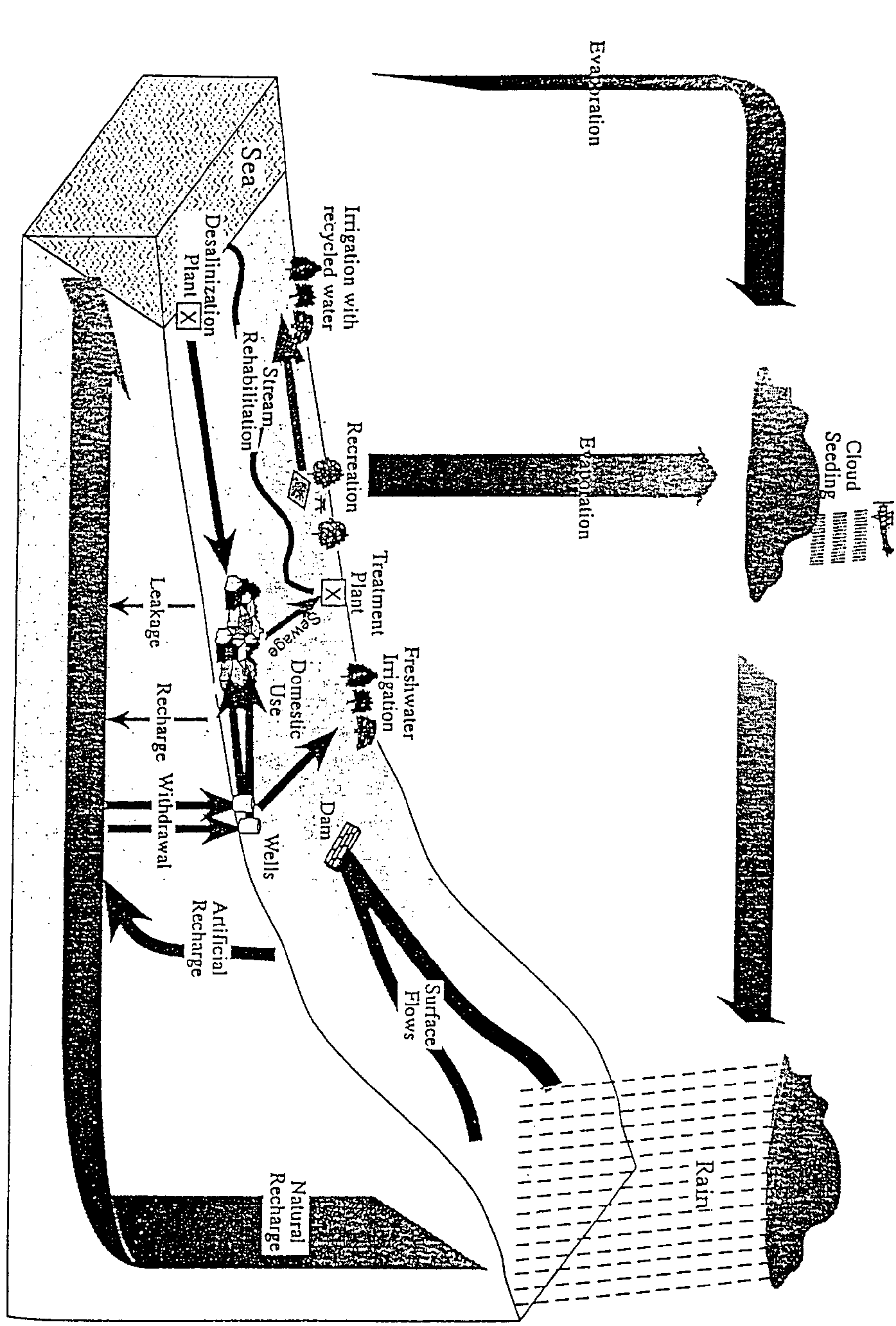


Figure 1. Human Intervention in Water Cycle

3. THE SHIFTS IN THE ISRAELI WATER SCENE

In Figure 2 the main water flow patterns within the Israeli economy are depicted schematically for two time periods. The first time period presents the flow patterns during the 1970s and 1980s. The main flows were from the three main storages (Lake Kinerret [Sea of Galilee] and the two aquifers) to agriculture. Domestic use was less than half of the water used for irrigation. Most of the effluents were treated at a primary level at best. Still there was considerable use of such effluents for irrigation. In-stream uses received almost no allocations except in very limited circumstances (mostly in peripheral areas in the far north).

In the second period, which is only beginning, domestic use is expected to increase dramatically, mostly due to population growth. This would require that much of the water used today for irrigation be shifted away from agriculture.

As domestic consumption rises, so does the amount of effluents. In recent years Israel made considerable investments in sewage treatment plants. Thus, it can be expected that in the future the amount of treated wastewater will increase significantly. Moreover, the level of treatment will improve, and thus the range of uses that could take advantage of such water increases too. In a recent study of Jerusalem's sewage system, it was suggested that in addition to irrigation recycled water may have many additional benefits (Feitelson & Abdul-Jaber, 1997). These include recreation, electricity generation and health authorities. Naturally, the type of use would determine the level to which the wastewater would need to be treated.

At some point desalination is likely to become a major water source (Bargur, 1993; Ben Meir, 1994). The timing of this step is, at the time of writing, still unclear. However most scenarios suggest that large scale desalination would become a significant factor sometime between 2010 and 2040 (Bargur, 1993; Schwartz, 1996).

When desalination becomes a significant source the total volume of wastewater is likely to increase too. This may open new options for recycling water. One new use already being contemplated is the rehabilitation of the coastal streams with recycled water. These streams, once free-flowing freshwater streams, have become in many places sewage streams, where the only fresh water is flood water. However, with the rise in environmental awareness the requirements for recycling water, in general, and for in-stream uses, in particular, is likely to rise.

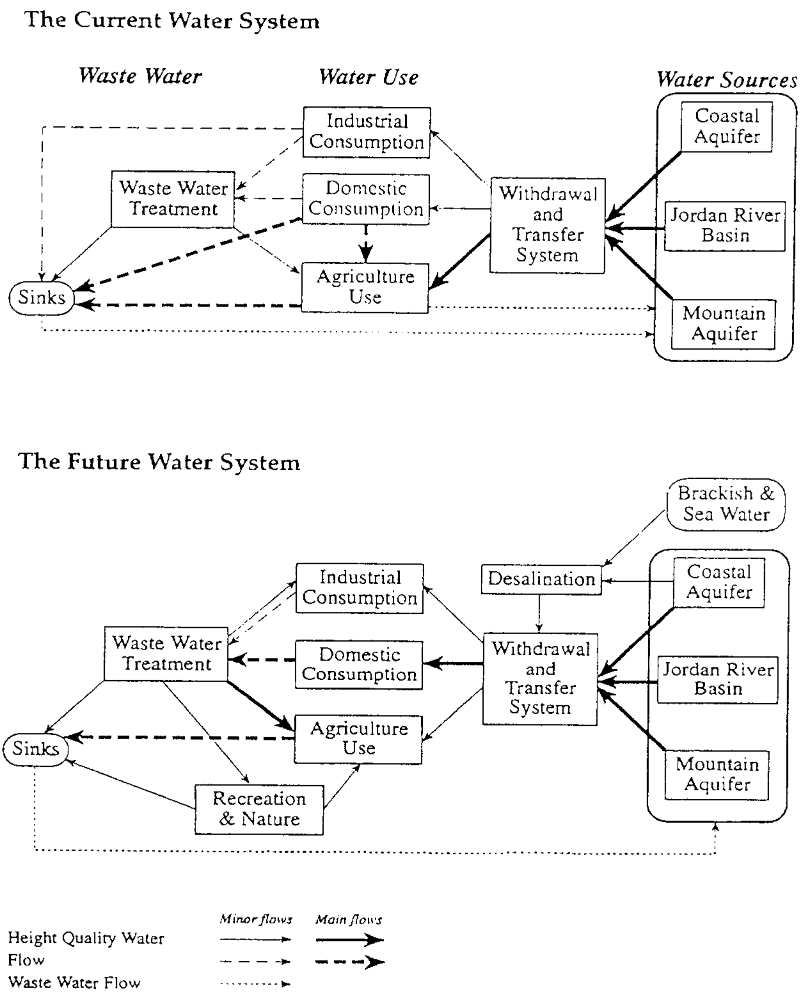


Figure 2. A Conceptual Scheme of the Shift in the Israeli Water

Still as the main recreational demand in Israel, particularly during the summer months, is for water-based recreation, the calls to allocate water for in-stream uses have been made, regardless of desalination. Thus, in the national wastewater masterplan, currently being prepared, an allotment of recycled water for in-stream uses has been assured also in the interim period prior to desalination. These in-stream usage is, therefore, depicted in Figure 2.

4. MULTI-DIMENSIONAL WATER RIGHTS

The multiple interventions in the water cycle in Israel, and the increasing importance of non-conventional water sources, imply that water rights and allocations cannot be limited to conventional sources. Rather, when allocating water, or determining water rights, all the interventions and sources should be taken into consideration. Also, allotments have to be made to an increasing variety of uses.

To allow for multiple types of sources and uses it is suggested that a multi-dimensional definition of water rights is needed. In Figure 3 a conceptual three-dimensional typology of water rights is presented.

Use / Sources	Domestic	Industrial	Agriculture	Nature
Groundwater				
Artificial Recharge				
New Sources				
Inter-basin Transfers				
Recycled: 1) Secondary				
2) Tertiary				

Figure 3. A Typology of Water Rights

In essence a water right according to Figure 3 is initially defined according to source and use. Thus, a water right for a certain party may include the right for a certain amount of fresh water from an aquifer for domestic use, a different amount from the same source for agriculture, and to which some water will be added as a function of artificial recharge undertaken by that party, and a certain amount of freshwater for agriculture. This framework provides greater flexibility for addressing the actual needs of the different parties, as different uses in different places need different quality water, and investments enhancing the resource can be reflected in the rights' structure.

Once the basic structure of water rights has been determined, these rights need to be allocated between the parties. This allocation is the third dimension in Figure 3. In the next sections we turn to the question how this conceptual structure can be applied to the Israeli-Palestinian case.

5. WATER AND WASTEWATER RIGHTS IN THE ISRAELI-PALESTINIAN CONTEXT

The discussion of water rights in the Israeli-Palestinian context, and particularly in reference to the mountain aquifers, has to begin with the recognition of the great discrepancy in current allocations between the two parties. Moreover, as can be seen in Table 1, the current agreement between the parties, the Oslo B agreement signed in September 1995, does only little to address this discrepancy.

Table 1. Water use and Replenishment of the Mountain Aquifer (in MCM annum)

	Replenishment	**Pre-agreement Use**		**Oslo B**	
		Israeli	**Palestinian**	**Israeli**	**Palestinian**
Northeast Aquifer	140	130-136	20-21	103	42
		150-157		46	
Western Aquifer	365	130-136	20-21	340	22
		150-157		362	
Eastern Aquifer	146	40	54	40	54
		94		172*	

* According to the Oslo B Agreement an additional 78 MCM are to be extracted from the aquifer.

Actually, the water allocated to the Palestinians under this agreement will suffice for a population of 1.2-5.6 million people, depending on per capita water consumption and the amount of water that can actually be developed with reasonable cost in the eastern aquifer. If per capita consumption goes up (even by little as 50cm/person/year) and not all the 78 MCM mentioned in the agreement developed, the population that could be supported will be less than 3.9 million. Given population growth rates in the West Bank (even when discounting the possibility of some return from the Palestinian diaspora), it is quite obvious that current allocations are not sustainable.

Therefore, water will need to be transferred from Israeli to Palestinian use, or additional sources made available. This has been realized by many analysts, coming from different vantage points (Ben Meir, 1994; Eckstein et al., 1994; Shuval, 1992; Zarour & Isaac, 1993). In practice the question of how much water would be transferred and who would bear the necessary financial cost would be, hopefully, settled in the permanent status negotiations between the two parties.

From an intra-Israeli perspective the main losers of any transfer of water allotments from Israeli to Palestinian use would be Israeli farmers. Their freshwater allotments would necessarily be reduced. Another potential loser are future generations. Dery and Salomon (1997) have shown that future generations were always treated as the de facto buffer sector in the Israeli water allocation algorithm during droughts. That is, long-term resource management considerations took a back seat to short-term water supply demands. This may happen also in the Israeli-Palestinian context. The transfer of water to Palestinians is likely to lead to higher sewage outflow over the aquifer recharge areas on the West Bank. Moreover, sewage flows from the West Bank may pollute streams in Israel's coastal plain, thus impairing the budding efforts to rehabilitate these streams. As it is unlikely that sewage treatment will receive a high priority on the West Bank, given the other problems faced by the nascent Palestinian entity, these concerns are increasingly being voiced in Israel. Also, unless effective joint management is put in place, pumping may exceed the "red lines," especially during droughts, thus increasing the danger of salinization.

A water-cycle view of water rights and allocations may help mitigate these problems. The idea is that Israel's transfer of freshwater to the West Bank be made contingent upon it receiving back treated wastewater at predestined amounts and quality. Thus, one type of right transferred from Israel to the Palestinians (freshwater currently allocated to Israeli farmers) would be substituted, at least in part, by an alternative right (recycled water for irrigation in Israel).

This simple idea has several potential benefits:

1. It would mitigate the loss for Israeli farmers, which can naturally be expected to be the main opponents to any freshwater transfer to Palestinians;
2. It would provide incentives to build wastewater treatment plants and recycling systems on the West Bank, thus reducing the likelihood of pollution of both aquifers and streams;
3. It would make wastewater treatment and recycling an integral part of the permanent settlement, thus providing international agencies and donor countries with a substantial incentive to help finance such projects, and perhaps also desalination projects that would help bolster freshwater supplies to both parties.
4. The need to manage a more complex set of water transfers, agree upon quality issues, and maintain a relatively complex system with a high level of interdependencies may provide a basis for a comprehensive joint management system. Such a system has many benefits from a sustainable water management perspective (Feitelson & Haddad, 1995).

However, the implementation of this suggestion would be contingent upon the ability to address several problems:

One, to determine the return flow recycled water rights it is necessary to estimate how much water can be realistically recycled. Such estimation is always fraught with uncertainty. However, in the Palestinian case this uncertainty is magnified by several factors:

a) Population growth, and distribution, may be affected by future geo-political changes, in addition to a possible transition from a rural-based traditional society to an urban industrial society.

b) Water use per capita is currently very low and is likely to rise with economic growth. Yet, the rate at which such growth will take place is highly speculative, as Palestinian economic growth will be much affected by the travails of the peace process, and its outcomes.

c) A major factor affecting water use, and the ability to recycle wastewater, is the connection to central water and sewage systems. Today many Palestinian villages are still not connected to such systems. The rate at which such systems will be built will depend on the availability of finance, which would in turn be affected by the overall geo-political situation.

d) The demand for water, and subsequent supply of wastewater, are also a function of pricing and regulatory policies. Higher prices, restrictions on irrigation or planting of certain crops, or quality requirements affect water demand and supply cost. The distribution of these would affect total water consumption.

e) The level of water that would be needed, and availability of recycled water would be a function of the level of maintenance of the water and sewage systems. Current maintenance levels on the West Bank in most systems is wanting, resulting in high water losses. The future maintenance levels of such infrastructure are hard to project.

The second problem that would have to be addressed in the water for wastewater idea expressed above is the limited capacity within Israel to absorb recycled water. More to the point, the locations at which recycled water may become available may not conform to the locus of demand. Actually, along parts of the coastal plain wastewater supply from within Israel may outstrip demand. Naturally, additional recycled water would provide only limited benefits under such circumstances.

A third problem are the de facto rights certain Palestinian farmers claim over the currently free-flowing sewage. If all this sewage is taken out of the currently free-flowing streams and diverted to Israel such farmers stand to lose.

Finally, the question of allocation of financial cost of wastewater treatment, and particularly transport, would need to be settled before any such scheme can be implemented.

6. CONCLUSIONS

The water cycle perspective advanced here shows that there are greater degrees of freedom to address water allocation problems than apparent from the conventional approach whereby fresh water is allocated for a single purpose. This approach provides decision makers with a wider array of options for making deals, thereby enhancing the chances for success.

The water cycle perspective highlights the need to include all parts of the water cycle in the upcoming negotiations between Israelis and Palestinians. In particular, it is suggested that rights over recycled water be discussed, as they may help overcome what otherwise may be viewed as a zero-sum game. Moreover, by identifying and inter-linking wastewater treatment and recycling with freshwater allocations within a comprehensive Palestinian-Israeli framework, wastewater treatment may become extremely attractive for international funding agencies and donor countries. Such funding may help make the whole arrangement into a clear win-win situations, whereby both sides stand to gain, as well as future generations of Israelis and Palestinians alike.

However, the pitfalls that were identified in the previous sections suggest that much careful planning is needed before the proposed approach can be implemented. Unless such planning is undertaken the potential benefits may not be realized. Furthermore as there is no experience in making interlinkages between water and recycled water rights in circumstances such as those facing Israel and the Palestinians, it is obvious that adjustments will need to be made as experience accumulates. This conclusion accentuates the need for institutionalizing mechanisms for making adjustments in the structural elements of any joint management structure agreed upon in the permanent status negotiations.

REFERENCES

Bargur Y. (1993). The Israeli Water Market – Trends and Resource Development in Scarcity Conditions. In: *Israel 2020: Master Plan for Israel in the 21st Century*. Final Report Stage A, Vol. 2, Technion Research and Development Foundation, Haifa (in Hebrew).

Ben Meir M. (1994). Water Management Policy in Israel: A Comprehensive Approach. In: I. Isaac & H. Shuval (eds.), *Water and Peace in the Middle East*. Elsevier. Amsterdam.

Dery D. & Salomon I. (1997). "After Me, The Deluge": Uncertainty and Water Policy in Israel. *Water Resource Development*, 13:93-110.

Eckstein Z., Zakai D. & Nachtom Y. (1994). *The Allocation of Water Sources Between Israel The West Bank and Gaza: An Economic Viewpoint.* The Pinhas Sapir Center for Development and the Armand Hammer Fund for Economic Cooperation in the Middle East, Tel Aviv University.

Feitelson E. & Haddad M. (1995). *Joint Management of Shared Aquifers: Final Report.* The Palestine Consultancy Group and the Harry S Truman Research Institute for the Advancement of Peace, Jerusalem.

Feitelson E. & Abdul-Jaber Q. (1997). *Prospects for Israeli-Palestinian Cooperation in Wastewater Treatment and Re-use in the Jerusalem Region.* The Jerusalem Institute for Israel Studies and the Palestinian Hydrology Group, Jerusalem.

Kolars J.F. (1997). River Advocacy and Return Flow Management on the Euphrates/Firat River. *Water International*, 22:49-53.

Schwartz J. (1996). Issues in the National Water Masterplan, paper presented at a conference of the Israeli Water Resource Association on: 'Planning the Water Sector Towards the 2000s'. Beit Dagan, December 3rd (in Hebrew).

Shuval H.I. (1992). Approaches to Resolving the Water Conflicts Between Israel and her Neighbors – a Regional Water-for-Peace Plan. *Water International*, 17:133-143.

Zarour H. & Isaac J. (1993). Nature's Apportionment and the Open Market: A Promising Solution to the Arab-Israeli Water Conflict. *Water International*, 18:40-53.

Chapter 22

The Legal Framework of Joint Management Institutions for Transboundary Water Resources

Eyal Benvenisti
Faculty of Law, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem

1. INTRODUCTION

The discussion in this chapter is based on the normative guidelines put forth by international law. These guidelines call for optimal and sustainable management, taking into account the human rights perspective.[1] They require careful balancing of conflicting demands by the decision-making bodies. Hence the importance of the decision-making process in reducing the possibilities of skewed or uninformed decisions. Hence, too, the potential contribution of jointly run institutions for water management which have procedural guarantees that protect them from capture by interest groups and ensure informed and impartial decisions.

Shared management of resources requires sensitivity to the interface between the shared institution and the national governments. A carefully planned system of checks and balances must be created to avoid ineffective joint management, on the one hand, or inattention to national concerns, on the other. States will agree to confer sovereign authority on the shared institution only if they retain important tools – such as veto power, control of budget, representatives in the institution's bureaucracy and judicial review – to ensure reasonable control over the decision-making process, the decisions adopted, their implementation or modification. However, effective shared

[1] *See* Eyal Benvenisti, *Standards or Rules? The Definition of Water Rights* in JOINT MANAGEMENT OF SHARED AQUIFERS: THE FOURTH WORKSHOP, 61-75 (M. Haddad & E. Feitelson, eds., 1997).

institutions require the dependency of the national lawmaking power of the participating states, which therefore signifies a substantial loss of sovereignty. This loss implies, first, that national prescriptions concerning the allocation of shares must become dependent on the prescription of the international institution. Second, it implies that subsequent unilateral attempts to change international commitments will be ineffective. To reconcile this tension, it is necessary to construct sophisticated mechanisms.

This chapter reviews the different characteristics of joint management institutions for transboundary water resources. Section 2 discusses the structure of such institutions, addressing the relationship between institutional and national prescriptions and the potential of delegating authority to sub-national units such as provinces, towns and villages. Section 3 examines the decision-making process within the joint management institutions, attending to the efforts to provide flexibility and mutuality in a transparent process that ensures voice to the interested public, and deals with the possibilities of judicial review over institutional decisions. The discussion in all sections explores the possible legal structure of such institutions, taking into account the constraints imposed by international law.

2. THE NORMATIVE STRUCTURE OF JOINT MANAGEMENT WATER INSTITUTIONS

2.1 Supremacy of Institutional Policies

National policies and procedures affect the possibility of regional cooperation of shared air, freshwater and other transboundary resources. This is because the national legal and institutional arrangements for the internal uses of the resource shape each state's ability to commit itself to international obligations. The national policies and institutions are relevant in a number of ways. First, the method that is used within states to allocate shares among individual users, be it a rather rigid system of inalienable property rights or a more flexible system of revocable permits, impacts the government's ability to implement a reduction of its share of a transboundary resource. The existence of property rights to shares of the resource may tie the hands of state negotiators, willingly or unwillingly, or increase the enforcement costs through litigation of expropriation cases.[2]

[2] For a similar suggestion in the context of U.S. state law, see THE REGULATED RIPARIAN MODEL WATER CODE 200 (JOSEPH W. DELLAPENNA ED., 1997) ("The Regulated Riparian Model Water Code's most fundamental departure from the common law of riparian rights

Second, different internal allocation methods shape differently the incentives of users to intervene in the political process: the more rigid the allocation system, the higher the users' reliance on their "property rights" and, hence, the higher the users' incentives to invest in protecting it through the obstruction of an international agreement. Finally, poor administration and ineffective monitoring of uses and users by the government may add to the difficult task of implementing the international undertakings, or may be used as an excuse for failure to comply with them. Not surprisingly, powerful domestic groups are usually responsible for the existence of rigid allocations and for poor governmental controls.

Joint management institutions must not be constrained by how participating states manage the internal allocation of the transboundary resources. This implies that the policies adopted by the joint management institutions must enjoy supremacy over domestic policies. Such a priority for institutional policies, in turn, implies first that institutional policies will have effect within the national legal systems without the need to obtain the prior ratification of the national legislature or government as if it were a treaty obligation, nor to undergo complex expropriation litigation. Priority of institutional policies requires states to modify national laws regarding resource use to enable transnational policies to take effect. One important implication of this principle is that instead of rigid systems that provide owners with inalienable property rights in specific shares of a transboundary resource, each participating state must establish a flexible system of revocable permits for individual users of the resource, instead of a system based on private ownership.[3] Although governments are usually empowered to requisition private property, and hence could also take property rights in shares of a resource, the process of taking, especially when protected by constitutional guarantees and judicial scrutiny, would be more complex and expensive than the termination or non-renewal of temporary permits. Such a flexible permit-based system is important for three reasons. First, it is a prerequisite for the regional management of transboundary resources that must remain flexible in order to be sustainable. Second, a permit-based allocation system requires institutional framework that assigns, amends and revokes permits. Such an institution could lower the likelihood of skewed domestic allocations to powerful groups of users by providing procedural

is the requirement that, with few exceptions, no water is to be withdrawn without a permit issued by the State Agency under the Code.")

[3] Eliminating the possibility of granting property rights does not preclude the option of establishing trade in transboundary resources. The trade could be effected through market exchange of revocable permits, issued periodically by the institutions that manage these resources.

guarantees for accountability in decision making. Finally, such institutions will encourage respect to the demands of all, because they will have to base allocative decisions on notions of non-discrimination and equal access to national resources.

The supremacy of transnational management institutions implies that the locus for interest group activity shifts from the domestic political scene to the regional institution. The risk of capture by interest groups at the institution level is substantial. Hence, the decision-making process within the joint management institution will have to include guarantees to contain them. These guarantees are discussed in Section 3.

At the outset, we should be aware of the possibility that states parties to shared joint management institutions may be tempted to excuse themselves from their treaty obligations. Such a temptation may result from interest groups' pressure or from hostile public opinion, manipulated by interest groups or reflecting fear of a perceived new health or other risk. Such governments may try to invoke a number of legal doctrines as escape clauses. In addition to the right to "terminate" a treaty in retaliation to the other party's prior material breach,[4] the doctrine of *rebus sic stantibus* is also a potentially important and manipulable escape clause,[5] as is the claim of a "state of necessity."[6] Lowering the threshold for any of such claims would increase the likelihood of domestic pressure on governments to invoke them and unilaterally exit from international obligations. Because long-term cooperation is the key for sustainable and optimal water management, and because the management of such resources is particularly prone to domestic pressures to renege, a high threshold for a unilateral right of exit is in the long-term interest of the participating states and is therefore appropriate. Other things being equal, the stricter the rules precluding unilateral exit from

4 Article 60 of the 1969 Vienna Convention on the Law of Treaties.

5 Under Article 62(1) of the 1969 Vienna Convention on the Law of Treaties, a party may not unilaterally withdraw from its treaty obligations except under very strict conditions. This party must show, *inter alia*, that "a fundamental change of circumstances has occurred with regard to those existing at the time of the conclusion of the treaty, and which was not foreseen by the parties." (*See also* the decision of the International Cout of Justice in the Gabcikovo-Nagymaros case: International Court of Justice, Case concerning the Gabcikovo-Nagymaros Project (Hungary/Slovakia) (1997), rep. in http://www.icj-cij.org/idocket/ihs/ihsjudgement/ihsjudframe1.htm; 37 ILM 167 (1998), at para. 104). In most cases, the change in water demand or supply would be incremental, quite foreseen by the parties to the agreement over the initial allocation.

6 For a discussion of that claim which was raised by the Hungarian government, see the Gabcikovo-Nagymaros case, *supra* note 5, paras. 49-59.

treaty obligations, the stronger a state party's commitments to long-term cooperation, and less is the uncertainty of possible future breaches.[7]

Fortunately, international law addresses this concern adequately. The 1997 decision of the International Court of Justice (ICJ) in the Gabcikovo-Nagymaros dispute between Hungary and Slovakia is clearly attentive to the possible unilateral breaches, and aims at restricting them. The decision stipulates that the diversion of the Danube river, a project with huge proportions and irreversible consequences, conceived by communist regimes of a long-gone era, continues and will continue to constrain the decision-making power of current and future generations of leaders and communities of the two countries, unless changed through bilateral consent.[8] To arrive at its decision the ICJ had to reject all unilateral measures of the two governments. Without entering into the doctrinal aspects of the judgment,[9] it is revealing to examine its implications to the interface of domestic and international politics. The judgment clearly seeks to insulate international politics from the influence of domestic politics.[10] Notwithstanding momentous internal political, economic and social changes affecting both countries, and despite ardent public pressure and even parliamentary resolutions, domestic options remain constrained by an agreement conceived in a bygone era. Even when one side breaches its obligation to renegotiate in good faith, the government of the other side cannot bow to internal public pressure and adopt unilateral moves: it must exhaust all possible means, also through third parties, to persuade its counterpart to return to the negotiating table rather than act unilaterally. The Court stated clearly its preference for strong regional joint management institutions, institutions which "reflect in an optimal way the concept of

[7] Note that treaties that pertain to shared resources would be considered "localized treaties" and therefore also survive state succession. *See* Article 12 of the 1978 Vienna Convention on Succession of States in Respect of Treaties, which was recognized by the ICJ as reflecting customary law and applied to the 1977 treaty in the Gabcikovo-Nagymaros case (*supra* note 5, at paras. 122-23.

[8] The agreement signed in 1977 between the Hungarian's People's Republic and the Czechoslovak People's Republic provided for the construction and operation of a system of locks on the Danube River, between Gabcikovo (in Czechoslovak territory) and Nagymaros (in Hungarian territory), which would allow for diversion canals and two hydroelectric power plants. The project was to be financed, constructed and operated jointly, on an equal basis.

[9] The decision contains a number of important developments to the doctrine on international freshwater which are irrelevant to this Chapter.

[10] And perhaps also provide what they perceive as an appropriate ad-hoc solution, noticing the less than catastrophic outcomes of the "provisional solution," as implemented by Slovakia.

common utilization of shared water resources."[11] It certainly envisioned that in future disputes of that kind, governments, armed with this instruction from the ICJ, would be able to dodge domestic opposition to the international agreement simply because any alternative government would be likewise bound by the same obligations.

The outcome of the ICJ decision is not without difficulties. Assuming that governments generally put their short-term interests first, existing agreements would tend to reflect the preferences of the stronger domestic actors at the time of signature. Often these actors would be consisted of polluters and heavy users who would opt for lax control of their uses and impose externalities on third parties. Hence, other domestic interest groups that subsequently gain power would be constrained by what might be deemed an undesirable "fatal embrace" of their predecessors. Indeed, the 1977 treaty serves as a prime example for such an agreement whose implementation could carry dire consequences to the shared environment. But the ICJ addresses these concerns. It does so by reading into the treaty a flexibility that opens the way to renegotiating its basic provisions, in light of new developments in international law, new understanding of environmental impacts, and new circumstances. Indeed, the Court upholds the 1977 treaty only after interpreting it as providing for flexibility and mutuality, and after emphasizing the duty to achieve the object and purpose of the developing treaty relationship (an object and purpose that the ICJ in fact postulates in light of developing international law).[12] As acknowledged by this interpretation of the 1977 treaty, any treaty on transboundary resource management must establish procedures that would provide for flexibility and mutuality, the prerequisites of long-term cooperation.[13]

There is also a down side of relegating authority from governments to joint management institutions. Such a relegation reduces dramatically each state's powers. The reduction is dramatic not only in the narrow context of the allocation of the specific resource but also in many relevant contexts. Because, for example, diverse users and uses can affect the supply of clean and ample water, control of the activities having potential impact on water availability implies intervention in a sizeable chunk of national regulation, involving different aspects of life and branches of government, to ensure compliance with the transboundary resource institution's policies. In return

[11] *Supra* note 5, at para. 147.

[12] *Supra* note 5, paras. 132-147. Judge Bedjaoui criticizes this evolutionary interpretation: see his separate opinion at http://www.icj-cij.org/idocket/ihs/ihsjudgement/ihsjudframe1.htm.

[13] On these prerequisites see Eyal Benvenisti, *Collective Action in the Utilization of Shared Freshwater: The Challenges of International Water Resources Law*, 90 AMERICAN JOURNAL OF INTERNATIONAL LAW 384, 409-11 (1996).

for such a broad delegation of authority, governments would insist on maintaining control over the process of decision making within the institution and over its implementation processes. There are various ways to ensure such control, from requirement of decisions by consensus through budget control to judicial appeal or review procedures. These will be discussed in Section 3.

2.2 Integration and Delegation of Authority: The Case for Subsidiarity

Perhaps a potentially powerful way to overcome the tension between the supranational institution and national governments is by creating links between the institution and sub-state entities, such as provinces or towns. Indeed, a crucial element in setting up shared institutions is the design of its levels of operation to tailor the specific geographic, political and social constraints of the region.

The constitutional design of a government as a clearing-house for the diverse and conflicting national interests is often responsible for failure to reach agreements on the management of transboundary resouces. The monopolistic position of a government requires any domestic actor, such as a local municipality or provincial government, that wishes to establish cooperation across international boundaries with neighboring sub-actors to invest resources in persuading the government to represent it vis-a-vis the other government. Each of the relevant national governments may, however, have different interests, due to the influence of other domestic sectors or to linkage with other issues. To overcome this structural failure, it is often necessary to develop the possibility of direct low-level interaction among sub-state actors. The same consideration applies when joint management institutions are established. Direct local exchanges among towns and villages straddling the shared water resource may overcome gridlock at the inter-governmental level.

Lower-level decision making and interaction may serve additional goals. From the perspective of efficiency, lower-level interaction may increase the regulators' understanding of the particular natural attributes of a local resource and the impacts on it by the suggested policies.[14] Capture by interest groups may be less effective in local settings. Public participation, instead,

[14] Daniel C. Esty, *Revitalizing Environmental Federalism* 95 Mich. L. Rev. 570, 625 (1996) ("Bureaucrats in Washington ... cannot know the future land use of a contaminated waste site as well as those in the community where the site is located. In deciding "how clean is clean enough," local judgment is essential.")

may be more effective and produce positive effects on the locals' commitment to compliance.[15] Similar support for delegation of authority to sub-state levels comes from the point of view of democracy and self-determination.

The idea of delegating the task of natural resources management to sub-state agencies has been tried with much success within various countries.[16] Also in the transnational arena there are examples of sub-state trans-border cooperation in matters related to environmental protection and water utilization, particularly in Western Europe but also between U.S. states and Canadian provinces.[17] These examples suggest that to reduce the complexity involved with heterogeneous actors, such as states, it may be beneficial to resort at times to sub-state agreements negotiated by sub-state actors, such as governors of provinces or mayors of neighboring cities.

Sub-state cooperation may be particularly necessary when national interests such as security or trade overshadow the politics of resource management. A recent case in point is a 1996 agreement between two municipalities, the Regional Council of Emek Hefer, located on the Coastal Plain of Israel, and the municipality of Tul-Karem, in the Palestinian-controlled area of the West Bank. These two municipalities share a severely polluted small basin, in which runoff from Palestinian towns and villages as well as from Jewish settlements flows through a small stream across the Green Line into the Emek Hefer area. Because negotiations between the Israeli government and the Palestinian Authority were blocked, the only avenue open to local administrators to pursue efforts of rehabilitation was direct low-level negotiation, bypassing the deadlock at the national level. After receiving an implicit green light from both governments – the Israeli Ministry of the Environment and PA President Yasser Arafat –

[15] Esty, *id.*, *id.*

[16] For the experience in New Zealand in this respect see Lloyd Burton & Chris Cocklin, *Water Resource Management and Environmental Policy Reform in New Zealand: Regionalism, Allocation, and Indigenous Relations*, 7 COLO. J. INT'L. ENVTL. L. & POL'Y 75 (1996) (describing the new Resource Management Act of 1991 that devoluted responsibility to the communities most directly affected by the decisions related to the natural resources; organizing communities on the basis of watershed boundaries).

[17] Maria Teresa Ponte Iglesias, Les accords conclus par les autorites locals de different Etats sur l'utilisation des eaux frontalieres dans le cadre de la cooperation transfrontaliere, SCHWEIZERISCHE ZEITSCHRIFT FUER INTERNATIONALES UND EUROPAEISCHES RECHT 103, 129-130 (2/1995); Ulrich Beyerlin, Transfrontier Cooperation between Local or Regional Authorities, ENCYCLOPEDIA OF PUBLIC INT'L L (INSTALLMENT 6) 350; Pierre-Marie Dupuy, La cooperation regionale transfrontaliere et le droit international 23 ANNUAIRE FRANCAISE DE DROIT INTERNATIONAL 837 (1977). See also the New-York-Quebec Agreement on Acid Precipitation (1982), rep. in 21 ILM 721 (1982).

the heads of the two municipalities met and signed an agreement outlining their commitment to cooperation.[18]

A similar case is reported in the former Yugoslavia, during the bloody 1991-92 conflict.[19] Despite the atrocities of the inter-ethnic conflict, and the many incidents where dams were intentionally destroyed, a low-level agreement was reached in 1992 between Serbs controlling the upstream Trebisnica River in Bosnia-Hercegovina and the Croat managers of the Dobrovnik hydropower plant. The agreement permitted the continuous flow of the river to the Dobrovnik plant in exchange for the Croats' guarantee to allow the continuation of supply of the river's water to the Bay of Kotor area in Montenegro.

The promise of sub-state cooperation is significant in the design of joint institutions for water management. Instead of institutions that rely on the member states as their basic building blocks, they could be based on a system of smaller sub-units that coordinate the use of the resource in the different sub-components of the resource.[20] Thus, for example, instead of a

[18] The originals are both in Arabic and Hebrew. My translation follows:

"Letter of Intent

The District of Tul-Karem, the Municipality of Tul-Karem and Emek Hefer Regional Council recognize the acute necessity to promote and protect the environment, for the protection of the water we drink and the soil we cultivate. For the benefit of the inhabitants of Tul-Karem and environs, the Hefer Valley and environs.

It was therefore decided to establish a steering and planning committee, which will be entrusted with supplying mutual expert solutions to resolve the problems in the short and immediate term and in the long term.

Those who stand at the helm will jointly work for obtaining funding and consent from international bodies, in an effort to realize the plans and to implement them."

The written text, in both languages, was prepared in advance by Emek Hefer Regional Council Head Mr. Itzkovic. He was accompanied by Mr. Abu-To'ama, the mayor of an Arab municipality in Israel, who made the initial contacts. Mr. To'ama also signed the letter. The envisioned plans are rather ambitious and complex, and include sewage-treatment facilities to be constructed with international financing on West Bank territory, supplying the treated water for Palestinian agricultural use.

[19] Mladen Klemencic, *The Effects of War on Water and Energy Resources in Croatia and Bosnia* in THE PEACEFUL MANAGEMENT OF TRANSBOUNDARY RESOURCES (GERALD H. BLAKE ET AL. EDS., 1995)

[20] Negotiations over a similar sewage treatment facility are under way in another small catchment area further south, in which a few Israeli towns and the Palestinian-controlled town of Qalqilia are situated (*Ha'aretz*, 1 March, 1998). It seems that such a functional approach is nowhere more appropriate than in politically divided cities such as Jerusalem or Nicosia. Jerusalem remains the only major metropolitan area in Israel whose wastewater flows untreated, which is evidence of the immense political obstacles to a proper solution. Nicosia, however, although torn between the Greeks and the Turkish Cypriots, continues to benefit from the joint operation of a sewage system constructed before the division of

river commission headed by representatives of all participating national governments, the alternative system would be based on a cluster of sub-basin institutions, each comprising representatives of the local communities. Public participation could be more effective and less costly in smaller-scale institutions, which will be more sensitive to the concerns of those directly affected by the uses of the resource in question. The existence of a number of smaller institutions, each responsible for a single sub-basin, could facilitate efficient intra- and inter-basin trade in shares of the resource.[21] The higher institution could serve as a forum for negotiations and even a clearing-house for transactions among sub-basin representatives.

These considerations of efficiency may be further bolstered by considerations of human rights and group rights. One can trace in international law an increasing recognition of claims of minority groups, especially indigenous peoples, to a right to autonomous management of natural resources in their vicinity as part of their claim to self-determination and the protection of their culture.[22] Delegating authority over water management may therefore be beneficial not only economically, but also socially.[23]

This idea of a special type of subsidiarity is not a panacea, and there may be very good reasons why it should be resisted partly or entirely. Economies of scale suggest that questions of risk assessment and even risk management be explored on the regional level. Interest-group capture manipulation may be stronger at the local level rather than at the regional level. There could be regions where, due to social and economic reasons, cross-border cooperation

the city. For options for low-key yet crucial joint ventures for Jerusalem, and a description of the Nicosian model, see Eran Feitelson & Qasem Hassan Abdul-Jaber, PROSPECTS FOR ISRAELI-PALESTINIAN COOPERATION IN WASTEWATER TREATMENT AND RE-USE IN THE JERUSALEM REGION (1997).

21 *See* Eyal Brill, APPLICABILITY AND EFFICIENCY OF MARKET MECHANISMS FOR ALLOCATION OF WATER WITH BARGAINING 102 (Ph.D. dissertation, submitted to the Senate of The Hebrew University of Jerusalem, 1997) (in Hebrew).

22 *See* Draft United Nations Declaration on the Rights of Indigenous Peoples, adopted by the Sub-Commission on Prevention of Discrimination and Protection of Minorities, UN Commission on Human Rights, August 26, 1994 (*rep. in* 34 I.L.M. 541 (1995)), which recognizes the value of water resources to indigenous peoples' social structure, culture and tradition (*see* the Preamble). The draft Declaration sets out to ensure *inter alia* the indigenous peoples' right to maintain and strengthen their relationship with their land, territories, waters and other resources (Article 25), to own and to manage these resources (Article 26), and their right to participate in decisions affecting these resources. *See also* Benedict Kingsbury, *Claims by Non-State Groups in International Law* 25 CORNELL INT'L L. J. 481 (1992).

23 On Indigenous people and participation in the management of natural resources see note 22 *supra* and Timothy P. Duane, *Community Participation in Ecosystem Management*, 24 ECOLOGY L.Q. 771 (1997).

is particularly difficult and thus cooperation at the national level would be more effective. In multiethnic countries, central governments may be worried that such cross-border cooperation may spur secessionist efforts by ethnic minorities situated in border areas. But these concerns do not rule out the potential promise of such agreements, where they can provide positive results. They call for a refined approach to the design of the level of natural resources regulation.[24]

This discussion suggests that international law should offer normative frameworks to sustain such localized cross-boundary agreements and encourage their development.[25] So far, however, international law has not given sufficient attention to sub-state agreements, an omission that severely weakens their legal status and hence their very creation. Current doctrine seems to suggest that such agreements will not be governed by international law, but rather by one or a number of national laws. This doctrine is derived from two principles: first, the principle of unity of action of the state in the international level; and second, the lack of legal personality to sub-state entities in the international sphere.[26] Indeed, it is hardly surprising that national governments seek to maintain their monopoly as sole representatives of their constituency. As expected, international law, based and developed through state consent, reflects this cartel of power by national governments. As a consequence, the parties who construct the legal framework of joint water institutions and choose to delegate authority to sub-state units within the general framework must carefully define the status of these units as part of the international agreement establishing the joint institution.

[24] Esty, *supra* note 14, at 652 ("[T] the diversity of environmental problems we face demands a range of regulatory response strategies and levels of governmental activity.")

[25] *See* the European Outline Convention on Transfrontier Co-operation between Territorial Communities or Authorities, ETS No. 106, Madrid, 21 May 1980, *rep. in* http://www.coe.fr/eng/legaltxt/106e.htm (framework convention adopted by the Council of Europe). *See also* Dupuy, *supra* note 17, at 860 ("Moins que jamais, la frontiere n'apparait comme une ligne de partage brutale des competences etatiques. Elle designe au contraire une zone privilegiee de la collaboration des populations et des leurs representants."). See also Agenda 21, Chapter 18, principle 18.12 (o)(i) (recommending, "as appropriate," to develop and strengthen mechanisms at all levels concerned, including "at the lowest appropriate level," such as "the decentralization of government services to local authorities, private enterprises and communities." rep. *in* 4 AGENDA 21 & THE UNCED PROCEEDINGS (NICHOLAS A. ROBINSON, ED., 1992), 357).

[26] Ponte Iglesias, *supra* note 17, at 122-124; Dupuy, *supra* note 17, at 852; Beyerlin, *supra* note 17, id.

3. DECISION-MAKING PROCEDURES

So far we have examined the structural aspect of transnational water institutions and the relationships with the national legal systems. This section will discuss the basic themes that the decision-making process within the institution must ensure: flexibility and mutuality, accountability, public participation and judicial review.

3.1.1 Flexibility and Mutuality

The first element emphasizes mutuality and flexibility. When designing institutional arrangements, emphasis should be put not on minutely defined and rigid obligations, such as, for example, with regards to the allocation of quantities of water or permitted pollution. Due to the uncertain future conditions or the inability to characterize complex adaptations, the parties, when constructing the institution, are incapable of reducing important terms of the arrangement to well-defined obligations.[27] Most emphasis should therefore be given to structures and procedures for future exchanges. Moreover, flexibility in the institutional design is also important.[28] This observation conforms with the theory of relational contracts that distinguishes between discrete and relational contracts.[29] As relational contracts theory suggests, the agreement should be designed to maintain mutuality and flexibility in relations between the parties. More specific obligations are to be decided upon by the institutions to which the agreements assign governance.

Flexibility in the context of transboundary resource management implies that allocation decisions must remain subject to periodic change in light of new conditions or knowledge. This is particularly important in the sphere of freshwater management. Adjustment of shares is often necessary, because

[27] Andrew Hurrell & Benedict Kingsbury, *Introduction in* THE INTERNATIONAL POLITICS OF THE ENVIRONMENT (ANDREW HURRELL & BENEDICT KINGSBURY EDS., 1992) (flexibility because knowledge develops over time).

[28] See Barbara Koremanos, Charles Lipson and Duncan Snidal, *Rational International Institutions* (Rational International Institutions Project www.harisschool.uchi) (suggesting that two kinds of flexibility are necessary: flexibility of the norms and the institutional procedures to enable it to modify its work).

[29] See Benvenisti, *Collective Action, supra* note 13, at 404-05. On relational contracts *see* IAN R. MACNEIL, THE NEW SOCIAL CONTRACT (1980); *id.*, *The Many Futures of Contract*, 47 S. CAL. L. REV. 691 (1974); *id. Economic Analysis of Contractual Relations: Its Shortfalls and the Need for a "Rich Classificatory Apparatus,"* 75 NW. U. L. REV. 1018 (1981); Charles J. Goetz & Robert E. Scott, *Principles of Relational Contracts* 67 VA. L. REV. 1089 (1981); Alan Schwartz, *Relational Contracts in the Courts: An Analysis of Incomplete Agreements and Judicial Strategies* 21 J. LEG. STUD. 271 (1992).

relative demands for water change constantly, reflecting economic and social development in each country, while the supply side also fluctuates, with unpredictable droughts or floods.

3.1.2 Accountability

The provision and dissemination of information, and reliance on scientific findings can ensure the accountability of the institution. Reasoned opinions to explain the decisions taken by the institution also contribute to accountability. Shared institutions should accumulate and provide "the widest exchange of information"[30] on each state's current and expected supplies of and demands from a shared water, as one means to ensure effective communications among state actors as well as effective monitoring by non-government organizations (NGOs) and the public at large. A transparent decision-making process, which includes the dissemination of data, will nurture domestic debate within all the participating countries regarding the range of options available to the governments, thereby increasing the governments' ability to assess public support, and at the same time constraining possible attempts of the government to diverge from national interests.

The recognition of the duty of one government to provide information to the other ones could technically be based on the duty to cooperate in the utilization of shared resources,[31] or on the more general duty to negotiate resource-related agreements in good faith.[32] Because resource-sharing agreements focus on questions of management and allocation of the resource

[30] Article 6 of the 1992 Helsinki Convention on the Protection and Use of Transboundary Watercourses and International lakes, *rep. in* 31 ILM 1312 (1992).

[31] See, with respect to shared freshwater, Article 8 of the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (adopted on May 21, 1997), *rep. in* 36 ILM 700 (1997) ("the Watercourses Convention").

[32] *See* Article 3(5) of the Watercourses Convention, supra note 27; Articles 6, 7 of the Institute of International Law's Resolution on the Utilization of Non-Maritime International Waters (Except for Navigation) Adopted at its session at Salzburg (September 3-12, 1961) (49 (II) ANNUAIRE DE L'INSTITUT DE DROIT INTERNATIONAL, 370 (1961) (*trans. in* 56 AJIL 737 (1962 On the duty to negotiate in good faith *see e.g.* Julio A. Barberis, *Bilan de recherches de la section de langue francaise du Centre d'etude et de recherche de l'Academie* in CENTRE FOR STUDIES AND RESEARCH 1990, RIGHTS AND DUTIES OF RIPARIAN STATES OF INTERNATIONAL RIVERS 15, 54-55; JANOS BRUHACS, THE LAW OF NON-NAVIGATIONAL USES OF INTERNATIONAL WATERCOURSES 176-8 (1993). Charles B. Bourne, *Procedure in the Development of International Drainage Basins: The Duty to Consult and to Negotiate* 10 CAN. YB. INT'L L. 212, 224-233 (1972). Dominique Alhertiere, *Settlement of Public International Disputes on Shared Resources: Elements of a Comparative Study of International Instruments* 25 NAT. RES. J. 701 (1985).

on the basis of the respective supplies and demands, withholding ample and accurate information on these two matters runs contrary to the duty to cooperate and does not constitute good faith.

A similar case could be made for recognizing a duty to employ and consult experts. Scientists of various disciplines, identified by some as "epistemic communities,"[33] could suggest alternatives for reaching optimal solutions. Their contributions could diffuse politically skewed positions of domestic interest groups and hence of governments. Expert advice could also come from third parties, including NGOs. As the ICJ mentioned in its decision in the Gabcikovo-Nagymaros dispute, "the readiness of the Parties to accept [third party] assistance would be evidence of the good faith with which they conduct bilateral negotiations."[34]

The duty to disseminate the same information to the general public can be derived from the principle of freedom of information, a widely accepted principle in many democracies and embedded in international human rights law. It also finds support in international instruments related to transboundary resources. The 1992 Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes,[35] for example, requires riparians to "ensure that information on the conditions of the transboundary waters, measures taken or planned to be taken to prevent, control or reduce transboundary impact, and the effectiveness of those measures, is made available to the public."[36]

Finally, accountability requires also reasoned decisions. The process reasoning and persuasion that precedes the actual vote and is later reflected in the published decision is effective in eliminating inefficient outcomes and providing for more equitable distribution of resources. Such a deliberative process legitimizes the decision taken and thus ensures greater compliance.[37] At the very least, the requirement that joint management institutions offer reasons for their decisions increases the accountability of decision makers, just as the reasoning of court opinions serves as a constraint on judicial power.

[33] See Peter M. Haas, Introduction: Epistemic Communities and International Policy Coordination, 46 INT'L ORG. 1 (1992).

[34] Paragraph 143 of the decision, *supra* note 5. The ICJ was referring to the assistance and expertise offered by the Commission of the European Communities to settle the dispute.

[35] *Rep. in* 31 ILM 1312 (1992).

[36] Article 16. *See also* Agenda 21, Chapter 18 (on freshwater resources), Principle 18.12(p) (concerning the dissemination of information as one of the means to improve integrated water management), supra note 25, at 366.

[37] *See* James D. Fearon, *Deliberation as Discussion, in* DELIBERATIVE DEMOCRACY 44, 56 (Jon Elster ed., 1998). This trend has in recent years been developed following J? rgen Habermas's THE THEORY OF COMMUNICATIVE ACTION (vol. 1, 1984; vol. 2, 1987).

3.1.3 Fair Representation of All Interested Groups

Fair procedures require not only attention to the possibilities of external monitoring of the decision-making process but also to the opportunities of all affected groups to be fairly represented among the decision makers. The main issue in this regard involves the opportunities for minority groups potentially affected by management decisions, to be fairly represented among the decision makers. Such an interest stems from the identification of the problem of minority representation as related to the failures of the national political process, in which "discrete and insular minorities"[38] fail to exert influence.[39] This is particularly the case of indigenous groups whose wellbeing is closely linked to water management. Procedural guarantees, primarily a right for fair representation, is therefore crucial to protecting their interests.

This right has been recognized by the Human Rights Committee, which acknowledged the duty of member states to take "measures to ensure the effective participation of members of minority communities in decisions which affect them."[40] "The right to participate effectively" in public life and in matters concerning the minority has been recognized in a number of international instruments.[41] State practice in the new democracies in Central and Eastern Europe does reflect efforts to ensure minority representation in

[38] As the term coined by the U.S. Supreme Court in the case of United States v. Carolene Prods. Co. 304 U.S. 144, 152-53 n.4 (1938). On this consideration see also *infra* note 59 and accompanying text.

[39] The literature on Public Choice discusses the failure of various groups -- among them women, consumers, future generations -- to exert influence on the political process and the possible legal responses to this phenomenon: *see e.g.* DANIEL A. FARBER & PHILIP P. FRICKEY, LAW AND PUBLIC CHOICE (1991). The problem is exacerbated in the international context: see Eyal Benvenisti, *Exit and Voice in the Age of Globalization* 98 MICHIGAN LAW REVIEW 167 (1999).

[40] General comment under Article 40 (4) of the ICCPR No. 23/50, adopted on 6 April 1994. Doc. CCPR/C/21/Rev.1/Add.5., *rep. in* 15 HUM. RTS. L. J. 234-236 (1994) (hereinafter: "HR Committee General Comment"), at 236.

[41] Council of Europe's Framework Convention for the Protection of National Minorities, 1995 (rep. in 34 I.L.M. 351 (1995), Article 1(2), 1(3); Declaration on the Rights of Persons Belonging to National or Ethnic, Religious and Linguistic Minorities, United Nations G.A. Res. 47/135, 18 December 1992 (rep. in 32 I.L.M. 911 (1993); Draft UN Declaration on the Rights of Indigenous Peoples, adopted by the UN Sub-Commission on Prevention of Discrimination and Protection of Minorities on 26 August, 1994 (rep. in 34 I.L.M. 541 (1995).

parliaments. These efforts include provisions in constitutions,[42] as well as decisions of constitutional courts that protect this right.[43]

3.1.4 Public Participation

The duty to provide information to negotiators and to disseminate it to the public is not self-enforceable, and the opportunities for collusion by negotiators are numerous. The post-hoc ratification procedures cannot ensure adequate public scrutiny of the government's behavior in its dealings with foreign governments. The government-as-agent, enjoying the relative secrecy of international negotiations, may find it quite easy to pursue partisan, short-term policy at the expense of its larger constituency and as a result adopt skewed, sub-optimal and non-sustainable policies. The necessity has therefore been felt to allow representation of the "other voices" in the negotiation process, mainly NGOs who represent domestic voices who fail to form strong domestic interest groups. For this reason, a right to be represented or consulted during such negotiations, or at the very least a right to be heard before agreements are signed, especially for those who may be personally adversely affected by them, should be acknowledged. Such an involvement would provide an opportunity for representatives of less organized interest groups to have their concerns presented and examined not only by the governments but also by the domestic groups of the other states. The latter opportunity may lower the communication costs among environmentalists across national boundaries and increase their effectiveness. After an agreement has been ratified, public involvement in

[42] Florence Benoit-Rohmer & Hilde Hardeman, *The Representation of Minorities in the Parliaments of Central and East European Europe* 2 INTERNATIONAL JOURNAL ON GROUP RIGHTS 91, 94 (1994) (In these recent constitutions, there is a recognition of the right to participate in public life, but only the new Romanian constitution ensures in Article. 59 the mandatory representation of at least one seat for each group of citizens belonging to national minorities. Lithuania and Poland have specific provisions lowering threshold requirements for parties representing minorities (*id.*, at 100).

[43] *See* the decision of the Bulgarian Constitutional court no. 1/1992, of 21 April, 1992, English summary in (1992) EUROPEAN CURRENT LAW YEAR BOOK 304 (the right of a party representing a minority to take part in the general elections) For background to this case *see* Slavi Pashovski, *Minorities in Bulgaria*, *in* THE PROTECTION OF ETHNIC AND LINGUISTIC MINORITIES IN EUROPE 67, 70-75 (John Packer & Kristian Miyntti eds., 1993); In Croatia: Decision of 14 December, 1994, summarized in *Bulletin on Const. Case-Law* 223 (1994) (concerning participation in parliamentary voting); Decision of 2 February, 1995, summarized in *Bulletin on Constitutional Case-Law* 18 (1995) (the power of a county to determine minority rights). In Romania: decision of 18 July, 1995, summarized in BULLETIN ON CONST. CASE-LAW 188 (1995) (approving the constitutionality of the proposed education act which provided a proportional representation of professors and teachers of minority groups in the administrative bodies of educational institutions).

ongoing decision-making processes of transboundary management institutions, through consultations, hearings or even shared decision making, is necessary for the same reasons.

Public participation in institutional decision making has been recognized by many as crucial for responsible decision making. It has been observed that NGO participation improved the work of environmental decision-making bodies.[44] In addition to monitoring against interest-group capture, they provide useful additional information for decision makers, and otherwise contribute to improve the quality of decisions.[45]

The benefits of public participation have been recognized in recent international instruments. The 1992 Rio Declaration notes that "[e]nvironmental issues are best handled with the participation of all concerned citizens, at the relevant level."[46] Chapter 18 of Agenda 21 calls for active public participation in shared freshwater management, which includes not only the provision of a right of hearing to oppose plans which could be detrimental to certain individuals or groups, but more generally, require states to aim at "an approach of full public participation, including that of women, youth, indigenous people and local communities in water management policy-making and decision-making,"[47] and suggest the "[d]evelopment of public participatory techniques and their implementation

44 Kevin Stairs & Peter Taylor. *Non-Governmental Organizations and the Legal Potection of the Oceans: A Case Study, in*, THE INTERNATIONAL POLITICS OF THE ENVIRONMENT 110 (ANDREW HURRELL & BENEDICT KINGSBURY EDS., 1992) (describing the contribution of environmental NGOs in the development and implementation of international agreements on environment protection); Kal Raustiala, *Note: The "Participatory Revolution" in International Environmental Law*, 21 HARV. ENVTL. L. REV. 537 (1997) (describing NGOs as "major actors in the formulation, implementation, and enforcement of international environmental law.," and argues that states benefit from NGOs informational and legitimization services).

45 Lee P. Breckenridge *Nonprofit Environmental Organizations and the Restructuring of Institutions for Ecosystem Management* 25 Ecology L.Q. 692 (1999) (pointing out that NGOs "constitute a logical place for governmental out-sourcing for technical, resource management, training and other work."). An extensive listing of recent publications addressing the formation in the US of partnerships between governmental and non-governmental groups in the environmental field may be found in Kris Bronars and Sarah Michaels, *Annotated Bibliography on Partnerships for Natural Resource Management* (1997), available at <http://www.icls.harvard.edu/ppp/contents.htm> (the web site is maintained by the Institute for Cultural Landscape Studies of the Arnold Arboretum, Harvard University).

46 Declaration of the UN Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992. Principle 10 (emphasis added).

47 Agenda 21, *supra* note 25, Principle 18.9(c).

in decision-making."[48] A number of conventions provide room for public participation through NGOs as observers.[49] The North American Free Trade Agreement (NAFTA) also provides standing for NGOs to complain against a state's failure to comply with its obligations.[50] The 1997 Helsinki Declaration of the parties to the 1992 of Transboundary Watercourses and International Lakes declares that "broad public participation is essential for implementing and developing further the convention."[51] It mentions governments, public and private sector organizations, joint bodies, NGOs, the scientific community and all those involved in water management and environmental protection as potential participants in the process. The 1997 Watercourses Convention fails to mention this idea,[52] and maintains the stiff separation between the international and the domestic levels by providing only for state-to-state notification and consultation. However, there are scholars who find it possible to derive such participatory rights from more basic notions of civil and political rights,[53] and of general environmental law.[54]

Note that the growing importance of NGO participation in joint management institutions would necessitate paying more attention to the identity of the participating NGOs, to prevent possible abuse of their standing by unscrupulous actors.[55] In joint management institutions the

48 *Id.*, Principle 18.12(n). *See also* Allen Hey, *Sustainable Use of Shared Water Resources: The Need for a Paradigmatic Shift in International Watercourses Law*, in THE PEACEFUL MANAGEMENT OF TRANSBOUNDARY RESOURCES 127, at 133 (GERALD S. BLAKE ET AL. EDS., 1995).

49 Treaties that provide standing to NGOs as observers include the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, Article 11 (5); 1992 Framework Convention on Climate Change, Article 7(6); 1973 Convention on International Trade in Endangered Species of Wild Flora and Fauna, Article XI (7).

50 NAFTA's North American Agreement on Environmental Cooperation (incl. standing to complain against a state for failing to enforce domestically: Raustiala, 25 Envtl. L. 31 (1995); id, 36 Va. J. Int'l L. 721 (1996).

51 Adopted by the Meeting of the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes at Helsinki (Finland) on 4 July 1997 (Report of the First Meeting, ECE/MP.WAT/2), at 17.

52 *See* Hey, *supra* note 48, at 134-5.

53 *See* Alan Boyle, *The Role of International Human Rights Law in the Protection of the Environment in* HUMAN RIGHTS APPROACHES TO ENVIRONMENTAL PROTECTION 43, 59 (ALAN E. BOYLE & MICHAEL R. ANDERSON EDS., 1996).

54 *See* Boyle, *id.*, at 59-63; James Cameron & Ruth Mackenzie, *Access to Environmental Justice and Procedural Rights in International Institutions* in HUMAN RIGHTS APPROACHES *supra* note 54, at 129, (esp. 134-135); Sionaidh Douglas-Scott *Environmental Rights in the European Union -- Participatory Democracy or Democratic Deficit? in* HUMAN RIGHTS APPROACHES, *supra* note 54, at 109, 112-20.

55 Lee P. Breckenridge *Nonprofit Environmental Organizations and the Restructuring of Institutions for Ecosystem Management* 25 Ecology L.Q. 692, 698 (1999) As non-profit

decision over to whom to grant standing and to whom to deny it would have to become yet another matter for joint decision.

3.1.5 Review Procedures

If joint management institutions are granted the authority to issue decisions that have binding effect on the participating states, the question of review becomes crucial. We cannot assume such institutions, despite the careful design, to remain thoroughly impartial and without the potential of external review. Power corrupts, and it can corrupt also joint management institutions that remain without external scrutiny. Two questions arise: first, what role could judicial review play? In particular, can adjudicators second-guess institutions' decisions? Second, what type of review process is preferable? In particular, are transnational courts preferable to national ones?

It is my view that judicial review may be beneficial in ensuring the proper functioning of joint management institutions. Although national governments and NGOs can be effective in monitoring the activities of such institutions, their protests may be deemed partial or self-interested and thus dismissed by other actors as wrong or illegitimate. Judicial review could and should emphasize the procedural aspects delineated in this chapter.[56] In general, a wide margin of appreciation should be assigned to the institution's balancing of the different claims and considerations, provided all interests had been properly discussed in a proper process. Adjudicators are less qualified than the experts and bureaucrats in the institutions to reach a appropriate balancing of competing claims. Yet they are more qualified in examining whether procedural rules have been kept. They may be also more sensitive to procedural shortfalls that hindered the full presentation and weighing of claims of minorities, especially indigenous groups, whom the political process may disadvantage and whose interests in the water are often disregarded. When such groups are affected, adjudicators could prove crucial in ensuring their interests are properly considered. Therefore, while the margin of appreciation doctrine may be theoretically justified as motivated

organizations gain increasing influence in the management and allocation of natural resources, taking on functions that are both more governmental and more entrepreneurial, questions of accountability and fairness are bound to arise.. *See* Burton A. Weisbrod, The Future of the Nonprofit Sector: Its Entwining with Private Enterprise and Government, 16 J. Pol'y Analysis & Mgmt. 541 (1997) (Success of NGOs produces growing demands for accountability).

[56] See also Francois du Bois, *Social Justice and the Judicial Enforcement of Environmental Rights and Duties* in HUMAN RIGHTS APPROACHES TO ENVIRONMENTAL PROTECTION (BOYLE & ANDERSON EDS., 1995), 153, at 173-74.

by the necessity to relegate authority to specialized bodies, a caveat must be set for cases when minorities' interests are implicated. A more searching judicial inquiry, without recourse to the margin rhetoric, will clear the way for more effective international protection of minorities' interests in matters concerning the allocation of resources or of burdens.[57]

This last concern with minority interests also weighs heavily in favor of transnational adjudication, rather than on national judicial review processes. The gist of the argument is that there are often several groups within each community that tend to be persistently outvoted and hence to be underrepresented in the political process. They are the "discrete and insular minorities" that are in a very real sense political captives of the majority. These groups would usually include members of ethnic, national or religious communities, who are numerically inferior to the rest of the population.[58] In addition to their different culture, tradition and sometimes appearance, the loyalty of these groups to the majority-controlled institutions is often questioned by members of the majority, and concerns with potential irredentism or secessionism are rife. With no political influence, and faced with prevalent resentment, these individuals rely upon the judicial process to secure their interests.[59] But because the national judicial process – itself dominated by judges of the majority – may fail to protect them, international judicial and monitoring organs are often their only reliable and last resort. In conflicts related to water management, which often result in burdening exclusively or predominantly on the rights and interests of the minorities, no preference to national adjudication is called for. In such conflicts, supranational institutions staffed not only by representatives of governments are preferable. Good examples of this point have been set by the international human rights bodies that were able to safeguard minority interests also with respect to the allocation of resources among minority and majority. National plans to reduce, for example, grazing areas crucial for

[57] See Eyal Benvenisti, Margin of Appreciation, Consensus and Universal Standards, 31 NYU JOURNAL OF INTERNATIONAL LAW AND POLITICS 843 (1999).

[58] Compare Francesco Capotorti's widely accepted definition of minorities as: "[a] group numerically inferior to the rest of the population of a State, in a non-dominant position, whose members - being nationals of the State - possess ethnic, religious or linguistic characteristics differing from those of the rest of the population and show, if only implicitly, a sense of solidarity, directed towards preserving their culture, traditions, religion or language." (Francesco Capotorti, *Study on the Rights of Persons Belonging to Ethnic, Religious and Linguistic Minorities*, E/CN.4/Sub.2/384/Rev.1 (1979), at 96).

[59] JOHN HART ELY, DEMOCRACY AND DISTRUST (1980). *See also* Robert M. Cover, *The Origins of Judicial Activism in the Protection of Minorities*, 91 YALE L. J. 1287 (1982); Bruce A. Ackerman, *Beyond Carolene Products*, 98 HARV. L. REV. 713 (1985); Owen M. Fiss, *The Supreme Court, 1978 Term - Forward: The Forms of Justice*, 93 HARV. L. REV. 1 (1979).

maintaining the culture of the Sami minority in Finland,[60] were scrutinized strictly by the Human Rights Committee that refused to defer to the state's margin of appreciation.

Other considerations that support the preference to transnational, rather than national, review processes emphasize aspects of efficiency. Decisions will become final and binding upon both institution and participating states. The composition of adjudicators will include representatives with expertise in the specific matter. The above-mentioned concern for minorities' rights requires that their representatives should be included among the panel of adjudicators.

4. CONCLUSION

This Chapter described the main normative questions that require attention when constructing joint management institutions for transboundary freshwater and other natural resources. It is important to note that the very process of setting-up joint management institutions is in itself a collective action problem, which could entail attempts to capture opportunistic gains. The process of designing such institutions should include the participation of the wider public, through their representative NGOs and through the dissemination of accessible information. This design process is not an easy task. A delicate balance must be found to accommodate governmental, inter-governmental, and non-governmental representation, and to ensure that narrow interests, including those advanced by NGOs, do not gain dominance.

The same considerations apply to the process of institution reformation. Transnational water management institutions must remain flexible enough to enable modifications that respond to changed circumstances and to new information that reveal errors in the structural design. Any joint-management mechanism must provide rules and procedures concerning its own modifications. For the reasons elaborated earlier, this must not be left to representatives of governments negotiating behind closed doors. Rather, the procedure must involve also scientific experts, minority groups' representatives and NGOs representing diverse interests. With uses and allocations of transboundary resources under constant reappraisal,

[60] In the case of Lansman et al. v. Finland (Communication No. 671/1995, 28 August 1995, UN Doc. CCPR/C/58/D/671/1995 (1996)), which addressed Finnish development plans in an area used by the Sami minority, the HRC emphasized that its decision in *not* based on reference to a margin of appreciation (at para. 9.4).

renegotiations are channeled to the treaty bodies, away from potentially divisive domestic forums. Although there is always a risk that efforts to renegotiate problematic agreements would fail, this risk is significantly lower than the risks presented by unilateral abuses of any of the diverse "escape doctrines" from treaty obligations.

Chapter 23

Crisis Management

The Case of Drought Management in Semi-Arid Countries

Ismail Najjar
Hydrosult Inc., Montreal, Canada

1. INTRODUCTION

There are two approaches to crisis management: the reactive approach, also know as crisis management; and the proactive approach, also called risk management.

Droughts can be managed by either of the two approaches. For the purpose of this paper, the reactive approach will be considered. Figure 1 illustrates the sequence of measures that are taken for drought management. In any drought management plan, four sequential measures are usually applied:

1. Drought prevention
2. Minimization of drought impact
3. Mitigation of drought impact
4. Compensation

The first set of measures is applied to attempt to prevent the crisis, or as drought pre-paredness action, and is normally initiated as a result of the close monitoring of the climatic and hydrological parameters and the computation of drought indices. The second and third sets of measures are aplied during the crisis, either to minimize or to mitigate its impact. The last set of measures are applied to compensate the effect of the crisis (see Figures 2A-D).

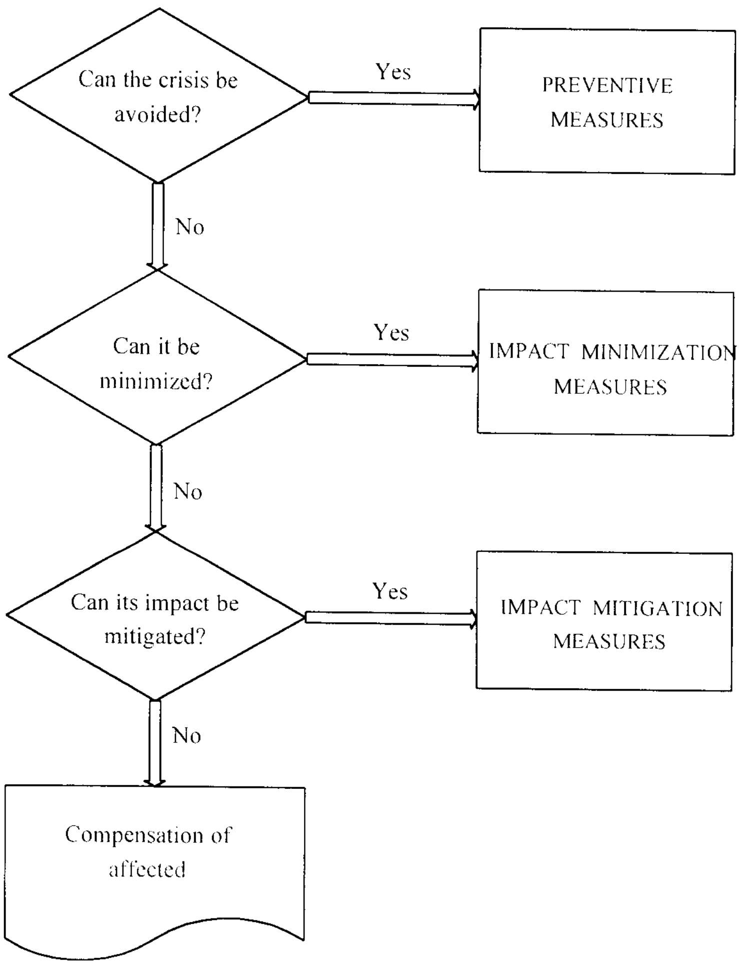


Figure 1. General Diagram Illutstrating Crisis Management

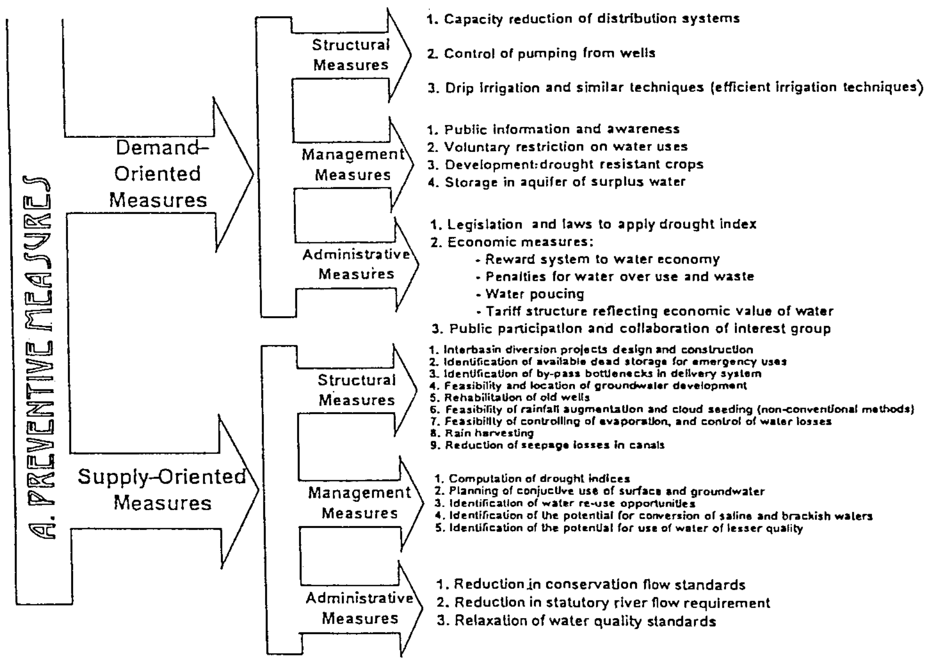


Figure 2a. Drought Crisis Management Measures: Preventative Measures

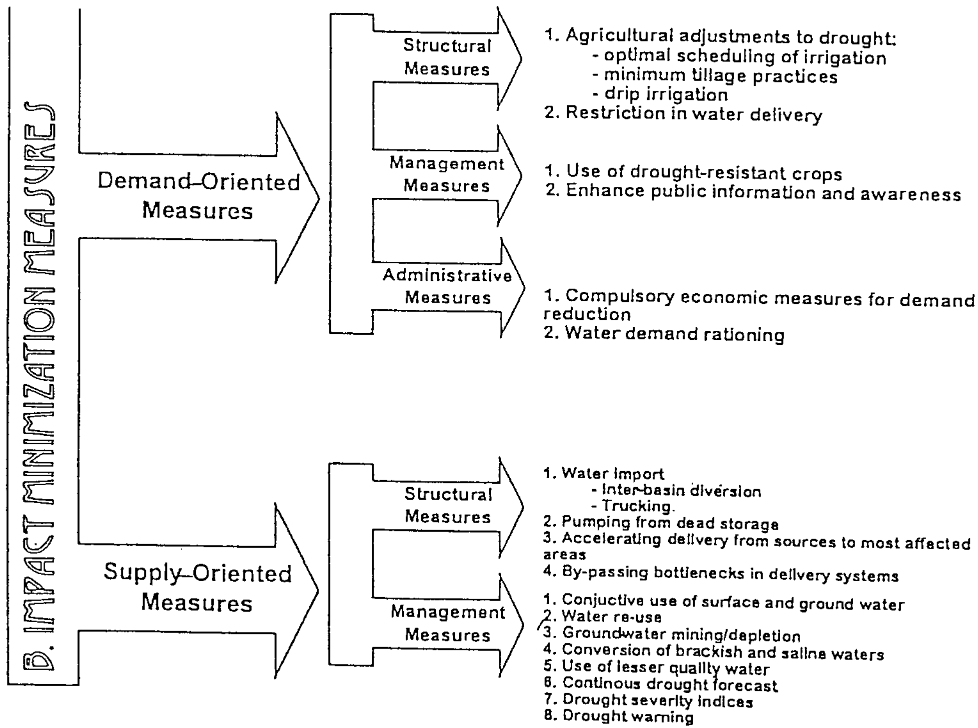


Figure 2b. Drought Crisis Management Measures: Impact Minimization

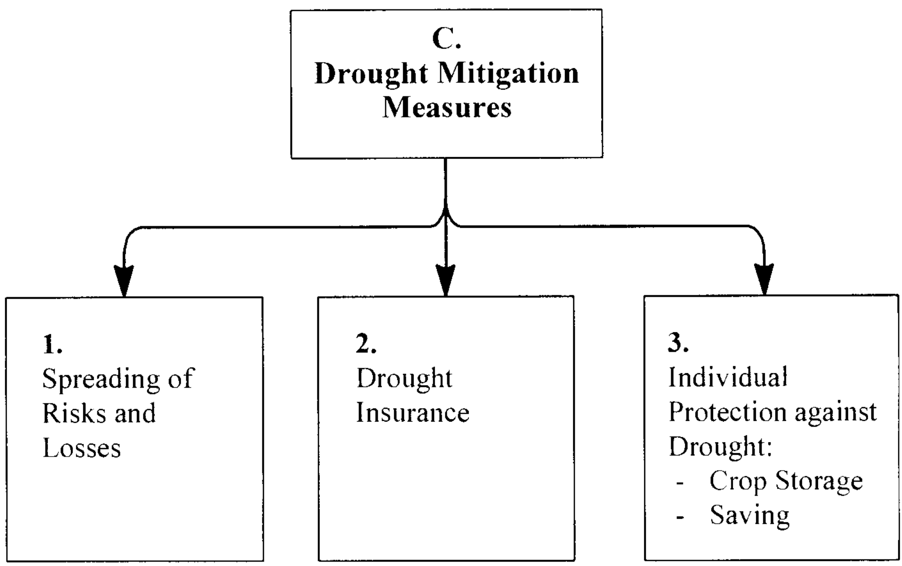


Figure 2c. Drought Crisis Management Measures: Drought Mitigation

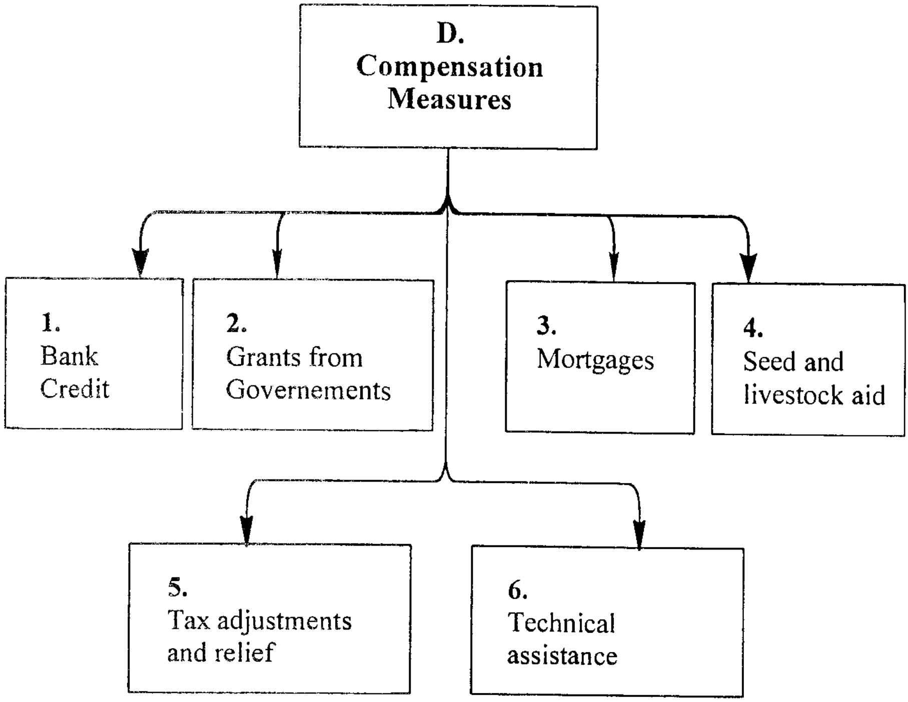


Figure 2d. Drought Crisis Management Measures: Compensation Meseasures

The measures described above for managing drought crises can be categorized into two main components of the water balance equation: Water-demand oriented measured which deal with the management of the demand side of the water balance equation, with an attempt at influencing demand and supply being made, thereby managing or optimizing the availability of water supply sources and minimizing water shortages. These demand-and supply-oriented measures fall into three functional categories: structural, managerial, and administrative.

2. DROUGHT PREVENTIVE MEASURES

A good example of a drought management plan which can be cited is that of the South Carolina Drought Response Act of 1985. The Act applies to all water supplies and to all ground and surface water resources of the State of

Carolina, excepting private ponds. All public water suppliers, such as municipalities, counties, public service districts, and commissions of public works are required to adopt a Drought Response Ordinance or plan and file it with the South Carolina Department of Natural Resources. For purposes of drought management, the state was divided into six Drought Management Areas (DMA). In each DMA, drought response committees are established, made up of public and private sector members.

The Act also define four levels of drought severity and the necessary respective responses as follows:

Drought Severity	Response Measure
Incipient	Monitoring
Moderate	Voluntary reductions in water use are encouraged
	Drought information center is activated
	News releases on drought conditions
Severe	Water suppliers recommended to implement voluntary or mandatory water use restrictions
Extreme	Mandatory water use restrictions are recommended

As noted above, a drought management plan is made up of structural and non-structural elements. Each plan must address the three sequential phases of a drought: pre-drought preventive, drought period minimization and mitigation, and post-drought, entailing compensatory steps. A preventive plan would include structural management and administrative measures. All three measures may be applied at the same time, or follow a sequence.

2.1 Demand Oriented Measures

2.1.1 Structural Measures

Examples of structural measures include the reduction of the capacity of water supply distribution systems, such as networks, irrigation systems, reservoir releases, and the control and reduction of groundwater pumping, and the exploitation of private well resources by metering. Another important measure is the improvement irrigation efficiency through the introduction of water-saving techniques or efficient irrigation systems, such as the reduction of evaporation, the use of drip irrigation, lining of canals, or conveying irrigation water by pipes.

2.1.2 Management Measures

Management measures may vary from activities such as supplying public information and heightening awareness on matters dealing with water conservation and demand management, to calling for voluntary restrictions on water uses, the development of drought-resistant crops, and the storage of surplus water in aquifers. The latter measures has been successful in California and Florida. Some Arab countries, such as Kuwait and Qatar, have been conducting experiments in the field by using surplus desalinated water (Najjar, 1995). Recovery of stored water varies from 10 to 50 per cent, depending on the nature of the aquifer material in which the surplus water is stored (Payne, 1995). Drought-resistant crops research work has also been progressing in several drought-prone countries, and good results have been obtained.

2.1.3 Administrative Measures

These measures should be contained in any drought management program. Administrative measures are mainly legislative and legal, and enacted to restrict water use below a certain drought index or severity. As illustrated above, the South Carolina Drought Act defined different kinds of drought conditions and recommended appropriate response measures for each. Economic measures, such as setting up a reward system as an incentive to save water, and having penalties for overuse and waste, are very effective. However, a great deal of public awareness and information is needed to render these measures successful. Water in most Third World countries is considered a gift from God and is thus not regarded as an economic commodity with a related value. Even in countries where water prices are set, it is only when the price reflects an economic value, that people deal with water as an economic commodity.

2.2 Supply Oriented Measures

2.2.1 Structural Measures

Structural measures may include the following: (a) The identification of available sites or sources of stored water, either in surface reservoirs or in aquifers. At this stage, all these sites must be mapped out and investigated, and their capacity established. Access to these sites must also be cleared or improved to prevent bottlenecks in conveyance. (b) In Middle Eastern countries, where groundwater is a principal source of supply, it is important to update and upgrade the knowledge available on its occurrence and potential, and to identify alternative groundwater sources of different qualities and quantities. Moreover, it is also necessary to keep an updated inventory of wells and to identify those that need restoration. The maximization of available supplies through non-conventional method is an important structural measure that can be effectively applied in arid regions. Such non-conventional methods include cloud-seeding, the reduction of evaporation and water losses, rain-harvesting and fog-collection.

3. MINIMIZING THE IMPACT OF DROUGHT

During droughts, rainfall amounts decrease to far below normal, and groundwater-tables drop by several meters. The catastrophic drought of 1991-92 which hit Zimbabwe offers valuable insights into the vulnerability of semi-arid to arid regions. During that drought, Zimbabwe's temperatures reached record heights, rainfall decreased to just 40 per cent of the normal amount, causing a severe drop in the water-table as wells tapping groundwater (traditional and boreholes) dried up and a large number of rivers, lakes, reservoirs and their related ecosystems disappeared. During the drought, people in remote areas often walked 10 to 15 kilometers for their daily supplies. Schools, hospitals and rural service centers were threatened with closure due to water shortages, meanwhile, irrigation programs failed completely. This extreme drought situation caused a total collapse in the nation's agricultural system, including of its irrigated and rainfed crops and animal herbs. The drought recovery program, which also included the importation and distribution of grain, cost over US $40 million, since 80 per cent of Zimbabwe's 10.5 million inhabitants are farmers, with many of the remaining city dwellers also being engaged in agro-industry. The resulting economic damage and human suffering were on a tremendous scale (IUCC/UNEP), 1994).

3.1 Demand-oriented Measures

3.1.1 Structural Measures

Two principle structural measures for drought impact minimization are: agricultural adjustments to drought, and restricted water deliveries.

3.1.1.1 Agriculture Adjustment to Drought

Late starts to rainy seasons, prolonged mid-season droughts, and shelter growing seasons have prompted drought-prone and afflicted countries to develop agricultural techniques that can adjust to drought conditions. Principal among the techniques are:

The adoption of an optimal schedule for irrigation

The practice of minimum tillage to keep the moisture in the soil

The use of efficient irrigation methods, such as drip irrigation, which maximize the benefits of scarce water, and reduce its losses

3.1.1.2 Restricted Water Deliveries

This is a type of overall supply management and water conservation plan and has as an objective the reduction of water use by restriction and control. Examples are rotating water delivery to users, or decreasing the capacity of delivery network systems.

It should be mentioned here, that such measures must be taken into account in combination with water users and water suppliers. It is also important to note that staged drought contingency plans should feature the implementation of various minimization measures at each defined level of water supply shortage.

3.2 Management Measures

Use of drought-resistant crops can be considered both as a structural and management measure in drought management. The actual use of drought-resistant crops as an alternative to conventional crops is a structural measure, while the policy for using these crops is a management step. Agriculture is the mainstay in many countries in the Middle East, and prolonged drought may cause a drop in the production of the major food crops, resulting in acute and recurrent food shortages. The farmer's and citizen's ability to adjust to droughts depends on the available technology and production systems in use. In drought regions, irrigation and the development of relatively drought-resistant crops are the best options for sustained agricultural output without causing damage to the environment. Examples of such crops can be cited from different countries, such as Zimbabwe, Syria, Ethiopia, and Israel.

In Zimbabwe, for instance, droughts prompted the development of seed varieties that require shorter growing seasons, while in Syria a variety of drought resistant wheat, barley and lentil seeds have been developed. In Ethiopia, a maize improvement program for low rainfall areas was begun more than a decade ago. Within the framework of the program, two maize varieties were recently produced which are early maturing and relatively drought-tolerant. At Israel's Ben-Gurion University of the Negev's T. Blaustein Centre for Desert Research a sizeable collection of arid-land plants have been developed, which are resistant to salinity and drought, many having agricultural or industrial potential (e.g. Guayule, Jojoba) (FAO, 1996). Also important, is the management measures at this stage of drought control should be accompanied by an intensive and expanded public awareness and information program).

3.3 Administrative Measures

Administrative measures to minimize the impact of drought are mainly concerned with water demand management. These include compulsory economic measures for demand reduction, such as higher tariffs, penalties for overuse, as well as water demand rationing the establishment of water banks for voluntary sale, the transfer of exchange of water, and voluntary farmland idling programs.

3.4 Supply-oriented Measures

Supply-oriented measures help in alleviating the pressure of water shortage by increasing the supply through water imports and/or increasing the efficiency of water delivery systems.

3.4.1 Structural Measures

These include, among others:

1. Water imports to affected areas through piping or trucking by tankers
2. Pumping from available inactive and dead, or aquifer storage
3. Accelerating the delivery of water supplies from available sources to the most affected areas. This is obviously a logistical matter which may involve other factors than water suppliers. The measure will also include steps to be taken for the removal or bypass of bottlenecks in the delivery systems.

3.4.2 Management Measures

Management measures are an attempt to provide efficient and optimal management for the use of available conventional and non-conventional water resources. Both the aspects of quantity and quality of the water supplies are considered. At any impact minimization phase, the following measures should be carried out:

1. Increasing water supplies though the coordinated operation of projects, groundwater recharge, surface water/groundwater conjunctive use, and water reuse for irrigation and other industrial uses.
2. Groundwater mining under controlled management conditions (planned depletion)
3. Treatment of brackish and saline water for various uses, as well as the withdrawal of lesser quality water
4. Broadening the availability of real-time hydro-meteorological systems and data collection improvements to encourage the optimal planning and use of water supplies. These measures should also be extended to include continuous drought forecasting and the setting of drought severity indices as well as the issuance of drought warnings.

4. DROUGHT MITIGATION MEASURES

Pre-planning is the key to drought mitigation. Measures should be considered to both increase available water supplies and improve their efficient use. The most effective measures which can be taken to mitigate the impact of droughts are a combination of initiatives mainly directed at the individuals or groups who were affected by the drought. The kind of steps necessary to be taken, however, will obviously depend on the level of severity of the drought. The most effective mitigation measures include:

1. Spreading of risks and losses across the regions including those affected, as well as by conservation and the application of sound resource management to optimize the use of water resources
2. Drought and crop insurance payments
3. Through public awareness and information, encourage individual protection against drought by crop storage measures and savings

These measures, coupled with resource management, should help in mitigating the impact of drought.

5. COMPENSATORY MEASURES

Compensatory measures are closely linked to mitigation measures. Farmers are usually the hardest hit by droughts. When drought conditions occurred in large parts of the US in 1987 and 1988. Congress responded by passing comprehensive drought legislation, which included the Reclamation States Drought Assistance Act of 1988. The Act set directives to help mitigate the effects of drought through financial aid and resource management (The Reclamation State Drought Assistance Act of 1988).

Compensation measures to those affected by drought may be made through bank credits, government grants, tax adjustments, and seed or livestock aid, or through a system of crop insurances. Examples from South Africa and Pakistan illustrate the mechanism in place or to be put in place, for bank credit and crop insurance policies. In Pakistan, initial suggestions about the crop insurance scheme point towards a welfare-oriented scheme, to be administered either by the state or some autonomous institution. The FAO suggested to link up the crop insurance scheme with the farm credit program; while officials involved in working out the scheme's details are of the opinion that crop insurance cover should be compulsory for all farmers borrowing from banks such as the Agriculture Development Bank of Pakistan. Premiums for this kind of insurance scheme would be paid in kind and amount to from one to three per cent.

In South Africa, the government granted R34 million for disaster relief to farmers for the 1994-1995 financial year. The money was given to assist farmers and communities who had suffered because of drought in large parts of the country. Some of the people and schemes who received assistance and were given priority are listed:

1. An emergency drinking-water scheme for farmers and farming communities
2. Drought disaster assistance scheme for stockbreeders
3. Drought disaster assistance for communal stockbreeders

It was also agreed that no direct crop-loss compensation be given; that assistance would only be for areas where drought disasters prevail for extended periods; and that community participation, and community concurrence with the proposed assistance measures and their administration be sought.

Technical assistance in drought planning is an important aspect of the Reclamation States Emergency Drought Relief Act of 1991. Section 206 of the Act authorizes the Secretary of the Interim of the US to provide technical assistance from drought contingency planning in some of the states. The Secretary is also authorized to conduct a precipitation variability and droughts survey in the western United States. Technical assistance can also be provided to farmers in group sessions to prepare them for drought conditions and provide them with help in seeking compensation to mitigate the effects of drought.

6. INSTITUTIONAL ARRANGEMENTS FOR TRANS-BOUNDARY DROUGHT MANAGEMENT

Planning is the key prerequisite and the basic foundation for all water management activities. Reliable, comprehensive national and transboundary data collection, analysis and dissemination is thus essential for all aspects of water management particularly when the resource is vulnerable to droughts.

Drought management plans should always be incorporated in all national and transboundary water plans, especially if joint management is to be adopted.

Such plans would depend on the magnitude of groundwater storage available to the areas of use and the long term conjunctive management as well as on the extent ton which interchanges with other sources, or water imports can be made.

Planning and managing droughts within the framework of the joint management of shared waters can be effected, in the case of Israel and Palestine, through the Trans-Boundary Ground Water Board of Control (Najjar, 1997). To this end, the Board would establish a Working Committee on droughts, and mandate it to plan and manage a trans-boundary drought management plan.

Within the framework of the plan, drought indices will be defined and hydro-meteorological preconditions delineated in order to categorize drought severity and make preparations for drought alert and emergencies, as well as for the measures to be followed and enforced at each stage of a drought.

Moreover, once the hydro-meteorological conditions have changed and based on the Working Committee's recommendation, the Board can end the drought alert or emergency, or modify the measures in place.

In so doing, the Board would coordinate and consult with the Government Authority, which should support the Board at all times by giving it access to the complete collection of relevant data and information concerning the drought.

REFERENCES

BUREAU OF RECLAMATION DROUGHT ASSISTANCE REPORT. 1991.Report to the President and the Congress of the United States, Executive Summary.

DROUGHT MITIGATION FOR AGRICULTURAL PRODUCERS (FARMERS). 1996. *Farm Journal Today*, under the editorship of *Successful Farming Magazine*.

FAO COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE. 1996. Countries profiles and reports.

IUCC/UNEP. 1994. Zimbabwe's Vulnerability to Climate Change. Information Unit on Climate Change IUCC/UNEP.

NAJJAR, I. 1997 Institutional Arrangements for International Groundwater Management: A Model for Israel and Palestine. IN HADDAD, M. and FEITELSON E. (eds.), *Joint Management of Shared Aquifers: The Third Workshop*, Jerusalem: The Harry S Truman Research Institute for the Advancement of Peace and the Palestine Consultancy Group (PCG).

PAYNE, R.D. 1995. Groundwater Recharge and Wells: A Guide to Storage Recovery.

NAJJAR, I. 1995. UNDP Project Evaluation. *Study for Artificial Recharge of Groundwater in Northern Qatar*

RECLAMATION STATES EMERGENCY DROUGHT RELIEF ACT OF 1991.

YITBAREK N. 1995. *Drought in Ethiopia and the Potential of Maize (Production) under Water Stress (Conditions).* Awassa, Sidomo, Ethiopia: Awassa College of Agriculture.

Chapter 24

Land Use Management in the Context of Joint Management of Shared Aquifers

Numan Mizyed
Faculty of Agricultural Sciences, Department of Plant Production, An-Najah National University, P.O. Box 7, Nablus, Palestine

1. INTRODUCTION

Shared aquifers are a major source for domestic and agricultural water supplies in both Palestine and Israel. The western aquifer extends from the mountains of the West Bank to the coastal areas of Israel. The direction of flow is generally towards the west in this aquifer. The northeastern aquifer extends from the northern areas of the West Bank (Jenin and Nablus) towards the northeast (Beisan area) in Israel. These two aquifer systems are very important for supplying domestic and irrigation water to Palestinians and Israelis on both sides of the "Greenline." The extension of these aquifers in both countries makes them shared aquifers which require joint management.

The boundaries between Palestine and Israel are not based on hydrology, and they are still subject to negotiations. As such, these aquifers will be kept as shared ones, requiring joint management and joint programs and efforts to preserve their water. Due to the extension of aquifers and the political boundaries between the two sides, yet neither side can claim they are always upstream. Although the Palestinians are upstream in many areas of the West Bank aquifers, they are downstream in the coastal aquifer of Gaza.

The intensity of human activities on the ground above these shared aquifers is great, on both sides of the borders. Population density is very high in the coastal areas of Israel, Gaza and the western areas of the West Bank, where the major recharge zones of the shared aquifers are situated.

In addition to the high population density there is extensive economic activity over the recharge areas. These include both industrial and agricultural activities. Agricultural activities are comprised of intensive agricultural activities such as irrigated agriculture and controlled agriculture in greenhouses which require intensive fertilization and pesticide use, that increase the risk of groundwater pollution.

In addition, the disposal of both solid and liquid wastes is a potential source for groundwater pollution. To preserve groundwater quality, there is a need to manage land use over these aquifers.

2. SOIL AND LAND

The impact of any human activity on groundwater is a function of the soil profile and the type of soils. Thick, deep clay soils are usually categorized by high cation exchange capacity and thus high adsorption capacity of cations. The self purification capacities of such soil is high as they retain large amounts of cations. Sandy and shallow soils have low adsorption of cations and low retention of pollutants. Therefore, the types of soils should be studied before deciding on land use so as to minimize the impacts of land use on groundwater quality.

Characteristics of soils that should be studied include physical and chemical properties of soils. The physical properties of soils, color, depth, structure and texture, should be surveyed. Chemical properties, such as PH, cation exchange capacity, salinity and its carbonate content, are also important properties that should be surveyed. These properties are usually a function of the soil forming factors which include parent material, climate, topography, time, and activities of living organisms (Foth, 1990).

Looking at the soil forming factors in Palestine and Israel, the following may be discerned:

1. The hilly topography in most parts of the West Bank causes high losses of soil by water erosion. As a result, soils are usually young and with shallow thickness and coarse texture in the mountains. Such soils, usually Terra Rossa and Rendzina, are normally formed from calcareous parent materials and their thickness is below 50 cm. They are rich in calcium carbonates and with 2-8% organic matter. As a result, their retention capacity is low.
2. The plains and wadis near the mountains usually have rich alluvial soils. These soils are highly productive and deep. Because of moderate rainfall and warm weather, the weathering rate is moderate there. Therefore, montmorollonite clay minerals dominate such soils. Some of these soils are classified as vertisoils, while others are alluvial or alluvial-colluvial

soils. Due to the presence of montmorollonites in these soils, their cation exchange capacity is high as well as their retention capacity is high.
3. The coastal areas are usually dominated by sand dunes with very low organic matter, and the resultant usually low retention capacity.
4. The desert areas are classified as sand dunes with minimal water and element holding capacity. Activities on these soils will affect what is underneath. However, human activities are usually low on such soils.

3. LAND USE ACTIVITIES TO BE ADDRESSED AND MANAGED

3.1 Urbanization

As a result of the rapid increase in population, urbanization is high in both Palestine and Israel. Consequently, population density in the coastal areas and in the western side of the mountains is very high, reaching 2297 persons/km^2 (WESC, 1995). As a result of such high population densities, the built-up areas are increasing dramatically, thereby reducing the amount of natural recharge to groundwater and increasing water losses through runoff. The increase in population also increases human solid and liquid waste which are potential pollutants of aquifers.

3.2 Agriculture

Agriculture plays an important role in the Palestinian economy, contributing about 20% of the gross national product in the West Bank (Haddad & Mizyed, 1993) and employing about 23% of the Palestinian labor force (ICBS, 1988). As a result of long summer months, irrigation is needed to grow most vegetables in both Palestine and Israel. For example, irrigated agriculture contributes more than 35% of the total value of agricultural production on the West Bank and 60% of the total in Gaza (Awartani & Juodeh, 1991). In Israel, irrigated agriculture consumes over 60% of the water used (World Resources, 1990-91; World Resources Report, 1992).

As a result of increasing water shortages and increasing economic values of water, every attempt is made to maximize production per unit of water. Consequently more agrochemicals, such as fertilizers and pesticides, are applied in more intensive agricultural patterns, thereby increasing the potential for groundwater pollution.

3.3 Sewage Disposal

Population growth results in rising demand for water and subsequently increased sewage production. If left untreated sewage may pollute the groundwater. As a result the reuse of wastewater becomes increasingly necessary. As wastewater contains elements which are potential pollutants of groundwater, wastewater reuse could be hazardous. Using wastewater over shallow soils with low retention capacity will result in adding pollutants carried by wastewater to the groundwater aquifers underneath. Such pollutants could include trace and toxic elements which are produced by industrial waste, or nitrates and nitrites produced by the mineralization of organic nitrogen in wastewater. Increasing the concentrations of such elements and compounds could result in deterioration of water quality of groundwater aquifers.

Currently, due to the lack of treatment plants in the West Bank, most of the wastewater flows untreated into valleys. Due to the lack of water for irrigation, much of this untreated wastewater is used in agriculture causing serious health problems to those consuming vegetables grown with raw wastewater and possibly polluting soil and groundwater aquifers.

Raw wastewater from many Israeli settlements in the West Bank also flows untreated. Some serious pollution problems of drinking water wells have been caused by raw wastewater coming from Israeli settlements. The water department had to close a well in the Ramallah area as a result of such pollution.[1]

3.4 Solid Waste Disposal

The amount of solid wastes is increasing too as a function of population. Up to now reuse options have not been common in Palestine or Israel. Most solid waste is burned at dumping sites. However, rainfall during wet years might result in increasing the leachate from such landfills to groundwater. Therefore, disposal sites for solid waste should be selected carefully, and recharge areas for groundwater aquifers should be avoided.

Since Israeli environmental restrictions do not apply to the West Bank, it has been reported that some Israeli solid waste is being dumped illegally in the West Bank. Such actions could cause serious contamination of the groundwater aquifers if continued.

1 Personal comunication with water department officials.

4. TOOLS FOR LAND USE MANAGEMENT

Land use management may be examined at different levels starting from the private sector and ending at the state or regional level. Land use management, therefore, involves several parties which might have conflicting interests. For the private sector, maximizing net benefits is a primary objective. The private individual prefers activities which may not be environmentally sound. This is a common problem which is faced when the role of the state and local governments is minimized. The result will be conversion of agricultural, forest and pasture lands into urban areas. To restrict the ensuing externalities, local governments or city councils can introduce zoning laws to restrict the use of land (Kupchella & Hyland, 1989).

Zoning is also used at the state level to protect agricultural land and water resources from the expansion of urban and industrial zones. Such zoning requires that regional plans be prepared. Such plans can take into consideration the protection of the environment, including protection of recharge areas.

Zoning usually faces problems in restricting the use of private land. As a result of zoning, the value of land might increase or decrease, depending on its classification. Therefore, private owners are usually affected by the zoning regulations. Another problem with zoning is related to its effects in reducing the development opportunities of land and increasing the commercial value of residential areas. Therefore, the opportunity for providing housing and services for low income families will cost more and development of less developed communities (Kupchella & Hyland, 1989).

Another mechanism for land use management is taxation and exemption from taxes on both state and local government levels. Activities with least effect on environment are encouraged by reduced taxes, while others are discouraged by increased taxes. Such policies could encourage reserving natural lands and protecting the natural resources. Fines are usually an important mechanism to discourage land misuse which leads to pollution of natural resources including groundwater.

5. RECOMMENDATIONS FOR LAND USE MANAGEMENT FOR THE SPECIFIC SITUATION OF ISRAEL AND PALESTINE

Due to the uncertainty of the political situation, the following recommendation and principles should be considered in land use management over shared aquifers:

1. Acknowledge the sovereignty of each state of its land and resources. The issue of boundaries between the two sides should be resolved and the jurisdiction on each side of its land and resources should be acknowledged. It will be the responsibility of each side to monitor and enforce agreed upon land use practices and regulations in its territory.
2. The two sides need to acknowledge that land is a natural resource to be used in a sustainable way and not a commodity to be used according to its highest economic return. This implies avoiding practices which negatively affect the environment and/or pollute groundwater, even if they involve higher economic returns.
3. As the best environmentally sound use of land requires data and information about land and the extent of aquifer systems underneath, the two sides need to establish mechanisms of data sharing and information systems. Each side will be responsible for collecting data in its territory. But data sharing is essential to assist both sides on regional planning of land use and utilization of groundwater aquifers. For this purpose, there is a need to upgrade a regional information system or a data bank system and make information and data available to both sides. To enhance the availability of data and verify its validity, additional studies and surveys are needed. Surveys for soil and land classification are of the highest importance in this subject. Also, the extension of groundwater aquifers, their recharge zones, descriptions of the Vadose Zone and its capacity for purifying water are of essential need to plan programs to preserve the aquifers.
4. An institutional setup to coordinate activities and develop policies regarding groundwater protection and management of land and water resources should be set up.
5. The institutional setup needs to address and search for comprehensive and integrated solutions for all problems related to preserving groundwater. To improve the efficiency of such institutions, local institutions on both sides should be developed, especially the newly-established Palestinian institutions.
6. As protection and preservation of groundwater, aquifers are the primary target, a water charter needs to be developed (Haddad & Mizyed, 1995). The terms and definitions to be agreed upon by the two sides, such as

water rights, the duties and responsibilities of every party related to pollution prevention and soil and water conservation, should be defined.

7. Considering the current allocation of water resources in the West Bank, the Palestinians are utilizing a small percentage of the natural recharge of aquifers. For example, the Palestinians are utilizing only 7% of the safe yield of the western aquifer while the Israelis are utilizing about 93% of the safe yield of the same aquifer.[2] With such unequitable allocations of water, it will be impossible to convince Palestinians to cooperate on the issue of preserving and protecting water aquifers. Therefore, protecting water aquifers should be part of a larger package concerned with water allocations, rights, management and protection of groundwater aquifers.
8. Zoning is an important mechanism that could be used to regulate activities, especially on lands which are recharge zones of groundwater aquifers. However, zoning should not be one sided. It will be possible to use this mechanism only if the two sides agree on some type of institutional setup to restrict some land use in some areas in both countries. As a result of such restrictions, private users should be compensated for restricting the use of their lands.
9. As a result of cooperation on land use and possible restriction of activities in some areas, comprehensive solutions will require other environmentally sound development options. Areas with least development should be assisted to develop without negatively affecting natural resources. For this purpose, a regional fund to preserve the quality of groundwater aquifers should be established to give financial assistance for better development practices which preserve quality and quantity of water.
10. Cooperation between the two sides is needed in the area of solid waste management. Joint disposal sites are an option to be studied. Coordination is needed to find and identify sites and methods for disposal of solid and hazardous waste.
11. The issue of wastewater reuse requires extensive coordination and broad joint studies. Exchange of experience is needed, especially for human resources development in this field. The possibility of trading wastewater with fresh water should be studied. In areas where there is risk for wastewater reuse, the possibility of exchanging wastewater with other areas where it is safe to reuse wastewater should be investigated. In general areas where wastewater is to be reused, soil profile and wastewater quality should be analyzed and the environmental impacts of such activities should be evaluated.

[2] Percentages estimated based on numbers given by Oslo B, Article 40.

REFERENCES

Awartani, H. & Juodeh, S. (1991). *Irrigated Agriculture in the Occupied Palestinian Territories.* An-Najah National University, Rural Research Center, Nablus.

Foth, H. (1990). *Fundamentals of Soil Science.* John Wiley & Sons Inc., New York.

Haddad, M. & Mizyed, N. (1993). Status of irrigated agriculture in Palestinian occupied territories. *Journal of Palestine Studies, 14.*

---------- (1995). Water issues in the Middle East: conflict and solutions. *MEWREW, water issues, 2, Water Issues Group at SOAS.* University of London, London.

Israel Central Bureau of Statistics (ICBS) (1988). Judea and Samaria and Gaza area statistics. 18(2), 196-222.

Kupchella, C. & Hyland, M. (1989). *Environmental Science: Living with the Systems of Nature.* Allyn and Bacon, Needham Hights, Massachusetts.

WESC (1995). Middle East regional study on water supply and demand development, phase 1 report.

World Resources (1990-91). *A guide to the global environment.* A report published by the World Resources Institute in collaboration with the United Actions Environment Program and the United Nations Development Program. Oxford University Press, Oxford.

World Resources Report (1992). *Development and the Environment.* Oxford University Press, Oxford.

VI

AN ACTION PLAN FOR THE MANAGEMENT OF SHARED GROUNDWATER RESOURCES

Chapter 25

A Sequential Flexible Approach to the Management of Shared Aquifers

Eran Feitelson & Marwan Haddad

Department of Geography, The Hebrew University of Jerusalem and the Harry S Truman Research Institute for the Advancement of Peace, Mount Scopus, Jerusalem

College of Engineering, An-Najah National University, Nablus, Palestinian Territory and the Palestine Consultancy Group (PCG), East Jerusalem

The sustainable management of an aquifer is always a difficult task. To undertake the actions needed to manage an aquifer requires that appropriate institutions be established. The existence of political boundaries over an aquifer further exacerbates the issue, as it requires that water be allocated among parties that do not recognize the same authority or conform to the same set of rules. Moreover, cross-boundary management regimes have to be considered.

In Chapter 1 four management options were identified: separate, coordinated or joint management and the delegation of responsibilities. These options need not be mutually exclusive. Actually, they should be seen as different regimes that are appropriate for different circumstances. Therefore, as circumstances change the management regimes should adapt too. The purpose of this chapter is to advance a framework that may allow decision makers to structure and modify the management regimes in response to shifts in perceptions and understanding of the aquifer's situation and the way they view the cross-boundary institutions. This sequential yet flexible approach can thus provide decision makers with a map of the options available to them at each particular junction.

1. INITIAL STEPS AND BUILDING BLOCKS

The management of an aquifer requires that many specific actions be taken. Lack of coordination or cooperation regarding any of these actions in a cross-boundary situation can potentially be inefficient, ineffective or outright detrimental. For example, if research and monitoring efforts are not coordinated and data are not shared certain efforts may be replicated, while other necessary research or data collection efforts do not receive adequate funding. Uncoordinated pumpage may raise total costs if pumping at one point affects another well across the boundary. Over-pumping due to uncoordinated pumpage regimes may cause salinization and thus deterioration of the resource. Hence, almost any one of these actions can be a potential base for cooperation.

The four options described in Chapter 1 are generic options. In practice there are many possibilities for cooperation and coordination at various levels. In Table 1 possible structures that may carry out the potential actions needed to implement an aquifer management regime are identified, in line with the principles outlined in Chapter 1, and their possible tasks and staffing outlined. These present a wide range of cooperation levels from minimal coordination to comprehensive joint decision making.

The question that has to be asked once the gamut of options has been identified is which options should be attempted in different circumstances. To address this question it is useful to further scrutinize the options. In particular it is important to assess the transaction costs involved in the establishing of each possible structure. The transaction costs are a function of the type of tasks involved in the particular structure, the number of activities it is set to carry out, the potential for disagreements in the operation of the structure and the opposition it is likely to encounter by existing institutions. This opposition is largely a function of the extent to which it would infringe on the authority of the existing institutions and on the sovereignty of the countries involved. On the basis of an assessment of these factors, the transaction costs that are likely to be encountered when setting up each structure identified in Table 1 are rated in the appendix to this chapter.

Table 1. Possible Joint Management Bodies

Structure	**Functions**	**Staffing**	**Necessary Cooperation**
Aquifer Monitoring	Monitor water quantity and quality	Joint or separate geo-hydorlogists	Low
Research Coordination	Coordinate and initiate research	Small administrative and professional staff	Low
Resource Conservation	Promote water conservation	Small separate technical staffs	Low
Training Center	Train professionals	Small administrative and professional staff	Low
Apportionment monitoring	Monitor extraction and compliance	Small professional staff	Low
Apportionment Body	Discuss allocation issues according to need	Small professional staff	Moderate
Arbitration Body	Dispute resolution	Small administrative staff	Moderate
Investigative Advisory Body	Investigation of technical disputes	Small administrative and professional staff	Moderate
Risk Management	Prepare for and manage emergencies	Technical staff	Moderate - high
Pollution Control	Advance measures for protecting the aquifer	Lawyers, planners and hydrologists	Moderate - high
Joint Regulatory Bodies	Advance and enforce regulations to protect the aquifer	Planners, Lawyers, enforcement officers and technicians	High
Wastewater Utility	Wastewater treatment	Large professional and administrative staff*	High
Water Utility	Supply water	Large professional and administrative staff*	Very high
Economic Development	Plan and coordinate economic development over the aquifer	Technical, economic, planning and engineering staffs	Very high
Project Management	Mange and coordinate water projects	Economists and engineers	Very high
Water Transfer or Market Administration	Administer water transfers and/or water markets	Moderate sized staff of economists, engineers and legal experts	Very high
Comprehensive Utility	Supply water and treat wastewater	Large comprehensive staffs*	Very high
Integrated Management	Manage the aquifer	Large comprehensive staff	Very high

* In the case of utilities a supervisory staff is needed to oversee and regulate the utility.

Aquifers underlie boundaries in different parts of the world. These varied situations are differentiated according to the level of water interdependence between the parties across the boundaries and the use ratio of the aquifer - the ratio of total freshwater used to the average annual recharge. Overall, as the use ratio and level of interdependence rise the damages from not cooperating in managing the aquifer are likely to be greater. Also, as the use ratio rises there is generally a need to shift water from less productive uses to higher value usage, if the water is to be used within the sustainable yield constraint. Transaction costs, however, do not rise, or hardly rise, as the use ratio increases. These relationships are shown conceptually in Figure 1.

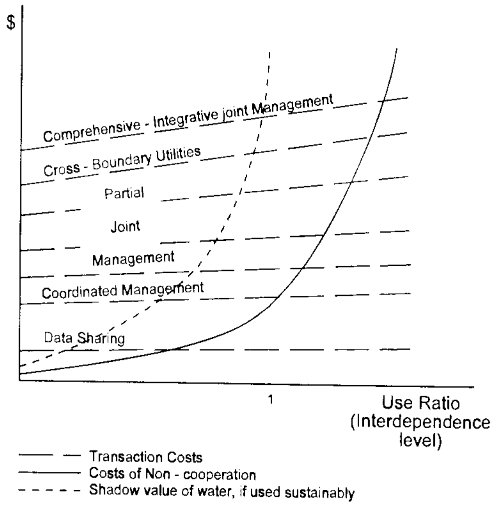


Figure 1. Comparative Benefits and Costs of Cross Boundary Management Options

When the use ratio is low the marginal value product of water is usually low, the risk of aquifer pollution is low, and consequently so are the likely costs of non-cooperation. In such circumstances it is unlikely that the parties would be ready to establish mechanisms that incur high transaction costs, as the benefits from cooperation would be lower than the transaction costs. Thus, separate management, or at most data sharing, can be expected. However, as the use ratio rises the costs of non-cooperation rise and the shadow value of water, if used in a sustainable manner,[1] rise too. Under such

1 This caveat is necessary as if water is not used within the sustainability constraints (such as when an aquifer is systematically over-drawn) the costs would be borne, at least in part, by future generations. Hence they would not be fully reflected in the shadow prices faced by current consumers.

situations the possibility for coordinating management become feasible, as otherwise the two sides are more likely to incur losses and may not be able to realize the marginal value product of water. Once the use ratio rises over 1, which means the aquifer is being depleted, the potential costs of non-cooperation rise exponentially, as the threats to the aquifer mount. Therefore, more sophisticated, and costly, structures may be contemplated. As can be seen from the appendix and as is depicted graphically in Figure 1, there are many options for increasingly more comprehensive management, or more intensive cooperation in managing the aquifer, albeit incurring higher transaction costs. Therefore, it is likely that transboundary management regimes would be built up gradually over time, as the need for more intensive and comprehensive management rises.

The experience with cross-boundary management of surface water suggests that the more successful transboundary management institutions have indeed been built up over time (Sadler, 1988). However, there are additional factors that explain this. One of these is the extent to which the parties have confidence in the institutions. Only when the initial transboundary institution has gained the confidence of the parties are they willing to entrust more power in these institutions. Therefore, the question that was asked at the beginning of this section has to be reformulated now. Rather than choosing an appropriate structure for a particular circumstance, it may be necessary to devise an appropriate institution-building course for each situation.

2. A FLEXIBLE-SEQUENTIAL FRAMEWORK

A prerequisite for any cooperation in the management of an aquifer is the understanding that unless the sides cooperate they both stand to lose in the long run as the aquifer may deteriorate. Such an understanding is not likely to come about if the aquifer is not properly monitored and studied, and if the different parties do not have some confidence in the results of the monitoring and the studies. Thus, some joint coordination in the monitoring and study of the aquifer is a first step toward any form of management of a shared aquifer. This can be induced through scientific cooperation and dissemination of results, and is recommended even when the situation allows for separate management, as it is easier to establish a cooperative structure before a conflict erupts than after (Bingham et al., 1994). An example for such a case is the Gourani aquifer underlying parts of Brazil, Argentina, Uruguay and Paraguay. This immense aquifer with an annual outflow of some 40 cu/km per year is barely tapped. Yet there is already cooperation between scientists from the four countries in monitoring and studying the aquifer. Thus, while there is no need for any coordination in the use of the aquifer at this point, given the low use ratio, the ongoing monitoring and research can establish the basis for identifying the stage where coordination may be needed.

Once it has been realized that the interdependence between the parties is at a level where extraction has to be coordinated, usually when the use ratio is already high, the parties have to choose an institutional development path. This choice would be a function of the way the aquifer's problems are defined. The framework proposed herein suggests that five routes can be taken, each with its own rationale. In essence, each rationale is a response to a different definition of the problem. Along each path the level of cooperation can rise and intensify. In four of the five routes it is possible to move gradually from a coordinated management framework to a joint management regime.[2]

The five problem statements requiring that some level of cooperation be introduced are:

- *The contamination and/or depletion of the aquifer* – This may be induced by the actions of the parties overlying the aquifer, thus diminishing the long-term capacity of the aquifer, to the detriment of future generations. In order to prevent this, or to mitigate it, the sides have to cooperate in their efforts to protect the aquifer. The rationale for the first path is, therefore, *aquifer protection*.
- *Crises* – The management of an aquifer becomes contentious in crisis situations, most commonly droughts. In such situations it may become necessary to coordinate policies so the aquifer would not be damaged, and all parties would be able to provide continuous supply of potable water. This is the *crisis management* path.
- *Inefficient water use* – As the parties differ in terms of their water use patterns it is possible that there will be wide differences in the shadow value of water across the boundaries. In such situations water use from an overall perspective may be highly inefficient, resulting in excessive use of the aquifer. In other words, some party may find it needs more water for high-value use, leading it to pump excessively from the aquifer, while cheaper water could be acquired without additional pumpage by transferring water from less efficient users with a low-value product for their marginal water. To facilitate such transfers it is necessary to

[2] In the fifth case – delegation of responsibilities to third parties (mainly through privatization) – the development path is somewhat different, a point elaborated upon in the next section.

establish structures that can reduce their transaction costs to a level where they become feasible, thereby increasing overall efficiency. Water markets are often proposed as a way to achieve this end. Yet, as made clear in earlier chapters, water markets too need to be structured. This is especially true if trading across borders is to be permitted.
- *Inefficient water supply* – As in many cases water supply by the public sector or by local jurisdictions is inefficient, or may not enjoy economies of scale, and excessive use of the aquifer may ensue. Thus, improving supply efficiency (and reuse of wastewater) can be important. *Privatization* is often advanced as the way to meet this challenge.
- *Need for comprehensive-integrative management* – As the management of an aquifer requires that many issues and aspects be addressed the problem statement can be formulated to state that no party can mange the aquifer comprehensively on its own. Thus, the focus of the cooperative effort should be on formulating comprehensive integrative structures for the management of the aquifer.

The approach advanced here, depicted conceptually in Figure 2, is a sequential process with many decision points that is upgraded over time. At the beginning a limited set of activities is undertaken jointly. This serves as a basis for the cooperative water management structures. Additional activities are added to the purview of the structures over time. The activities added can lead up to one of the five basic options, according to the rationale chosen. Alternatively, from the second stage onward activities can be added horizontally, thereby widening the scope of the cooperative structure to additional goals. For example, it is possible to begin with elements leading up to a crisis management structure, but at a certain stage include also pollution prevention elements (such as coordination of wastewater standards and reuse). The proposed structure is thus sequential, as additional actions are included over time, requiring more intensive cooperation. But these sequences are flexible, as it is possible to change the focus of the efforts and the structures mid-way.

There are two caveats to this statement. First, as privatization options involve contractual agreements, often with international firms, it may not be possible to change the purview of an institutional structure based on this approach as easily as other structures. The heavy line in Figure 2 separating the latter stages of the privatization option from the other options indicates this. Second, as a comprehensive-integrative approach includes most other facets it is likely to emerge as a combination of other orientations, rather than be an alternative to them. This option is, therefore, shown in Figure 2 as a combination that may evolve at a later stage than the other options.

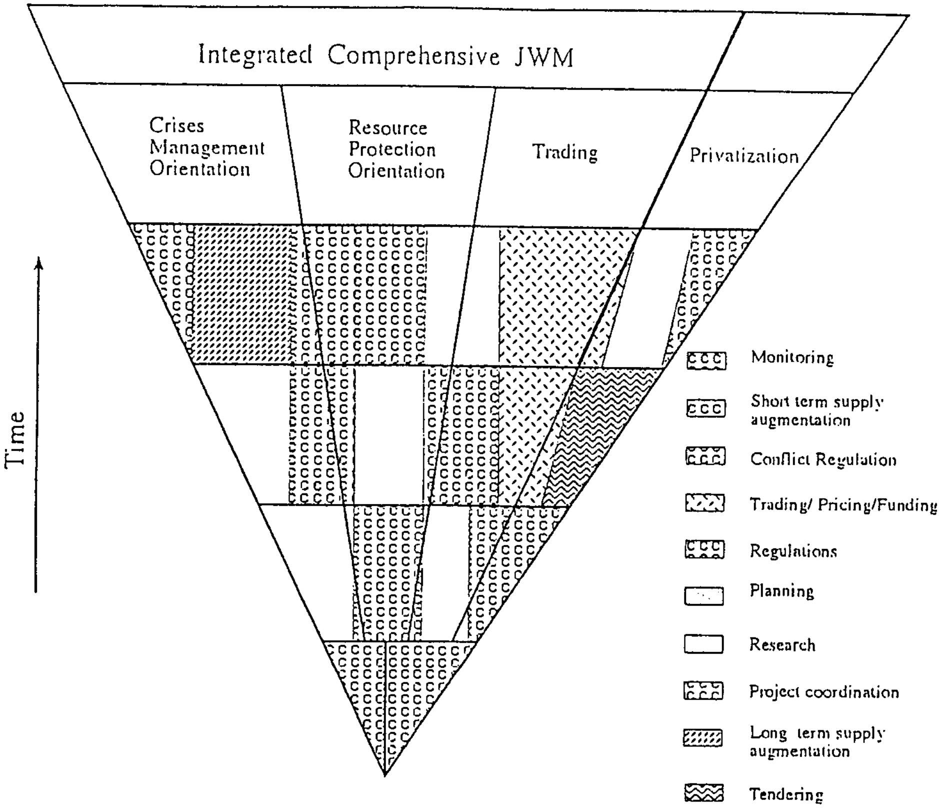


Figure 2. The Evolution of Joint Water Management (JWM)

The approach advanced here allows decision makers to embark on a cooperative route without committing themselves in advance to a fully integrative structure, thus contrasting it with the approach implicitly proposed in the Bellagio Draft Treaty. The parties can begin (as they usually do) with a very limited level of cooperation pertaining to a very limited set of activities, but without being reduced to a myopic perspective as they embark on a path that has been mapped in advance. At the same time, embarking on a certain route does not limit their choices in the future, as the parties can change course as circumstances change without compromising past achievements.

3. THE SEQUENCING OF THE ACTIVITIES

Figure 2 is conceptual. It is necessary, therefore, to delineate the actual sequence of tasks for implementing each basic development path.

However, before turning to this discussion it is important to clarify the assumptions under which this sequencing is done:

1. Many activities can seem pertinent to all structures. Therefore, an effort was made to identify the minimal number and scope of activities that need to be incorporated in each stage to make the process rational and operational.
2. An agreement on water rights and allocations is reached initially and separately. Therefore, each structure is designed so that it can be implemented regardless of the specifics of such an agreement.
3. Most of the existing water institutions of the different parties will continue to exist. Thus, in no case is it assumed that a completely new institutional structure within any party would be construed solely as part of the effort to manage the shared aquifer.

3.1 Resource Protection Structures

Perhaps the most important inducement for joint management is the joint interest all parties have in maintaining the water quality of the aquifer and its storage capacity. This factor makes joint management a potential win-win solution, and the lack of it a likely lose-lose situation.

Four or five stages can be identified in the sequence leading up to most resource protection structures. As qualitative and quantitative monitoring of the aquifer and the compilation of resulting data in an agreed upon database are a prerequisite to any cooperative management effort, they are placed in the first stage. At the second stage emphasis shifts to addressing the main threats to the aquifers. These often pertain to particular economic activities and to wastewater treatment (or lack thereof), discharge and reuse, as is the Palestinian-Israeli case. Therefore, pollution prevention from economic activities, wastewater issues, preparation of plans for containing pollution incidents and resolving disagreements are placed in the second stage. The last element is placed early so as to preclude the possibility of disagreements leading to a loss of confidence in the joint institutions, something that may be detrimental to the whole process.

After the foundations for addressing the most immediate concerns have been laid, more comprehensive long-term issues can be addressed. These include the capacity toset standards for water quality and wastewater treatment and reuse, control of solid and hazardous waste, coordination of research on long-term threats to the aquifers, and advancement of possible solutions to such threats.

In subsequent stages joint planning and funding of projects that may help protect the aquifer (most notably wastewater treatment plants) can be introduced, as well as drought planning (to preclude over-pumping), and assumption of drilling licensing power.

3.2 A Crisis Management Orientation

The management of any aquifer faces its most severe test during crises. Several types of crises are possible: 1) sudden crises, such as the spilling of toxic material in highly porous areas, the discovery of hazardous materials in drinking water coming from certain wells, or the breaking of levies built as part of aquifer recharge efforts; 2) cumulative crises, stemming from the cumulative effects of certain trends or natural events, such as droughts; or 3) over-pumping by one side, above the quantities agreed upon. Such crises may cause widespread public concern, especially if domestic supply is affected.

Crises management involves three basic actions: recognition of the crisis (the realization that a crisis has occurred); agreements on the steps that need to be taken to address the crises (contingency planning); and implementation of the crisis management scheme, which requires the availability of appropriate facilities, accurate real-time data, personnel and means.

In order to identify a crisis, and agree on its extent, it is necessary to establish a joint monitoring and data-sharing system, including the monitoring of both water extractions and use. In addition, it is necessary that background information be available, and serve as a basis for monitoring and inspections, as well as the basic knowledge necessary for both contingency and drought planning. The institutionalization of monitoring and data-sharing activities is, therefore, a prerequisite for any crisis management structure.

In the second stage a decision-making mechanism and clear guidelines for declaring a crisis situation need to be established. Such mechanisms are especially needed to cope with sudden emergency-type crises. Crisis situations obviously involve much stress and ensuing potential for disagreement, especially as the requisite steps in such situations often impinge on practices and allocations of various water users, generating sometimes vehement opposition. Conflict resolution and enforcement mechanisms should therefore complement all crisis management efforts. As these elements are inherent to all crisis situations they should be incorporated already in the second stage. If water supply shortfalls occur, in particular for domestic use, emergency procedures for augmenting supply should be enacted. Such procedures have to be planned for in advance.

Over-pumping needs to be recognized and managed at the earliest stage because of its potential long-term impacts on the aquifer, and in order to preclude the creation of vested rights in the over-pumped water. The terms for resolution of such a crisis have to be spelled out clearly at the outset – in the political agreement – and may include a process with several steps, beginning with fact finding and discussions within the joint management structure. The establishment of such a conflict resolution mechanism should also be undertaken at the second stage.

Drought management, including contingency plans and agreement on tentative measures for responding to such situations should be incorporated into the structure in the third stage. These measures should include means for transferring water between sectors and parties, including perhaps water trading mechanisms. Since lessons can be learned from each crisis, it is worthwhile to have a feedback mechanism that will allow for adjustments in following these lessons. This mechanism should be introduced in the fourth stage

3.3 Efficient Water Use

As the demand for water rises the need to use it efficiently increases. An efficient water use pattern, from a societal perspective, requires that water be shifted between sectors and among users, so it can be used at any given moment by those needing it the most. In other words, that water be shifted from less efficient uses to more efficient use, and that wasteful use within sectors be eliminated. Market mechanisms are geared toward achieving this end (Dinar et al., 1997). If water is priced correctly, from a societal perspective (including social and environmental aspects), then it will be used in the most efficient manner and provide an incentive for eliminating wasteful use (Winpenny, 1994). Essentially, all users will be paying the full price of their usage and thus would use water only to the extent that it is indeed beneficial from a societal point of view. Yet it is difficult, if not impossible, to set in advance the socially-efficient prices in an administrative manner, especially as these prices would need to be continually adjusted to reflect changes in circumstances. If trading in water is allowed, within an appropriate framework that ensures that environmental and social aspects are accounted for, the prices determined by the market would provide the necessary signals for assuring continuous efficient water use.

In a market mechanism water is allocated at a price set by the free exchange of "equity through use" or property right to the use of water, either for a limited time period (a lease) or in perpetuity (a sale). The market is the institution that facilitates the exchange of water among sellers and buyers. For a water market to exist it is necessary that water allocations be clearly defined and well specified, that there be public information on the supply and demand for water and that there be a physical and legal possibility to transfer water (Lee & Jouravlev, 1998).

For a market to achieve the best overall results the specification of water rights or allocations should take into account the priority to domestic use and differences in water quality. The other necessities for a market are affected by the way the market is structured. In essence, the utility of a market is a function of the cost of obtaining information, of bargaining and contracting, and of the policing, monitoring and enforcement of transactions (collectively known as transaction costs). The challenge is to minimize these costs while assuring that the aquifer's quality is not damaged in a joint management framework.

The first stage in establishing a water market, in addition to the specification of water allocations (a prerequisite), is the creation of a monitoring system that would enable the monitoring of both the aquifer and the water use. This is essential for the enforcement and policing of transactions, as without monitoring, policing and enforcement cheating would ensue, undermining the market. This may be especially dangerous in a cross-boundary context, where establishment of confidence among the parties is of primary importance.

In the second stage the trading rules need to be agreed upon. In transboundary situations it is likely that the trading rules would allow only for leasing of water but not for outright sale of water rights in perpetuity. In such a case time limits would have to be set. These would have to be related to the fluctuations in overall water availability (that is, to the occurrence of drought years). Also, the rights to lease would have to be determined. That is, would the market involve national authorities, regional utilities, local jurisdictions or private consumers? In addition, it would be necessary to determine at this stage the total quantity of water that may be traded, and whether a water banking system may be established.[3] Finally, due to the variance in water availability water allocations should be prioritized (Berck & Lipow, 1994). The trading rules should reflect these priorities, so they can

[3] A water bank system essentially stabilizes the trades temporally, as it can purchase water when sellers are willing to sell, store it and sell when buyers need the water, without compromising rights. Such a system was successfully implemented in California (Howitt & Vaux, 1995).

address drought situations. As disagreements in such cases are likely, there would be a need to agreat this stage on a conflict resolution mechanism geared to dealing with market transactions.

Once the basic trading rules have been agreed upon, the legal and infrastructure implications have to be drawn. From an institutional perspective this would necessitate that the parties make internal legal adjustments, if they do not have in place the legal structure needed to enable trades. At this stage environmental implications of trading may be reviewed and trading constraints introduced. The establishment of a water market also requires that a decision-making structure be established to plan and review the conveyance projects, if necessary, for transferring the water bought and sold.

In the fourth stage the funding of water transfers would have to be discussed. It is also likely that at this stage the initial experience with the trading mechanisms could be evaluated. Such an evaluation may lead to adjustments in the trading mechanisms. This implies that in the agreements establishing a water market provisions be made for adaptations and adjustments in these provisions. Given the very limited experience with international water trading in general and the virtually non-existent experience of the two parties with water trading, the establishment of a water market would necessarily be a trial and error process.

3.4 Efficient Water Supply

Water supply is costly. In many parts of the world, especially those experiencing rapid population growth, these costs have been a major obstacle to meeting the international targets of clean water supply to all. Water supply and wastewater treatment systems enjoy in most places economies of scale. Boundaries may limit the ability to enjoy these economies of scale. Thus, it is important in structuring transboundary management systems to find ways to supply water as efficiently as possible, overcoming the deleterious boundary effects.

The last decade has seen growing awareness of the potential of the private sector to provide water and wastewater services in an effective and efficient manner. Private sector participation may have a special appeal in the context of transboundary management as, in addition to its efficiency and effectiveness benefits, such involvement may help reframe the water and wastewater issues and overcome some of the problems stemming from lack of confidence between parties embroiled in long-standing conflicts, such as the Palestinians and Israelis. The reason is that when services are supplied by a private enterprise disagreements are likely to focus on commercial or legal issues rather than political ones. Also, the need to issue a tender would require both parties to combine expertise to assure that they get the best possible deal vis-a-vis the private enterprise. This may change the overall framework from one where the two sides just face each other to one where they have to cooperate in order to get the best deal from a third party.[4]

There are many possibilities for private sector participation in water and wastewater service provision (Lee & Jouravlev, 1997). At one extreme is full divestiture of the infrastructure and service provision. This is rare, and usually undesirable in a natural monopoly situation. At the other extreme is the contracting of service provision, where all infrastructure development is done by the public sector. Given the need for substantial infrastructure upgrade (or, in the case of wastewater treatment, the building of much of the infrastructure from scratch), this may not utilize the full potential benefits of private sector involvement.

The first stage in introducing private sector participation into a joint management framework is reaching an agreement on what type of franchising is sought, and which elements are to be franchised. There are numerous possibilities that would have to be considered. They pertain to the level at which the franchising would take place (regional, national or local) and the services that would be supplied. It is possible that there would be several franchising agreements (for example, separate ones for water supply and wastewater treatment). At the same time it is important to agree on the issues that would have to remain in the public domain, and the issues for which the private sector should be accountable. In particular, it is important to agree on the losses for which the private sector would be accountable.

Based on the decisions made in the first stage, the issues to be addressed in a tender need to be identified in the second stage. In addition, it would be wise to establish in this stage the monitoring and data-sharing systems that would be necessary to monitor, police and enforce the agreement with the private enterprise. It would also be necessary to establish the planning and approval mechanisms that could evaluate and authorize investment and infrastructure decisions made by the franchise. Finally, there would be a need to establish the legal basis for privatization of the elements decided upon and of the fee collection and transfer mechanisms, as well as all the precautions necessary to avoid misuse of natural monopoly power and the mechanism to terminate the contract.

In the third stage the tender would be prepared. In this tender the boundary conditions, between the privatized elements and those remaining

[4] In discussing the privatization experience of the Severn Trent Water in Britain Baynard (1997) notes it was useful to overcome the cross-boundary problems between England and Wales.

in public hands would have to be specified. The focal point of this stage would be the determination of what has to be put into the agreement to make the supply of service efficient, effective and sustainable. It must specify who bears what cost, provide the enterprise with incentives to provide a high level service and assure that the agreement is financially solvent, so that it would be sustainable over time. This is the most critical stage of the process, as mistakes made here would be hard to rectify once the tender is issued. It is therefore important that by this time the two sides gain sufficient confidence in each other to work effectively toward protecting their joint interests – to receive a high-quality service in an efficient and effective manner, without compromising social or environmental goals.

In the fourth stage the tender would be issued. At this time the two sides need to establish a mechanism and criteria for choosing among the applicants. Given the novelty of a cross-boundary franchising effort, it may be useful at this point to obtain support from a third party in identifying the criteria and evaluating the applications.

The fifth stage would, essentially, be an evaluation stage. At this stage the ramifications of the franchising would be analyzed. In particular, it would be important to analyze whether the franchise misused the natural monopoly power inherent in water supply systems. This may serve to improve further tenders (if the franchising is done piecemeal) or set the stage for the refinement of the terms once the original contract runs out. It may also be necessary to refine the contract over time to address issues unresolved in the original contract, to the extent that it would be possible to do so from the legal perspective.

3.5 Comprehensive-Integrative Management

The goal of an integrative structure is to cover all, or most of, the aspects of aquifer management comprehensively (incorporating resource protection, crisis management, water use and water supply), so as to assure the best result from an aquifer management perspective and its long-range sustainability. To accomplish this, such a structure would need to be more than a combination of the previous three types of structures, as it would need to address issues not addressed thus far.

As an agreed-upon database and monitoring system are a prerequisite for successful comprehensive aquifer management, a joint monitoring and data storage and compilation unit should be established at the outset. This unit, whose field work would be conducted jointly by teams from both sides, would focus on monitoring the aquifer's parameters and water use at this stage.

In the second stage, mechanisms for resolving disputes would be set up, as well as a crisis management unit. These are intended to ameliorate the dangers of an early crisis in the accommodation process. At this stage it would also be necessary to establish a coordinated drilling and pumping permit system so that aquifer yield and quality would be sustained. Joint water supply planning, to address current supply problems, including water allocations to users, would follow this. Joint research could then be initiated to address fundamental issues that are likely to be faced in the future by the aquifer managers.

In the next stage policies for drought situations would be drawn up and agreed upon, as drought periods are likely to cause the greatest stress in the system and thus put the joint management structure to its severest test. In order to help address future strains reallocation mechanisms should also be established in this (third) stage to accommodate future structural changes. It would also possible to add financing instruments and a joint water project management capacity to the structure. A water levy on each cubic meter pumped could provide the essential financial resources for sustainable operations of the mechanism.

At a later stage a comprehensive regulatory capacity and enforcement unit should be set up. This unit would be able to propose standards or by-laws and, following their approval, enforce them. This stage is perhaps the most problematic in the transition from a comprehensive structure, covering many facets, to an integrative one, whereby a single aquifer management authority is established. Still, this authority should be linked to the legal water institutions of both parties.

In the next stage the regulatory capacity can be expanded to other issues, such as land use controls. Other issues might include water-trading mechanisms. At this stage a self-financing capacity may be necessary. This could be achieved by imposing an aquifer use levy, whereby the authority would collect a fee for any water pumped from the aquifer, and/or a water use tax.

4. INSTITUTIONS, FINANCING AND ALLOCATIONS

The identification of goals and tasks that would be carried out and sequencing them still does not amount to a management structure, as it is necessary to establish institutional structures to execute them and identify the financial base for the operation of these institutions and the actions undertaken by them. Moreover, as premised earlier, a transboundary management framework is contingent upon an agreement over allocation principles and would not evolve if confidence in the institutional structure does not build up. Therefore, any proposal for a transboundary aquifer management structure should include the institutional and financial aspects and be backed by an agreement over allocations.

The institutional structure of the management framework adopted in each case would have to adapt to the changes in the management structure. As the number of activities included in the transboundary management structure increases and the level of cooperation rises the complexity of the structure is likely to increase. Essentially, however, these institutions will have several basic ingredients. The first would be an upper-level commission or board, where an equal number of senior representatives from the different parties would make the policy decisions within the purview of the management regime agreed upon. In the case of privatization, this body would set the terms of reference for the tender, administer the tender and later may serve as a governing board for the utility established. In addition, professional teams that would carry out specific assignments (monitoring, planning, supervision, etc.) may be formed. While at the outset these may be separate teams that would coordinate their activities, it is quite likely that joint teams will be formulated even if at the upper level the governing board is still only a coordinating body. If a joint management regime is established an intermediate-level joint management authority may be formed to administer the day-to-day decisions made by the governing board. In all cases, however, it is likely the institutions established will continue to work vis-a-vis local water bodies from the different parties.

Any transboundary management structure will incur some costs. These will in most cases include both operating and capital costs. Unless the financing of these costs is ingrained in the agreements establishing the management structure they may quickly become bones of contention. Thus, it is essential that the sources for finance be an integral part of the shared aquifer management regime.

These issues, as well as the allocation and confidence-building issues, are further discussed in the Israeli-Palestinian context in the next chapter.

5. CONCLUSIONS

This chapter presents a conceptual framework for establishing transboundary management regimes for shared aquifers. Naturally, the form, level of cooperation and focus of such a regime would be a function of the local circumstances. Therefore, the framework advanced here is sequential and flexible, allowing decision makers to choose and change courses from a coherent set of options. This framework is thus, in essence, a map of the options available for managing shared aquifers, and of the possible routes decision makers may take in addressing the problems inherent in transboundary groundwater.

At present most of the options identified within this framework have not been tried. But as the use ratio of additional aquifers rises and the inevitability of interdependencies becomes increasingly recognized, more decision makers in an increasing number of cases would need to make decisions regarding shared aquifers. As the circumstances within which these decisions would have to be made vary, as do the physical features of the different cases, it is likely that options raised here and not yet tried may become feasible. Moreover, it is likely that given human ingenuity new options not thought of thus far would arise. The framework advanced here can allow for the incorporation of such new options, provided that the sequencing appropriate for each is spelled out. This framework can help guide, therefore, even a wider set of circumstances than that explicitly defined here.

REFERENCES

Baynard J.K., 1997. Transboundary water management in the UK. Paper presented at the IXth World Water Congress. Montreal. September 1-6.

Berck P and Lipow J., Real and Ideal Water Rights - The Prospects for Water-Rights Reform in Israel Gaza and the West Bank. *Resource and Energy Economics* 16, pp. 287-301.

Bingham G., Wolf A. and Wohlgenant T., 1994. Resolving Water Disputes: Conflicts and Cooperation in the United States. The Near East and Asia, Report to the USAID, Washington DC.

Dinar A., Rosengrant M.W. and Meinzen-Dick R., 1997. *Water Allocation Mechanisms - Principles and Examples*. Policy Research Working Paper 1779. The World Bank, Washington, D.C.

Howitt R.E. and Vaux H., 1995. Competing Demands for California's Scarce Water. in A. Dinar and E. Tusak-Leohman (eds.) *Water Quantity/Quality Management and Conflict Resolution*, Praeger, Westport.

Lee T.R. and Jouravlev A., 1997. *Private Participation in the Provision of Water Services: Alternative Means for Private Participation in the Provision of Water Services*. United Nations Economic Commission for Latin American and the Caribbean. Serie Medio Ambiente Y Desrrllo 2. Santiago. Chile.

Lee T.R. and Jouravlev A., 1998. *Prices, Property and Markets in Water Allocations*. United Nations Economic Commission for Latin American and the Caribbean. Serie Medio Ambiente Y Desrrllo 6. Santiago, Chile.

Sadler B., 1988. The Management of Canada-U.S. Boundary Waters: Retrospect and Prospect. *Natural Resources Journal* 26, pp. 359-376.

Winpenny J., 1994. *Managing Water as an Economic Resource*. Routledge, London.

Appendix. Expected Transaction Costs of Possible Transboundary Management Structures

Structure	Number of Tasks	Potential for Disagreements	Infringement on Sovereignty	Transaction Costs
Aquifer Monitoring	Single	Low	None	
Technical Research Coordination	Single	Low	None	Low
Resource Conservation	Single	Low	None	Low
Training Center	Single	Low	None	Low
Apportionment Body	Single	High	Limited*	Medium*
Arbitration Body	Single	High	Limited*	Medium*
Apportionment Monitoring	Single	Moderate	None	Low - Medium
Investigative Advisory Body	Few	High	Limited	Medium
Risk Management	Few	High**	Limited	Medium
Pollution Control	Many	Moderate*	Significant*	High*
Joint Regulatory Bodies	Several	High	Major	Very High
Wastewater Utility	Several	Moderate	None	Medium
Water Utility	Several	Moderate	None	Medium
Economic Development	Several	Moderate - high*	Limited	Medium – High
Project Management	Several	High	Limited	Medium – High
Water Transfer or Market Administration	Several	Moderate	Limited	High***
Comprehensive Utility	Many	High	Limited	High***
Integrated Aquifer Management	Many	Very High	Major	Very High

* The effects would be a function of the exact specification of authority given to such a structure

** The potential for disagreement without this structure is great.

*** Highly innovative structures that would have to face therefore significant skepticism.

Chapter 26

A Proposed Agenda for Joint Israeli-Palestinian Management of Shared Groundwater

Marwan Haddad, Eran Feitelson, Shaul Arlosoroff & Taher Nassereddin
College of Engineering, An-Najah National University, Nablus, Palestinian Territory and the Palestine Consultancy Group (PCG), East Jerusalem
Department of Geography, The Hebrew University of Jerusalem and the Harry S Truman Research Institute for the Advancement of Peace, Mount Scopus, Jerusalem
The Harry S Truman Institute for the Advancement of Peace, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem
P.O. Box 19622, Jerusalem

1. THE CURRENT SITUATION

Israelis and Palestinians are heavily reliant on the already fully exploited Mountain Aquifer. The natural replenishment of all the sub-basins has been fully allocated in the Oslo B accords, and the current interim agreement does not leave any excess capacity as a reserve for crisis situations. Therefore, both Israeli and Palestinian professionals realize this aquifer has to be judiciously managed. Otherwise its already exploited operational storage capacity would be reduced, to the detriment of both parties, possibly leading to tensions between them. Moreover, as seen in previous chapters, both sides realize that neither can manage the aquifer independently – hence the need to cooperate in managing this shared resource.

Israel and Palestine are in a semi-arid region, where storage capacity is crucial for managing the natural variance in water availability. This region also faces particularly rapid growth, due to the relatively high population densities in both Israel and the West Bank and the rapid population growth of both societies, augmented by possible future immigration. When combined with the intensity of economic activity over the aquifer and the desire of both sides to accelerate economic growth it is obvious the aquifer faces severe threats from land sources as well as from situations that might lead to over-pumping.

If we relate this background to the discussion in the previous chapter we can describe the Israeli-Palestinian case as one where there is a high use to resource ratio and a very high level of interdependence. This is a classic situation where joint management is called for.

In the Oslo B agreement a coordinated management structure was established. This structure is composed of a Joint Water Committee (JWC) and Joint Supervision and Enforcement Teams (JSETs). The JWC was given de-facto veto power over any water resource development in the West Bank, as it has to authorize, by consensus, any such development initiated by any party. The JSETs were established under the JWC in order to oversee the activities on the ground. The effectiveness of the JWC and JSETs was compromised by the need for agreement on every action by representatives of two bodies (the Israeli Water Commissioner and the Palestinian Water Authority) which meet only occasionally and by the power discrepancy between the two parties. The need to coordinate each meeting separately, the fact that there was no permanent joint body and the virtual double veto power of the parties led to significant delays in developing water resources for Palestinian use as agreed upon in the accords. These new resources are direly needed by the Palestinians even for domestic supply. As a result, the distrust between the parties was not alleviated in the five years following the signing of the Oslo B accords.

The mechanism that was established in the Oslo B accords does not amount to a joint management structure. It was designed as an interim measure, primarily to coordinate actions initiated by the two parties during the transition period to the permanent status agreement. It did not establish a structure that would actively manage the shared groundwater resource, or at least certain facets of it necessary to achieve a coherent goal. It also did not include measures for developing the institutional structure, or resolving disagreements, since it was for an interim period. Moreover, despite the call for data sharing in the accords no data sharing occurred. The prerequisites identified in the previous chapter for an effective joint management mechanism have not been put in place in the Israeli-Palestinian case, though some initial experience in joint work, and particularly in the JSETs, has been gained.

2. THE OUTSTANDING ISSUES

Israelis and Palestinians have today a chance to embark on the route outlined in the previous chapter toward joint management.[1] However, the current experience raises several questions that would have to be addressed in structuring the joint management regime.

2.1 The Process

The first step identified in all structures pertaining to the five proposed management strategies is the establishment of joint monitoring structures and the sharing of data. In addition to the importance of such monitoring structures for the operation of virtually all JWM structures, they are seen as confidence-building measures. Yet, as van der Gun warns (Chapter 15), such efforts may backfire if they lead to the creation of "data graveyards": if monitoring and data sharing become an end to themselves, and do not feed into a decision-making system they may lead to further erosion of confidence in joint management efforts. Thus, it is imperative that monitoring, modeling and data-handling efforts be well integrated in a wider decision- and management-oriented framework, and not become an end to themselves.

This problem is, however, part of a larger issue. There is a danger that if the first steps in the process take a long time, and do not provide any tangible benefits for water users, especially in the Palestinian population centers, there may be further loss of confidence in the ability of the sides to work together. This would result in increasing pressure to break out from the confines of the JWM structure. Ultimately this may lead to a breakdown of the chosen management structure, to the detriment of the aquifer, and future generations.

To overcome this problem it is necessary to ensure that the process does not bog down in its initial steps and that concrete benefits are felt quickly. This requires that benefits to current generations and the public at large should be considered when implementing a JWM structure. Also, it is necessary to build the system so it will not break down in the face of a possible crisis. That is, it would be wise to develop the system in such a way that the first stages would evolve quickly and be well tied together. It may also be worthwhile to make sure these initial steps do not involve issues that are likely to be contentious.

[1] These lines are written at a time when the permanenet status negotiations between the parties have not yet commenced at the decision-making level.

Another problem related to the process as such is that there is very limited experience in structuring joint water management (JWM) systems for groundwater. Thus, a trial and error process is virtually unavoidable. To prevent the process from becoming contentious and getting bogged down before any benefits are felt it is necessary to incorporate modification and arbitration procedures at an early stage. Moreover, as the question of water allocation is of primary importance, the political echelon must establish initial water allocations early (as stated in the political agreement between the two sides), concurrent with a formula or system for modifying them over time. This may allow for a relatively quick agreement on the JWM, and for some benefits to be felt, without either party prejudicing or compromising its long-term aspirations. Financial arrangements must also be clearly defined early on in order to facilitate supply enhancement to the Palestinians without undue contention, as resource development may be lengthy and financial responsibility can easily become a source of contention.

In contrast to the previous considerations, which require speeding up the process of building JWM institutions, the case of privatization calls for caution. As there is only scant local experience in setting up transboundary franchises, and the firms with which such agreements would be signed are usually large multinational corporations with extensive experience (Beecher, 1997), the two parties should be wary of early contractual commitments. In this case it would be necessary, then, to identify quick steps that can be taken by the two sides to provide immediate relief to the Palestinians, thus building confidence, while working carefully, perhaps with outside help, on structuring the tenders. The tenders would be issued, in fact, only after several years.

2.2 The Participants

To be implemented a JWM needs to be accepted within each society. If an important sector, on either side, will feel threatened by the JWM proposition it is likely to obstruct its acceptance and implementation. Therefore, it is advisable that all pertinent sectors be represented within the JWM structure. Such a structure would need to be cognizant not only of the needs and desires of the two parties but also of the different sectors within each party, as many of the adjustments that would have to made over time may affect specific sectors, rather than the two parties as such. In other words, it is advisable that the composition of the managing board (whether called the JWC or a different name) be reviewed to assure that the main relevant interest groups from both parties are represented.

There is one group of participants that is of particular importance in a JWM framework yet cannot be represented within it. These are the future generations. Essentially, the logic behind the JWM approach is to safeguard water for future generations. Yet, in everyday decision making their interests cannot be represented directly. Therefore, it may be useful to include within the JWM structure groups that could serve as proxy representatives of future generations, such as "green" non-government organizations (NGOs).[2]

In the framework outlined the implicit assumption is that most coordination and cooperation would be established at the national level. That does not necessarily have to be so. It is possible that local agreements regarding various facets of the water systems can be reached, and that positive experience at the local level would help build confidence in the ability of the two sides to work jointly on water management issues at the regional level. In other words, it is possible that encouraging local incremental initiatives would accelerate the establishment of a regional joint management framework. Recently, for example, an Israeli regional council (Emek Hefer) reached a tentative agreement with a nearby upstream Palestinian city (Tul-Karem) for the treatment and reuse of the city's wastewater.[3]

2.3 The Overall Setting

The decision to institute a joint management framework is usually set within a wider context of international (or inter-jurisdiction) relations. These, in turn, are influenced by local legal structures and internal politics, as well as the way water issues are framed and discussed within each society. In the Israeli-Palestinian case, the joint management options would be discussed as part of the water negotiations, which is one element of the permanent status peace negotiations. The institutionalization of joint management would have to be embedded, therefore, within a wider set of agreements.

This wider set of agreements may have some implications on the joint management framework itself. It is inevitable that some conflict resolution mechanism would be established in the agreements. It may make sense, therefore, to embed the aquifer management conflict resolution mechanism within the overall conflict resolution mechanism. Additional issues that are likely to be addressed in the overall agreement are land use controls, funding of public works and environmental protection issues. These are also likely to

[2] For further discussion on the importance of such representation in a JWM structure, see Benvenisti's chapter in this volume.

[3] An area where such an agreement is obviously needed is the Jerusalem region, where wastewater flows would necessarily cross boundaries, especially on the eastern slopes (Feitelson & Abdul-Jaber, 1997).

have some implications for the joint management agreement. At the same time, the joint management framework may help address some of these issues, in particular the water quality issues that would be raised in the environmental forums.

The need to embed the joint management framework within a wider set of agreements may, however, slow down the implementation process, as it is possible that difficulties on other issues would hold up its ratification or implementation, even after a joint management framework is agreed upon. It is necessary, therefore, to structure the framework in such a way that (1) the benefits of the joint management would be felt early, regardless of the progress on other issues; and (2) that a degree of flexibility is given so that different elements of the joint management structure can be developed and/or phased in with time.

Water issues would most likely be part of the public discussions surrounding the peace process. At present these issues are largely viewed by the public as a zero-sum game. The joint management framework shows that water can, and should, be a basis for cooperation. But this view is not intuitive, and hence not obvious to much of the public. It would be necessary, therefore, to complement the implementation process with (1) a campaign that would boost public comprehension and support of the joint management approach; and (2) a strategy for introducing new educational programs and material to schools, with the same intention.

3. AN AGENDA FOR IMPLEMENTING JOINT MANAGEMENT

Considering the issues raised above, it is clear that the joint management framework will not be implemented instantaneously. This section outlines the series of steps that are essentially a prerequisite for implementing a joint management framework in the Israeli-Palestinian context. The agenda proposed here is, then, the basis for implementing the framework described in the previous chapter. The relationship between this agenda and the sequential framework advanced in the previous chapter is presented graphically in Figure 1.

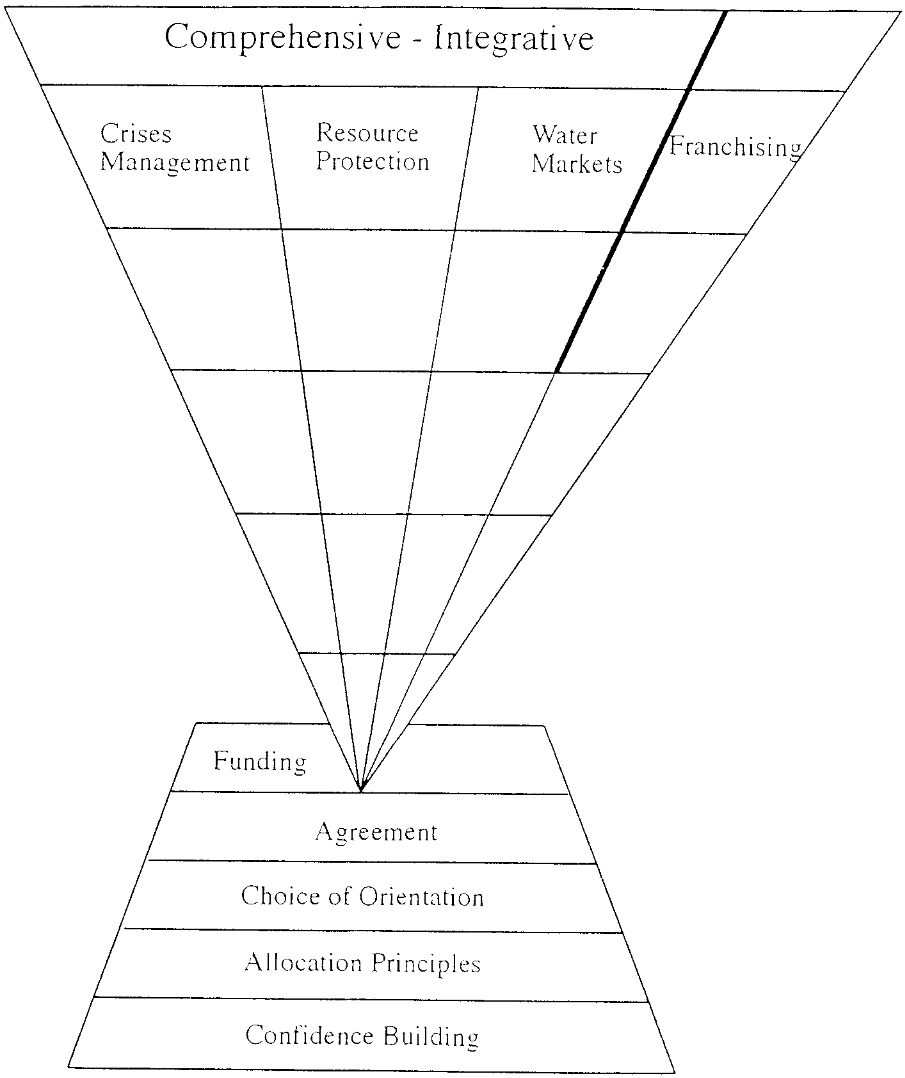


Figure 1. The JWM Framework and an Agenda for Implementing It

3.1 Confidence Building

The sustainability of the shared aquifers is a shared interest of the two parties. However, the success of any joint management institution depends to a large extent on the confidence that the parties have in the institution and procedures involved. The basic assumption behind the flexible-sequential framework is that as confidence in the existing joint management institution builds up its scope would be expanded, thus improving the management of the aquifer.

One of the major reasons for frustration on the Palestinian side has been the lack of progress in water supply to Palestinian population centers. Augmenting water supply to the West Bank by accelerating the development of the water sources referred to in the Oslo B agreement and by facilitating new water conveyance schemes or replacement of leaking systems may thus be of primary importance in improving the atmosphere between the water experts on the two sides. In particular, an effort by Israel to ensure that water supply to Palestinian residences is not interrupted during the summer months may be well appreciated. International capital may also have a useful role in achieving this target by financing the schemes necessary to improve the reliability of Palestinian water supply systems.

The first step in the agenda has to be, therefore, a sincere attempt to rebuild confidence among the technocratic strata, which will later have to work together to make the joint management structure work. To this end the modifications in the day-to-day operation of the JWC may be important. For example, rotating chairmanship, an effort to bring any project for discussion within a pre-specified time limit, full reporting of activities and a general aura of sincerity and openness in the discussions are indispensable.

Other actions that may help bolster confidence include allowing the JSETs the full mobility specified in the Oslo B accords and providing Palestinians with open access to data pertaining to the mountain aquifers, such as water levels in wells over time, water quality measurements and the amounts of water extracted. Creating a shared database may also facilitate the data exchange.

One of the impediments to the agreement on short-term projects for alleviating Palestinian water shortages is the perception that water is currently being wasted. It is thus imperative that water conservation and demand management measures be enacted by both parties at the outset, and throughout the operation of the JWM. Moreover, these should be enacted by both parties unilaterally, as they would serve as confidence building measures by indicating their good will to manage the water resources judiciously. It is also possible that certain actions in the JWM framework be made contingent on prior application of water conservation or demand management provisions. The application of such measures may preempt the allegations by one side or the other that it is required to give up water due to artificial demand of the other side, induced by inefficient water use.

3.2 Allocation Principles

One of the pre-requisites for establishing a joint management structure is that allocation principles be agreed upon. While the actual allocations that each side would obtain are a subject of political negotiations, certain principles and issues that should be considered in making the allocations and defining water rights can be advanced here, as they pertain to the joint management framework.

In a joint management framework the guiding principle is the well being of people, both of current generations and future generations, and the protection of natural resources. As within twenty five years, a single generation, most of the shared aquifers' water would be needed for domestic consumption, the implication of this principle is that water should be allocated on a per-capita basis.

The amount of water that should be allocated per capita would be subject to negotiation between the parties. It is assumed that ultimately per-capita water allocation for domestic purposes would be equal for both sides and, therefore, a timely plan to reach this goal should be prepared and agreed upon. However, in determining the allocations there is a need to address the climatological and hydrological fluctuations and differences in water quality. That is, the definition of allocations cannot be limited to a single amount of water. Rather, the timing of extraction and the quality of water extracted should be included in the parameters that define an allocation or right.

Once the per-capita principle and need to account for fluctuations have been recognized it becomes clear that allocations have to be modified over time. They have to be modified as a function of changes in the total population and its distribution and during drought years. Thus, from a joint management perspective, there is an advantage to structures that facilitate modifications of water allocations and to definitions that allow such modifications without a need for re-negotiations. At the same time, it is important that these structures assure that water is used efficiently, as otherwise the ability to reallocate water may not be sufficient to overcome allegations that the modifications are requested due to excess demand resulting from inefficient use.

Water is often used more than once, for different uses. A definition of water allocations as a single amount usually fails to take this fact into account. Therefore, water allocations should be made with a view toward the total water cycle, rather than merely at the point of extraction.

The water cycle view has several advantages. It makes a direct connection between water allocations and obligations – once water has been used return flows and wastewater flows are generated. These can be reused. Therefore, it may be necessary to oblige the user to provide these flows, and to assure that they are of a sufficiently high quality to allow for subsequent use. This view also highlights the fact that there are many sources for water, including for water in an aquifer. For example, recharge enhancement schemes can be built to recharge water during a wet season for use in dry periods. Such investments should be recognized in making allocations, lest they not be undertaken due to the "free rider" problem. Finally, the water cycle view highlights the fact that wastewater is not only a liability but also a resource. A combination of all these factors suggests that water allocations should be defined in a multidimensional way.

In the Israeli-Palestinian context this flexibility can be demonstrated in the recharge area above the western Mountain Aquifer. In this region it is important to prevent use of low-quality wastewater. Yet, as population over it grows, more freshwater would be needed there for domestic use (based on the per-capita allocation principle), and hence more wastewater is likely to be generated over the recharge area. If these two facets are combined, it is possible for additional freshwater to be allocated to the population over the recharge area (mostly Palestinian), while at the same time obliging the recipients to return a pre-agreed percentage at a pre-specified quality level for reuse either in the coastal plain to the west or locally. In this manner farmers who would lose freshwater may receive recycled water instead, and the treatment of wastewater would be embedded in the freshwater allocations to the population centers over the recharge area.[4]

3.3 Choice of Strategy

Once the initial confidence-building measures have been implemented, and the allocation principles agreed upon, negotiators will have to make a decision regarding the basic strategy of the joint management structure. Clearly, it is not the purpose of this chapter to make a single recommendation regarding this choice. Still, it may be possible to offer several observations that may be useful to negotiators in making this choice.

[4] This idea may have the additional benefit of making wastewater treatment on the West Bank more attractive to international funding agencies and donor countries. For further discussion of the advantages and limitations of this idea, see Chapter 21 in this volume.

The resource protection and crisis management strategies are relatively compatible. Thus, regardless of which one is chosen as the initial focal point, it would be relatively easy to expand the scope to include elements from the second strategy. From an institutional perspective both have a similar logic – the creation of a cross-boundary administrative structure that would enhance the sustainability of the aquifer by formulating a joint strategy. They ensure an obvious win-win outcome, without requiring substantial modifications in the way water policies are currently conducted (at least on the Israeli side).

The water market strategy has a somewhat different underlying logic, as it emphasizes the use of market mechanisms to enhance efficiency, rather that the management of the aquifer per se. While this strategy is compatible with a sustainable management perspective, it would not promote directly the sustainable management of the aquifer. In order to promote the sustainable management of the aquifer the definition of water rights, allocations and trading rules would have to be sensitive to climatological and hydrological fluctuations and to water quality facets. While there is substantial literature on these topics,[5] practical experience is limited – and non-existent in the Palestinian-Israeli context. Thus, a choice of this strategy should be made contingent on a definition of property rights that is sensitive to these facets. It is also likely that this strategy would require more preliminary studies than the previous two. Still, it can provide substantial benefits, especially as it allows for modifications in allocations without renegotiations.

One of the most innovative strategies advanced as part of the framework is the franchising strategy, whereby some of the JWM activities are franchised to the private sector, presumably an international firm or consortium. This strategy incurs long-term contractual commitments, and thus may be less compatible with the other options. In a sense, while it is possible at any point to add this strategy or shift to it, it would be more difficult to shift away from it once an international tender has been issued. After contracts with large multinational firms have been signed such a shift becomes problematic from a legal perspective as well. Despite these limitations this strategy has several important potential benefits that warrant its serious consideration. In addition to assuring a higher probability of efficient water supply and wastewater treatment services, it may be conducive for attracting foreign capital for building the much-needed infrastructure systems on the West Bank. More importantly, this strategy

[5] For a concrete suggestion see Vaughan and Emerson (1997). Their suggestion pertains to the Edwards aquifer in Texas, an aquifer that has several similar attributes to the Mountain Aquifers.

may de-politicize discussions regarding water use, wastewater issues and infrastructure development and encourage cooperation among the two parties vis-a-vis the international consortiums.

The franchising option does not have to pertain to the whole aquifer, as in any case it is not proposed that the responsibility for the resource would be privatized. This option is likely, therefore, to be limited to certain elements of the water system, which are of importance from an aquifer management perspective, such as the wastewater treatment and reuse sub-system. It may be possible to conduct a trial-and-error learning process in implementing this strategy, whereby the experience gained in one place will be used to improve subsequent tenders elsewhere. In other words, the implementation of this strategy can be gradual, even if no adjustments are made to signed contracts. Thus, while this strategy may take more time to implement than the alternative strategies, it may be more compatible with them than first meets the eye.

The comprehensive-integrative systems referred to in the literature usually are comprised of the first two strategies only. In some cases they may allow for the creation of water markets, too. A decision to try and establish directly a comprehensive-integrative structure has the benefit of assuring a long-term commitment to the sustainability of the aquifer. It provides a stronger statement than other options for the joint management framework. This may be important to allay fears that the joint effort will fizzle out at the end of the first stage in the process, producing no concrete benefits. However, this strategy may also seem more threatening to existing institutions, and may be perceived as encroaching on the sovereignty of the parties. In essence, it leaves less leeway in the structure for future modifications in response to changes in circumstances and policy preferences.

The important point that arises from this discussion is that in making the choice of strategy decision makers should consider not only each strategy in itself, but also the possible relationships among strategies. In addition. it is important that research continue on strategies that may initially not be chosen, as some of the more promising ones are the least tried and understood options, especially in a joint management framework.

3.4 The Agreement

Once the basic strategy has been chosen, the parties would need to institutionalize the JWM structure in a formal agreement. In this agreement the principles for cooperation mentioned in the Introduction should be reflected. While it is not our purpose to address here the legal aspects that would have to be dealt with in this agreement, it is possible to make several observations regarding the content of the agreement.

The agreement has to assure the two sides that they would be equally represented in decision making with respect to all water-related issues. To this end, the agreement should clarify the actions that need to be approved by the JWM institutions, the decision-making procedures within the JWM institutions, the actions the JWM institutions can take, and the means to be provided to them to accomplish their tasks. The agreement would also have to clarify the relations between the JWM institutions and local jurisdictions, on the one hand, and the national bodies of the two parties, on the other. As data exchange has become a source of contention it may be necessary also to specify which data, and from which data sources, should be part of the shared database, and how this database should be maintained and accessed. To this end, a GIS-based system may prove useful (see Chapter 17).

Given the complexity and novelty of the agreement it should include provisions that would clarify how misunderstandings and conflicts can be resolved, how the JWM authority is to be upheld, and how modifications may be introduced in an orderly manner.

Given the current distrust between the two parties it may be useful to include in the conflict resolution mechanism some neutral experts as potential facilitators allowed to assess the differences and raise suggestions. In Figure 2 a procedure for making use of such a function is advanced. Essentially, this procedure calls for the establishment of an international advisory panel that would receive periodic updates on the progress of the JWM agreement and have access to the shared database. If either party to the JWC raises a problem but no solution is agreed upon, it would be referred to this international advisory panel. The advisory panel would try to narrow down the issue under contention and suggest possible ways to address it. These would be referred back to the JWC. If these ideas are not accepted by the JWC, and no alternative resolution is reached, the issue would be raised to the conflict resolution mechanism established within the permanent status negotiations (most likely involving the political level). The report and suggestions of the international advisory panel would be attached to this referral.

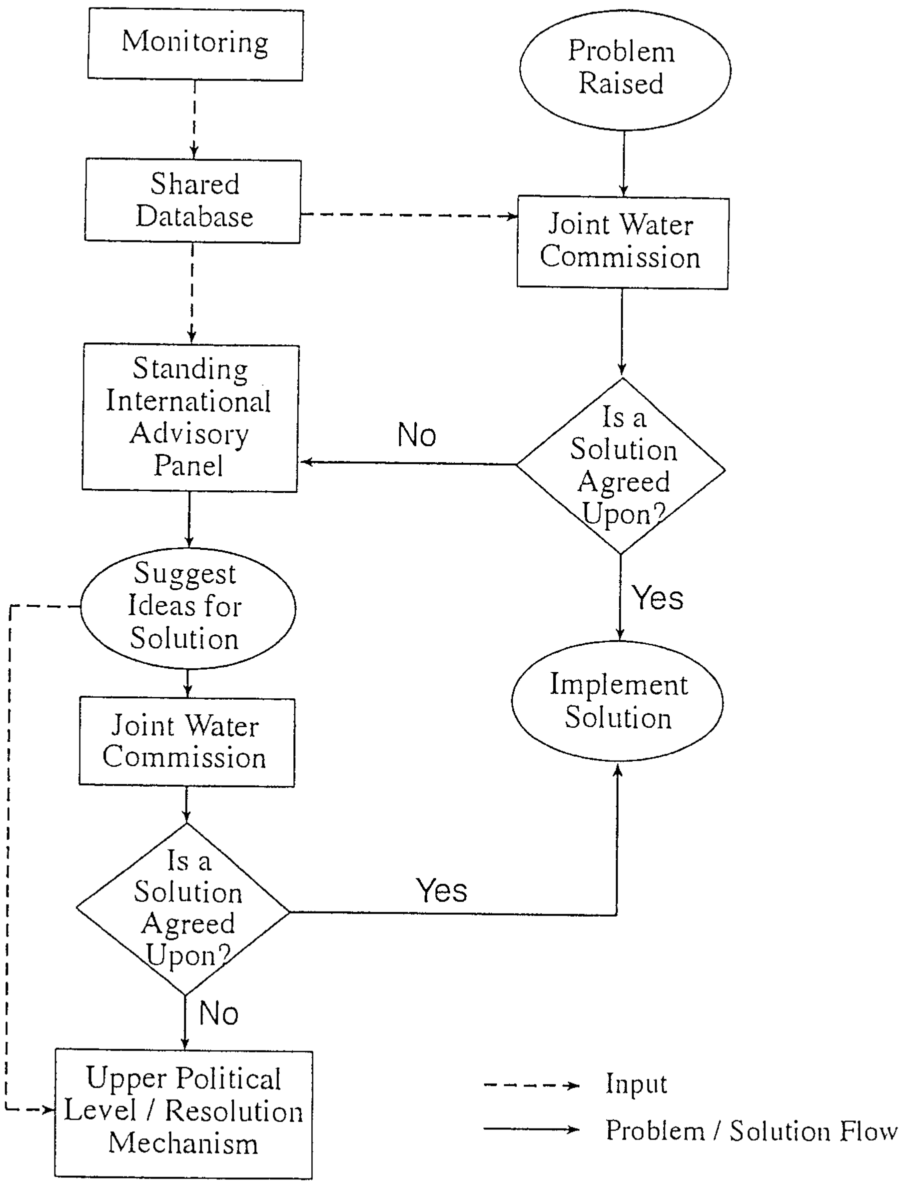


Figure 2. A Possible Conflict Resolution Algorithm

Regardless of whether the conflict resolution mechanism advanced in Figure 2 is accepted or not, it highlights some of the issues that would have to be addressed in the agreement: whether there should be any formal role to third parties; the need to allow for introduction of new ideas from uninvolved persons in conflict situations, the need to clarify at which point conflicts are referred to upper levels that are not part of the JWM institutional framework, and the need to make sure there is an agreed-upon shared database when addressing conflicts. The same types of issues are also likely to be pertinent when the need to allow for modifications is addressed in the agreement.

In addition to addressing the relations between the two parties the agreement would have to acknowledge the local-regional-national interfaces. There are two aspects that would have to be addressed in this context. One is the issue of enforcement. This was addressed in the Oslo B agreement in the form of the JSETs. In the permanent status agreement it would be necessary to address the problems identified in the operation of the JSETs. It may also be necessary to specify adjudication procedures for dealing with offenders.

The second aspect involves the possibilities for local cooperation. As noted above, these possibilities may be especially pertinent in the wastewater treatment and reuse field. As it is impossible to scope all the possibilities for such cooperation in advance, it is suggested that the agreement leave sufficient leeway for local jurisdictions to pursue such local cooperative options, and that the JWM structure be designed to accommodate such initiatives.

3.5 Funding

The operation of a JWM structure incurs costs. These costs should be shared between the two sides. To preempt disagreements in the future the costs that each side should bear and the sources of revenue should be documented and elucidated in the agreement. These costs include several components:

- Operating cost of the JWM institutions;
- Capital cost needed for the JWM operation or to meet the JWM requirements;
- Operating cost of water facilities needed for the JWM operation or resulting from JWM requirements.

There are several possible sources of revenue to cover these costs:

- General revenues allocated for the JWM structure by the parties;
- User fees for services;
- International funds of donor agencies and countries.

These revenues can be leveraged through various financial institutions. It is possible to create a special fund or bank that would specialize in leveraging the money derived from the three revenue sources in order to be able to get the maximum service from these revenues for joint management purposes.

The revenue and cost streams vary over time. Capital costs are usually incurred in large lump sums. In contrast, operating costs are usually a relatively constant stream. Similarly, user fees are relatively stable. Funds from international sources, meanwhile, may be erratic as they are a function of the discrete decisions by the donor agencies or countries (whose considerations include many unrelated factors, such as changes in other areas competing for the same resources). General revenues may also be affected by local economic and political shifts. The general funding problem is, thus, to match revenues and needs. This problem is made more difficult in a joint management context, as it is overlaid by the questions of how to allocate costs among the parties (and sectors within the parties) and who benefits from revenues from outside sources. Moreover, the answers to these questions may be affected by the choice of JWM structure.

The operation of the JWM structure itself usually does not require significant funds. However, these funds have to be forthcoming in a predictable manner. As these sums are not substantial they can be borne by the two parties equally from general revenues.[6] Alternatively, they can be derived from an aquifer levy, whereby anyone who pumps water from the aquifer would have to pay a levy as a function of the amount of water pumped and possibly the externalities it imposes.[7]

The capital cost and water facility operating cost attributable to the JWM structure would most likely include water conveyance facilities between the two parties, drilling and pumping, aquifer recharging, monitoring and wastewater treatment and reuse facilities (and conveyance of wastewater from the treatment facilities to reuse points).[8] One of the issues the JWM structure would have to address is the identification of facilities that are germane to the operation of the JWM structure, versus those that should be the responsibility of local jurisdictions or the two parties. The choice of

[6] By "general revenues" we mean that these are funds not generated specifically for the JWM effort or by it. It does not limit the ways in which either party actually raises the revenues, as it is possible to dedicate a certain revenue stream (for example, a percentage of a certain fee or tax) for this purpose.

[7] Such a levy was advanced by the Arlosoroff Commission as part of the reforms it proposed in the Israeli water market. For more details, see Arlosoroff (1997).

[8] For discussion of some of the issues which may be included in these categories see Nevo (1994) and Dvoskin (1994). Dvoskin also identifies some of the potential sources for revenues.

strategies of the JWM structure may affect the identification of facilities as germane to the JWM operation, and hence their applicability for receiving JWM funds. For example, if a crisis management strategy is chosen it is possible that recharge schemes would get priority for JWM funds, while if a water market strategy is chosen, water conveyance schemes, necessary to facilitate trades, would receive that priority. Regardless of the designation of projects, it would be necessary also to establish an institutional funding mechanism to administer the funds. This could be an administrative mechanism or it could be a unit set up as a fund or bank. In the latter case it may collect user fees from local jurisdictions for services rendered (for example, water conveyance) and combine them with international funds to leverage additional sums for capital investments at a better interest rate.

If a franchising strategy is chosen it may be possible to fund the elements selected to be franchised separately, as part of the franchising agreement. For example, if a certain wastewater system serving both parties is franchised it is possible that the generation of funds for the construction of this system would be one of the elements included in the tender. While the financial terms may not necessarily be better in this case (because of the risk element to private enterprise in a still-unstable region), this option may allow access to additional sources, and provide international donors with a greater interest in the success of the joint management effort.

It is not our goal to discuss here all the funding implications of joint management. Rather, the purpose of this section is to highlight the need for addressing the issues as part of the joint management agreement. However, as the funding aspects of joint management have not received sufficient attention to date, at least in the Israeli-Palestinian context, it may be worthwhile to conduct a separate study to identify which funding options may be suitable for each strategy, and what are the institutional and legal requirements for setting them up.

4. CONCLUSIONS

Where water is concerned, Israelis and Palestinians can be viewed as Siamese twins – two entities sharing a vital resource. It is thus imperative that they manage this resource as best as they can, for the benefit of current and future generations. This requires that a sustainable development approach be adopted. As neither side can manage the aquifer alone in a sustainable manner they need to manage it jointly. To this end the two parties have to create a joint management structure. As there is only scant international experience in the joint management of shared aquifers, and as the extensive experience in managing transboundary surface water is not directly transferable to groundwater, it seems that Israelis and Palestinians may need to come up with novel solutions to their joint management problem.

Based on a five-year cooperative study, a framework for developing a sustainable joint management structure for shared aquifers is proposed. This framework suggests that from a narrow base one of five strategies for a joint management regime should be chosen. Once the strategy is chosen additional tasks can be added over time as confidence in the structure increases. It is also possible to change strategies or expand the scope of an existing structure to include additional strategies over time. Eventually, a comprehensive-integrative management structure may evolve.

This general principle is limited only in the case where a franchising strategy is chosen, as at some point legal contracts limit the ability to shift away from this strategy. Yet, this strategy holds special promise in a joint management framework, as in addition to its efficiency and effectiveness advantages it may help overcome political obstacles and transform the content and form of discussion, emphasizing economic and supply issues rather than political ones. It may also force the two parties to cooperate closely in order to obtain the best deal from a multinational corporation.

The implementation of this framework, regardless of the strategy eventually chosen, requires that several issues be addressed. Foremost among them is the distrust between the parties. Regrettably, this distrust grew after the establishment of a Joint Water Commission as part of the coordinated management prescribed in the Oslo B accords. To overcome this distrust it is necessary to ensure an immediate improvement in water supply to Palestinian population centers and that the process will not get bogged down before discernible benefits have been realized.

To overcome the obstacles an implementation agenda is advanced in this report. It begins with steps that may help boost confidence, including adjustments in the operation of the JWC, supply augmentation to the West Bank and data sharing. Then water allocation principles have to be agreed upon. A water-cycle perspective of defining allocations (and rights) is advanced. It allows for greater flexibility in addressing the allocation of water among the parties, and focuses attention on quality issues and return flows. In making these allocations special attention has to be given to the fluctuations in water availability and water-quality issues. Once the allocation principles have been defined the strategy of joint management structures should be chosen. In making this choice decision makers should consider the possible relationships among the different strategies in order to allow future generations to adapt the evolving structures to changing circumstances and policy preferences. This should be framed within a binding agreement. While this study does not deal with the legal aspects of this agreement, it does note several issues which have to be part of the joint management agreement in order to make it sustainable. As any joint management agreement for a shared aquifer is novel, it is likely that there will be many points that would have to be clarified over time. Thus, special attention should be given to the conflict and disagreement resolution mechanisms. One suggestion for such a mechanism was advanced here. Finally, the financial ramifications of joint management have to be addressed as part of the agreement setting up the joint management framework.

The main lesson from this effort, however, is not limited to a specific aspect of joint management. It is that the aquifer can serve as a basis for Israeli-Palestinian cooperation, and thus advance the prospect for peace, rather than be a source of contention. If the aquifer is indeed managed jointly in a sustainable manner both current and future generations of Israelis and Palestinians alike will benefit.

REFERENCES

Arlosoroff S., 1997. The Public Commission on Water Sector Reform, *International Water and Irrigation Review,* 1-9.

Beecher J.A., 1997, Water utility privatization and regulation: Lessons from the global experience, *Water International* 22, 54-63.

Dvoskin D., 1994, Financing of jointly operated aquifers, in E. Feitelson and M. Haddad (eds.) *Joint Management of Shared Aquifers: The First Workshop*, The Palestine Consultancy Group and the Harry S Truman Research Institute for the Advancement of Peace, Jerusalem.

Feitelson E. and Abdul-Jaber Q., 1997. *Prospects for Israeli-Palestinian Cooperation in Wastewater Treatment and Re-Use in the Jerusalem Region*, The Jerusalem Institute for Israel Studies and the Palestinian Hydrology Group, Jerusalem.

Nevo N., 1994, elements of water and sewerage installations that require regional water cooperation. in: E. Feitelson and M. Haddad (eds.) *Joint Management of Shared Aquifers: The First Workshop*, The Palestine Consultancy Group and the Harry S. Truman Research Institute for the Advancement of Peace, Jerusalem.

Vaughan B.F. and Emerson P.M., 1997. Protecting the Edwards Aquifer: An efficient and ecological alternative, in: T.L. Anderson and P.J. Hill (eds.) *Water Marketing - The Next Generation*, Rowman & Littlefield, Lanham, MD.

List of Contributors

Karen Assaf	Currently Advisor to the Palestinian Water Authority, Al Bireh, Palestine
Shaul Arlosoroff	The Harry S Truman Institute for the Advancement of Peace, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem. E-mail: sarlo@inter.net.il
Eyal Benvenisti	Faculty of Law, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem
David B. Brooks	International Development Research Centre, 12th floor, 250 Albert St., Ottawa, Ontario, Canada, K1G 3H9. E-mail: dbrooks@idrc.ca
Joseph W. Dellapenna	Professor of Law, Villanova University, Villanova Pennsylvania 19085, USA; Rapporteur, Water Resources Committee, the International Law Association. E-mail: dellapenna@law.vill.edu
Ariel Dinar	The World Bank, Room S 8-039, 1818 H St. NW, Washington DC, 20433, USA, adinar@worldbank.org
William K. Easter	Professor in the Department of Applied Economics, University of Minnesota, St. Paul, MN, USA
Eran Feitelson	Department of Geography, The Hebrew University of Jerusalem and the Harry S Truman Research Institute for the Advancement of Peace, Mount Scopus, Jerusalem. E-mail: msfeitel@mscc.huji.ac.il
Jac A.M. Van der Gun	TNO Institute of Applied Geoscience, Delft, The Netherlands
Marwan Haddad	College of Engineering, An-Najah National University, P.O.Box 7, Nablus, Palestinian Territory and the Palestine Consultancy Group (PCG), East Jerusalem. E-mail: haddad@najah.edu
Yoav Harpaz	Water Resource Planning, 39 Rishonim Rd., Ramat Hasharon 47242, Israel
Robert Hearne	Assistant Research Professor and Environmental Economist at CATIE, Turrialba, Costa Rica
John K. Horowitz	University of Maryland, College Park, USA
Jad Isaac	Director, Applied Research Institute (ARIJ), Caritas St., P.O.Box 860, Bethlehem. Telfax: 972-2-2741889
Richard E. Just	University of Maryland, College Park, USA
Yona Kahane	Israeli Center for Waterworks Equipment (ICWE), 42 Haim

	Levanon Street, Tel Aviv 69977.
Steve Lonergan	Centre for Sustainable Regional Development, University of Victoria, P.O.Box 1700, Victoria, BC, Canada. E-mail: lonergan@uvic.ca
Numan Mizyed	Faculty of Agricultural Sciences, Department of Plant Production, An-Najah National University, P.O. Box 7, Nablus, Palestine
Ismail Najjar	President, Hydrosult Inc., 3333 Cavendish Blvd., Suite 410, Montreal, Canada
Taher Nassereddin	Palestine Consultancy Group and West Bank Water Department Ramallah, P.O. Box 19622, Jerusalem
Sinaia Netanyahu	Ben-Gurion University of the Negev, Beer-Sheva, Israel
Maher Owewi	Applied Research Institute (ARIJ), Caritas St., P.O.Box 860, Bethlehem
Gregory A. Thomas	Natural Heritage Institute, San Francisco, California, USA
Miguel Solanes	Division of Environment & Development, ECLAC, Casilla 179-D, Santiago, Chile. E-mail: mssolanes@eclac.cl
Carel de Villeneuve	The International Water Policy Division of the Netherlands' Ministry of Transport, Public Works and Water Management, Directorate-General for Public Works and Water Management
Aaron T. Wolf	Department of Geosciences, Oregon State University, Eugene, OR, USA. E-mail: wolfa@geo.orst.edu.

Most of the world's freshwater resources in liquid state (i.e., not in glaciers and polar caps) are underground. As the population grows and demand for water rises, the reliance on groundwater increases. In many cases the groundwater underlies boundaries, or is part of a hydraulic system that crosses boundaries. In such cases there is always the danger that the "prisoner's dilemma" will run its course and all parties will compete over who will pump the most water, ultimately destroying the storage potential to the detriment of future generations of all parties based on the groundwater. This book explores the options and means for averting this all too realistic scenario by managing these shared groundwater resources.

Nowhere is the likelihood of excessive use of groundwater greater than in the water-scarce Middle East, and especially in the Israeli-Palestinian case. Here both sides are heavily reliant on a shared aquifer, the Mountain aquifer. This book is the outcome of a seven-year effort to find ways to manage the Mountain aquifer, perhaps the most important resource shared by Israelis and Palestinians. As part of this cooperative study, four workshops were held in which a selected number of Palestinian, Israeli and foreign experts were invited. The chapters in this book were originally presented in one of these workshops. To these papers, introductory and concluding chapters were added.

ISBN 0-88936-912-7

9 780889 369122

Kluwer Academic Publishers
Boston/Dordrecht/London

IDRC CRDI

Canada