WORLD BANK TECHNICAL PAPER NO. 456

Work in progress
for public discussion

WTP456
November 1999

Groundwater

Legal and Policy Perspectives

Proceedings of a World Bank Seminar

Edited by
Salman M. A. Salman

Recent World Bank Technical Papers

No. 374 Jones, *Sector Investment Programs in Africa: Issues and Experiences*

No. 375 Francis, Milimo, Njobvo, and Tembo, *Listening to Farmers: Participatory Assessment of Policy Reform in Zambia's Agriculture Sector*

No. 376 Tsunokawa and Hoban, *Roads and the Environment: A Handbook*

No. 377 Walsh and Shah, *Clean Fuels for Asia: Technical Options for Moving toward Unleaded Gasoline and Low-Sulfur Diesel*

No. 378 Shah and Nagpal, eds., *Urban Air Quality Management Strategy in Asia: Kathmandu Valley Report*

No. 379 Shah and Nagpal, eds., *Urban Air Quality Management Strategy in Asia: Jakarta Report*

No. 380 Shah and Nagpal, eds., *Urban Air Quality Management Strategy in Asia: Metro Manila Report*

No. 381 Shah and Nagpal, eds., *Urban Air Quality Management Strategy in Asia: Greater Mumbai Report*

No. 382 Barker, Tenenbaum, and Woolf, *Governance and Regulation of Power Pools and System Operators: An International Comparison*

No. 383 Goldman, Ergas, Ralph, and Felker, *Technology Institutions and Policies: Their Role in Developing Technological Capability in Industry*

No. 384 Kojima and Okada, *Catching Up to Leadership: The Role of Technology Support Institutions in Japan's Casting Sector*

No. 385 Rowat, Lubrano, and Porrata, *Competition Policy and MERCOSUR*

No. 386 Dinar and Subramanian, *Water Pricing Experiences: An International Perspective*

No. 387 Oskarsson, Berglund, Seling, Snellman, Stenbäck, and Fritz, *A Planner's Guide for Selecting Clean-Coal Technologies for Power Plants*

No. 388 Sanjayan, Shen, and Jansen, *Experiences with Integrated-Conservation Development Projects in Asia*

No. 389 International Commission on Irrigation and Drainage (ICID), *Planning the Management, Operation, and Maintenance of Irrigation and Drainage Systems: A Guide for the Preparation of Strategies and Manuals*

No. 390 Foster, Lawrence, and Morris, *Groundwater in Urban Development: Assessing Management Needs and Formulating Policy Strategies*

No. 391 Lovei and Weiss, Jr., *Environmental Management and Institutions in OECD Countries" Lessons from Experience*

No. 392 Felker, Chaudhuri, György, and Goldman, *The Pharmaceutical Industry in India and Hungary: Policies, Institutions, and Technological Development*

No. 393 Mohan, ed., *Bibliography of Publications: Africa Region, 1990–97*

No. 394 Hill and Shields, *Incentives for Joint Forest Management in India: Analytical Methods and Case Studies*

No. 395 Saleth and Dinar, *Satisfying Urban Thirst: Water Supply Augmentation and Pricing Policy in Hyderabad City, India*

No. 396 Kikeri, *Privatization and Labor: What Happens to Workers When Governments Divest?*

No. 397 Lovei, *Phasing Out Lead from Gasoline: Worldwide Experience and Policy Implications*

No. 398 Ayres, Anderson, and Hanrahan, *Setting Priorities for Environmental MAnagement: An Application to the Mining Sector in Bolivia*

No. 399 Kerf, Gray, Irwin, Lévesque, Taylor, and Klein, *Concessions for Infrastructure: A Guide to Their Design and Award*

No. 401 Benson and Clay, *The Impact of Drought on Sub-Saharan African Economies: A Preliminary Examination*

No. 402 Dinar, Mendelsohn, Evenson, Parikh, Sanghi, Kumar, McKinsey, and Lonergan, *Measuring the Impact of Climate Change on Indian Agriculture*

No. 403 Welch and Frémond, *The Case-by-Case Approach to Privatization: Techniques and Examples*

No. 404 Stephenson, Donnay, Frolova, Melnick, and Worzala, *Improving Women's Health Services in the Russian Federation: Results of a Pilot Project*

No. 405 Onorato, Fox, and Strongman, *World Bank Group Assistance for Minerals Sector Development and Reform in Member Countries*

No. 406 Milazzo, *Subsidies in World Fisheries: A Reexamination*

No. 407 Wiens and Guadagni, *Designing Rules for Demand-Driven Rural Investment Funds: The Latin American Experience*

No. 408 Donovan and Frank, *Soil Fertility Management in Sub-Saharan Africa*

(List continues on the inside back cover)

WORLD BANK TECHNICAL PAPER NO. 456

Groundwater

Legal and Policy Perspectives

Proceedings of a World Bank Seminar

Edited by
Salman M. A. Salman

The World Bank
Washington, D.C.

ISBN: 0-8213-4613-X
ISSN: 0253-7494

Salman M. A. Salman is senior counsel in the World Bank's Legal Vice Presidency.

Library of Congress Cataloging-in-Publication Data

Groundwater : legal and policy perspectives : proceedings of a World Bank seminar / edited by Salman M.A. Salman.
p. cm. — (World Bank technical paper ; no. 456)
Includes bibliographical references
ISBN 0-8213-4613-X
1. Groundwater—Congresses. I. Salman, Salman M. A., 1948– . II. World Bank. III. Series.

GB1001.2.G79 1999
333.91'04—dc21 99-052396

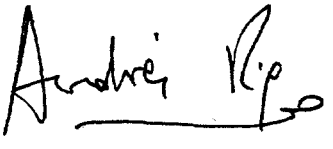
CONTENTS

FOREWORD

Groundwater is the least understood and least appreciated, yet the most important, natural resource available to mankind. Groundwater represents about 97% of the fresh water resources available, excluding the resources locked in polar ice. More than one and a half billion people in the urban parts of the world today depend on groundwater. Groundwater supply is more reliable than the seasonal, and sometimes erratic, surface water, and provides the main line of defense against drought. Moreover, the quality of groundwater is, by and large, superior to surface water, and cheaper to develop.

However, data on groundwater, when available, is very scanty. Many countries do not know how much groundwater exists beneath their soil, and a fairly large number of countries do not have legislation regulating the use and protection of groundwater. Although we have fairly reliable estimates of how many rivers are shared by two or more countries, no such estimates exist for transboundary aquifers, and international groundwater law is still in its early stage of development.

It is not surprising, under those circumstances, that the World Bank is now paying increasing attention to this valuable resource, through both operations and sector work. The organization of the seminar on "Groundwater: Legal and Policy Perspectives" by the Legal Vice Presidency in April 1999, should be a major contribution to this effort. The publication of the proceedings of the seminar is timely, and will certainly allow for a wider dissemination of the valuable information presented and discussed at the seminar within the Bank and its members countries and other interested institutions. This Report should also assist in a better understanding and appreciation of this valuable, but least understood and least appreciated, resource.



Andres Rigo Sureda
Acting Vice President and General Counsel
The World Bank
September 7, 1999

ABSTRACT

The structure of this Report follows closely the design and format of the seminar on "Groundwater: Legal and Policy Perspectives" held in Washington on April 19, 1999. Like the seminar, the Report consists of an introduction and four separate, but inter-related parts, each with a separate set of chapters.

The Introduction includes the keynote address delivered at the seminar. The Introduction argues that water crisis is likely to result, not from physical scarcities, but rather from two other reasons: quality deterioration and lack of investments in the water sector as a whole, including groundwater. The Introduction also highlights the linkages between groundwater and energy, and the need to ensure proper recharge of groundwater.

The first part of the Report deals with understanding groundwater. Chapter 1 explains some basic technical aspects of groundwater and discusses how groundwater is insufficiently understood, irrationally exploited, and inadequately protected. The chapter highlights some essential concepts for groundwater regulators. Chapter 2 deals with groundwater and society and describes how the perception and treatment of groundwater as a private resource has thwarted the attempts to exercise a measure of equity and control over abstraction and protection of groundwater. The chapter underscores the importance of engagement of users to encourage sustainable use of the resource.

The second part deals with the regulatory framework for groundwater. Chapter 3 surveys a number of groundwater regulations, and traces the move from private ownership of the resource to the current practice where most governments exercise a wide range of regulatory authority. The chapter discusses some issues, options and best practices associated with such regulation. Chapter 4 deals with institutional and legal issues relevant to implementation of water markets and explains how groundwater markets are used in different parts of the world today, both as a tool for efficiency, and for improving access to the resource. The chapter discusses how groundwater marketing without appropriate knowledge and management of the aquifer could prove unsustainable.

The third part deals with the World Bank experience with groundwater. Chapter 5 discusses the objective and components of the Bank-financed Bangladesh Arsenic Mitigation – Water Supply Project. The chapter underscores the importance of considering all aspects of groundwater quality in the environmental impact assessment of development projects that impinge upon groundwater. Chapter 6 deals with groundwater resources management in Jordan, and discusses some policy and regulatory issues. The chapter explains the sources and uses of groundwater and the challenges that scarcity poses on the management of groundwater, including the issue of cost recovery. Chapter 7 deals with legal and institutional issues related to groundwater management in Mexico, and summarizes the aquifer stabilization study conducted for some of the overexploited aquifer. The chapter emphasizes the importance of users involvement, water rights and water markets and tariff. Chapter 8 discusses the World Bank experience with groundwater irrigation in Nepal and highlights some major issues that arose in some of

the Bank-financed projects there. Similar to Mexico, those issues include lack of farmers involvement and ownership in groundwater development. Chapter 9 describes the groundwater situation in Yemen and the World Bank involvement there. The chapter stresses the urgent need for a regulatory and legal framework for water resources in Yemen; a need which is typical of many developing countries.

The fourth part deals with international groundwater law. Chapter 10 describes the evolution and context of the legal principles that govern the use and protection of shared groundwater resources, including a discussion of what constitutes international groundwater. The chapter discusses the sources of such principles and concludes that international groundwater law is still in the embryonic stage. Chapter 11 deals with international groundwater law and the World Bank policy for projects involving transboundary groundwater. After similarly tracing the legal principles for shared aquifers, the chapter analyzes the World Bank practice in the few cases involving such shared aquifers. The chapter underscores the need for the policy to incorporate the practice as enunciated in the few projects involving transboundary groundwater. Chapter 12 highlights principles of international environmental law that may be relevant to transboundary groundwater, particularly those incorporated in the Rio Declaration and the concept of sustainable development. The chapter discusses how the application of the precautionary modalities could be extended to transboundary groundwater.

ACKNOWLEDGMENTS

The organization of the seminar on "Groundwater: Legal and Policy Perspectives" on April 19, 1999, and the preparation and editing of the proceedings of the seminar has been a demanding job, and I would like to thank all the colleagues who assisted me in both tasks. At the outset, I would like to extend my sincere thanks and appreciation to the guest speakers: Messrs. Asit Biswas, Stephen Foster, Jacob Burke, Stefano Burchi, Miguel Solanes, Stephen McCaffrey and Raj Krishna for their outstanding presentations, and for their contribution to this Report. My special thanks are extended to Mr. Andres Rigo Sureda for his advise throughout the preparation of the seminar, and for his introductory remarks that provided the directions for the seminar. I would also like to thank the Bank colleagues: Messrs. Nadim Khouri, Andrew Macoun, Ohn Myint, David Freestone, Tony Garvey, and Mmes. Karen Hudes and Karin Kemper who rearranged their mission plans and their other assignments to be present and give their presentations at the seminar, and for the contribution to this Report. My thanks and appreciation are also extended to Messrs. Marcus Moench, Claude Sauveplane, Hazim El Naser and Ms. Sarwat Chowdhury for their contribution to this Report.

I am also grateful to the coordinators of the sessions of the seminar: Messrs. David Grey, Ashok Subramanian and Paatii Ofosu Amaah for the smooth running of those sessions, and for the extensive preparatory work. I would also like to thank Mmes. Rosemary Thompson-Elhosseine and Valerie Peters from the Legal Vice Presidency, and Misun Choi from the World Bank Institute for their help with the logistics of the seminar. My special thanks and appreciation are extended to Mr. Goetz Reichert for his assistance in putting together this Report.

I would also like to acknowledge the assistance of, and funding from, the World Bank Institute, the Water Resources Management Thematic Group and the Legal Vice Presidency, and to thank the colleagues who facilitated such assistance and funding.

Last, but not least, I would like to thank the participants for devoting the entire day for the seminar, and for the lively discussion that enriched the seminar.

INTRODUCTION

Water Crisis: Current Perceptions and Future Realities*

Asit Biswas**

INTRODUCTION

Mr. Leonardo da Vinci, the eminent renaissance scholar and philosopher said, "water is the driver of nature." Many may have considered it to be an overstatement in the past, but at the threshold of the third millennium, no sane individual would disagree with Mr. da Vinci's view. Water is becoming an increasingly scarce resource for most of the world's citizens. The current trends indicate that the overall situation is likely to deteriorate further, at least for the next decade, unless the water profession eschews "business as usual" practices, which can only allow incremental changes to occur.

GLOBAL WATER PERSPECTIVE: 1990-2000

Strangely enough, the water profession as a whole neither realized nor appreciated the seriousness of the global water situation as late as 1990, even though a few serious scholars have been pointing out the increasing seriousness of the situation from around 1982. For example, the seriousness of the crisis was not a major issue, either at the International Conference on Water and the Environment, which was organized by the UN system in Dublin, or at the UN Conference on Environment and Development at Rio de Janeiro. Held in 1992, both Conferences are considered important events for the water sector for the current decade. It is now being increasingly recognized that the Dublin Conference was poorly planned and organized, and thus, not surprisingly, it produced very little, if any, worthwhile results. Furthermore, as the Dublin Conference was expected to make the necessary inputs to the Rio discussions, water did not receive adequate emphasis at Rio. For all practical purposes, water was basically ignored at Rio by all the heads of states, whose primary interests were focussed on issues like climate change, biodiversity, and deforestation. Water, at best, was a very minor issue during the plenary session at Rio. Equally, the chapter on water in Agenda 21 is the most poorly formulated. Thus, despite the rhetoric of many international institutions, the impacts of Dublin and Rio Conferences on water management globally and regionally have not been discernible. In all probability, the development in the water sector would not have been

---

* This Introduction includes the keynote address delivered by the author at the seminar on "Groundwater: Legal and Policy Perspectives." The address was delivered at the seminar under the title, "Looking Ahead: Water in the Next Millennium."

** President, Third World Centre for Water Management, Mexico City, Mexico; and member of the World Commission on Water.

materially different even if these two events had not occurred. Thus, both Dublin and Rio constituted lost opportunities for water, since they failed to put water on the international agenda.

In retrospect, it has to be admitted that the global water crisis was put firmly on the international agenda, not through the efforts of the international organizations like the United Nations agencies, but primarily because of the efforts of the Stockholm Water Symposium, an annual event which started in 1991, and is now attended by leading water experts from all over the world. By constantly focusing on the importance and relevance of water to the future socio-economic development of the world and its importance to environmental conservation, the Stockholm Water Symposium managed to convince the water profession that the global water situation, at least during the early part of the 21st century, is likely to get worse, and thus must be considered most seriously This is a remarkable achievement since the Symposium is not an institution, and its overall direction is provided by a small Scientific Programme Committee. Furthermore, the Symposium itself has managed to reach this pre-eminent position of influencing the global water discussions in only nine years. Viewed from any direction, it is a most laudable feat.

By the second half of the 1990s, much of the water profession had accepted that the world is heading for a water crisis that is unprecedented in the human history. Just as at the beginning of the decade, the water crisis was not taken very seriously by most members of the profession; now nearly every one believes such a crisis is inevitable. It would be argued later that just as the previous position was erroneous, so is the current thinking.

Another water-oriented development of the late 1990s is worth noting. During the 1972-1992 period, the global discussions on water were mostly carried out under the aegis of the United Nations Agencies. The UN System during the 1970s and the early 1980s had many competent, dedicated and charismatic water leaders, who provided the leadership for these discussions. With their departure from the global scene, the UN System has played increasingly less and less relevant role on global water discussions as the decade of the 1990s progressed. Current trends indicate that this process is likely to accelerate further in future.

During the last five years, new institutions like World Water Council (WWC) and Global Water Partnership (GWP) have filled the vacuum created by the continually diminishing role of the UN System. Also, increasingly, the Stockholm Water Symposium is providing a focus where global and regional discussions are taking place each year, either within the framework of the Symposium itself, or within the events associated with it during the same week in Stockholm. Thus, the Symposium, by providing a clear focus for timely relevant and objective discussions on the various aspects of water each year, on a multi-disciplinary and multi-sectoral basis, has now firmly established itself as the "global centerpiece" for discussions on water. In addition, increasingly important water-oriented institutions like WWC and GWP have started to congregate each year in Stockholm to conduct their own activities, thus giving added impetus to the importance

of the Symposium. However, while this has added considerable *gravitas* to the Stockholm Water Symposium, it also may pose a major threat to its future, as the world's most important annual water event. Too many activities in one week and in one place may start to detract from the overall technical focus of the Symposium, and thus dilute its overall impacts.

Two other global developments of the current decade are also worth noting. First is the establishment of the World Commission on Water (WCW). This blue-ribbon commission clearly has forced the water community into thinking about the future of the world's water, a feat the profession has never achieved during its entire history. It is still too early to judge what would be the overall impact of WCW, since a preliminary draft of its report is not yet available. However, at the very least, it has already forced the water profession into thinking seriously about the global water future on a collective basis, which by itself is a most remarkable achievement. Furthermore, what WCW has already achieved in less than a year's work and with a very limited budget, other international institutions have been unable to accomplish even a fraction of, over the decades and with a cumulated budget several hundred times that of WCW. Depending on the quality of its final report, WCW undoubtedly has the potential to set the global water agenda for the next 5-10 years, in a way that has never been possible before.

The second event is the formation of the Club of Tokyo. This informal group of around 15 most influential water personalities of the world, selected on the basis of a peer-survey, is loosely based on a model of the Club of Rome during its heydays of the early 1970s. This very select group of influentials will make a determined attempt not only to put water on the international political agenda, but also to guide discussions at the various international fora in an appropriate direction.

It is highly likely that the work and activities of the WWC, the GWP and the Club of Tokyo will have significant impacts on the future global water developments, especially during the first decade of the new millennium.

WATER CRISIS

While predicting the future is an extremely hazardous business, one item can be predicted with complete certainty: the world in the year 2025 will be vastly different from what it is today, in the same way that the world today is significantly different from what it was in 1975. Among the main driving forces which are likely to contribute to these changes are rapidly evolving demographic conditions, technological advances in all fields, speed and extent of globalization, improvements in human capital, and national and inter-governmental policies.

The water sector is an integral component of the global system, and thus it would undergo major changes as well during the next 25 years. In fact, water development and management will change more during the next twenty years than it has during the past 2000 years. The water profession has generally ignored so far the global forces outside the water sector that are already shaping its future availability, use and management

practices. These impacts are likely to increase significantly in the next quarter of a century. And yet, the water profession has not yet started to consider seriously the implications of accelerating developments in areas like globalization, biotechnology, desalination, information and communication, which are likely to revolutionize water use and management practices in the coming decades.

It is now widely accepted that the world will face a major water crisis in the coming decades because of increasing scarcities in numerous countries. Many international organizations have published maps in recent years, all somewhat similar, which show that more and more countries of the world are becoming rapidly water-stressed because of increasing scarcities.

It is high time to review critically the reliability of such forecasts for many different reasons. First, the information base on which such forecasts and maps are based is highly unreliable. Extensive review by the Third World Centre for Water Management indicates that the national estimates on which the current global figures are based, are often erroneous (in many cases by several hundred percents), and in other instances, the facts are totally wrong. For many major countries, like India and China, estimates of water availability and uses are currently available, but no one has a clear idea about the accuracy and usefulness of such national statistics. Thus, it is impossible to get any reasonably reliable picture of the global and regional water situations, which are based on the aggregation of such incomplete and unreliable national data sets.

Second, water abstraction is at present widely used as a proxy for water use. Methodologically, this of course is fundamentally wrong. Unlike oil, water is a reusable resource, which can be used and then reused many times. For example, some scientists have pointed out that each drop of the Colorado River water is currently used 6-7 times before it reaches the sea. Also, globally water is being increasingly reused, both formally and informally, and all the indications are that the extent of reuse in all countries will accelerate further in the coming decades. Thus, the current practice of using water abstraction as a proxy for water use is already significantly erroneous. In about a decade, when reuse becomes even more extensive, this practice of using water abstraction data would be completely meaningless because of very serious underestimation of water actually used.

Currently, no reasonable estimates exist for reuse of water, even at the national levels, let alone for the world as a whole. Some data exists for a very few developed countries like Japan. In addition, the water profession, regrettably, has not considered reuse as an important factor in global water availability and use considerations, as a result of which all the existing forecasts are highly suspect.

Third, private sector and water pricing are likely to play increasingly important roles as the 21st century progresses. The net result of these two developments is likely to be significant advances in demand management, which currently plays a minor role in most countries of the world. This would mean that within a short period of about a decade

or so, all projections of future water use would have to be significantly revised downwards because of increasing emphasis on demand management.

Fourth, as water pricing becomes increasingly acceptable, and technology advances further, it is highly likely that the estimates of groundwater availability would have to be revised significantly upwards. At present, since water for agriculture, which is the major user of water, in most countries is virtually free, there has not been much economic incentive to explore groundwater on a comprehensive basis. Accordingly, the current global and national estimates of usable groundwater are likely to be very serious underestimates.

In this connection, it is worth noting a possible analogy with oil. In 1973, when energy crisis hit the world, proven oil reserves amounted to 640 billion barrels. By 1996, the proven reserves had increased to 1,030 billion barrels. This is in spite of the fact that the global annual oil consumption increased by 32% during this period. Because of the energy crisis, as oil prices increased and many oil companies moved from the public to the private sector, oil exploration economically became an attractive alternative. This, plus continuous advances in technology, has steadily increased the proven world oil reserves, even though tremendous amount of oil is used each year.

It is highly likely that in the coming years:

- Water pricing will become more widespread than what it is at present.
- Technological advances will make many sources of groundwater that are not economically exploitable at present, usable in the future. Furthermore, as water prices increase, there would be more demand for groundwater exploration to increase supply, which will stimulate accelerated research to develop new technology to abstract this resource, thus creating a virtual cycle.
- The private sector will play an increasingly important role in water development and management.

Under the above conditions, the global estimates of economically usable groundwater are likely to increase significantly.

Thus, the current estimates of the future global water requirements are likely to prove far too high, and this would have to be revised significantly downwards during the next decade. Simultaneously, the amount of water that is available for use at present is seriously underestimated because reuse and recycling are ignored, estimates of groundwater availability would have to be revised upwards, and technological advances are making costs of desalination and new non-conventional sources of water (i.e. rubber bags to transport water over long distances) more and more attractive. Because of the upward adjustments in water availability and downward revisions in requirements, one can now be cautiously optimistic of the global water future.

This, of course, does not mean that it would be an easy process for countries to adjust to the new realities of a rapidly changing global water scene. Equally, many countries are likely to find it difficult to manage the transformation without discontinuities because of sociopolitical constraints, institutional inertia, increasing management complexities and current and past inefficient water management practices. However, since the "business as usual" will not be a feasible option for the future in nearly all countries, policy-makers, water professionals, and water institutions, whether they like it or not, would be forced to embrace the new conditions, most probably within the next 10-15 years. All these and other associated developments are likely to make the present "gloom and doom" forecasts of a global crisis due to water scarcities somewhat unlikely in the coming decades.

On the basis of the above analysis and other associated issues, the threat for a global water crisis because of physical scarcities only, as expected at present, is now probably overstated. If there is likely to be a crisis in the water sector, it would probably be due to two reasons, none of which is receiving adequate attention at present.

The first cause which could contribute to a crisis could be due to continuous water quality deterioration. Globally, water quality is receiving inadequate attention, even though it is rapidly becoming a critical issue. While global data on water quantity is poor, it is virtually non-existent for water quality. Even for major developed countries like the United States or Japan, a clear picture of national water quality situation currently does not exist. For developing countries and for countries in transition, ranging from Indonesia to Nigeria, and Russia to Mexico, existing frameworks and networks for water quality monitoring are highly deficient, adequate expertise on water quality management simply does not exist, and laboratories for water quality assessments suffer very seriously from poor quality control and quality assurance practices. Furthermore, senior water policy-makers in most developing countries become interested in quality aspects primarily when there are major local crises due to political and/or media interventions. Sadly, for all practical purposes, water quality is still receiving only lip service from most senior bureaucrats and politicians of developing countries and countries in transition.

Not surprisingly, because of the above deficiencies, water quality problems are becoming increasingly serious in all developing countries. For example, nearly all surface water bodies within and near urban-industrial centers are now highly polluted. While data on the existing groundwater quality are extremely poor, it is highly likely that groundwater is also getting increasingly contaminated near centers of population.

Because of a poor water quality management system, whatever national data available in developing countries and countries in transition, give mostly an erroneous picture of the existing water quality conditions. As a general rule, in these countries the official pictures of water quality situations are mostly rosier than the current conditions warrant.

Recent estimates made by the Third World Centre for Water Management indicate that in spite of the official rhetoric and figures published by several international

organizations, only about 6% of wastewater generated in Latin America is properly treated and disposed of. Furthermore, most universities in the developing world cannot provide appropriate education and training on water quality management. Accordingly, rapid capacity building in this area would be a Herculean task under the best of circumstances. In addition, currently no reasonable estimates exist as to what would be the investment needed in Latin America to improve wastewater treatment from a paltry 6% to a reasonably tolerable level of 60%-70%. All that can be stated at present with complete confidence is that the total investment costs for wastewater treatment and management are likely to be astronomical, and most countries would find it extremely difficult to meet these very high resource requirements in a timely manner.

The second possible crisis is likely to come from lack of investments for both water quantity and quality considerations. Investment requirements for wastewater treatment was noted earlier. These are for point sources only: investment needs for controlling non-point sources of pollution, like agricultural runoffs, are simply unknown at present even for the OECD countries. In addition most existing water development projects in developing countries need massive investments for rehabilitation and modernization. Equally, new projects are becoming increasingly expensive to develop because more efficient project sites have already been developed, or are in the process of development and due to social and environmental countermeasures necessary. Analyses of current cost estimates for the next generation of water supply projects in developing countries indicate that these are likely to be 1.75 to 3 times the cost of the present generation of projects, in real terms and per m^3 of water supplied. These high costs are still not adequately reflected in the current budget estimates of nearly all water agencies.

Construction of new large dams in the United States, Canada and Western Europe during the past two decades have been few and far between. The costs in Japan, one of the few advanced countries that is continuing to build new large dams, have increased significantly in recent years. For example, for the 155-metre high Miyagase Dam in Japan, with a 2 million m^3 volume, construction of which is now nearly complete, the cost per cubic meter of water storage is approximately 200 yen ($1.62 at July 1999 exchange rate). This is significantly higher than the current costs of desalinating sea water.

Globally, the total investment costs for modernizing and efficiently managing existing water development projects and wastewater treatment plants, and for constructing new ones, are likely to be astronomical. Currently, not even ball park estimates of such costs are available. The main issue thus is from where would such high financial investments be available? The governments all over the world now have high national debts; resource generating capacities of all developing countries and countries in transition where most of the water projects have to be rehabilitated and the new ones are to be constructed, are limited; and the World Bank and the regional development banks have steadily reduced their assistance to water development projects as a percentage of their total loan portfolio. Furthermore, because of strong pressures from social and environmental activists, international financial institutions are becoming increasingly reluctant to finance new water projects, particularly dams, irrespective of their overall

societal benefits. In fact, a historian in the 21st century may very well argue in a retrospective analysis that the Sardar Sarovar (Narmada) Dam Project in India became the World Bank's "Vietnam" in terms of support to dam projects during the 1990s. The regional development banks, which for all practical purposes follow the World Bank leadership in most areas, have taken, at least unofficially, a very similar stance.

Thus, it is likely that unless the current situation improves, the lack of investments may precipitate a water crisis in the 21st century.

GROUNDWATER

Groundwater management is often considered to be a "poor cousin" to surface water. An "out of sight, out of mind" mentality has resulted in its contamination in many areas near significant human activities, and simultaneous overuse and underuse in many different places. This is in spite of the fact that urban and rural areas often depend on groundwater as the principal source of potable water. Increasingly, however, it is being realized that:

- Groundwater is an important source of potable water, and hence, its quality must be suitable for its intended use.

- Quality of groundwater is inextricably linked to what happens on the ground as well as in the atmosphere. Atmospheric deposition, contaminated rainfall, storm and agricultural runoff, improperly treated or untreated wastewater and discharge from municipal and industrial sources, and accidental spills of undesirable materials are all potential sources of contamination.

- As a general rule, in most countries, availability of data on both groundwater quantity and quality are significantly less than that for surface water. Reliability of groundwater data is also less. This, however, is not surprising since the cost of collecting information on quantity and quality of groundwater is significantly higher than surface water, and so is the cost of the necessary expertise.

- Globally, mapping of groundwater leaves much to be desired. Even when estimates of safe yields are available, vast majority of aquifers are not classified by their qualities or intended uses.

- Regulatory frameworks for groundwater management that exist at present vary significantly from one country to another, and many times from one state to another, as in the United States or India. Its legal management is mostly affected through a series of environmental, water, industrial and agricultural regulations and legislation. In the United States, at least nine Federal Acts can be identified which have implications for its use and protection. This is in addition to the Environment Protection Agency (EPA) policies and regulations as well as those of the states and local governments. In some countries,

multiplicity of overlapping legal requirements, which some times could even be contradictory, as in Mexico, make its management a most difficult process.

- Legal regime for the management of international groundwater bodies, that is, those bodies that are shared by two or more countries, has been basically a most neglected subject.

It is clear that during the next millennium, groundwater management must receive much higher levels of interest than it has been receiving thus far. The present World Bank meeting is thus an important step in this direction.

There are many critical issues in the area of water management that have not been receiving adequate attention so far. Because of paucity of time, and space, only two issues would be briefly discussed herein.

Groundwater and Energy

The linkages between groundwater and energy requirements are high. Groundwater has to be pumped up for use, for which it is necessary to have electricity or diesel. Electricity demands in many developing countries are increasing now at an annual rate of 7% to 10%, compounded. Electricity generation and distribution is poorly managed by the public sector in most developing countries. This, in turn, is affecting groundwater use since energy is not always available at the appropriate time to pump up this resource.

Two examples would be given to illustrate this point. In Dhaka, Bangladesh, there were major riots in May 1999, since the citizens did not have access to water supply for several days. According to newspaper reports, some 200 people were injured in those riots. This problem, however, did not occur because of groundwater scarcity since water tables were at normal levels. This was exclusively because of shortages in electricity because of poor planning, operation and maintenance practices. Many of the state electricity boards in India are broke because of heavy subsidies to the farming sector, poor pricing and cost recovery systems, and improper management. All these adverse developments in the energy sector would undoubtedly have discernible impacts on groundwater management practices in the future.

Estimates by the Third World Centre for Water Management indicate that 12%-13% of all electricity generated in Mexico is used to pump water up and down. Because both water and energy sectors are basically controlled by the federal authorities, such information has not been available in the public domain.

Similarly, as the number of pumps in South and South East Asia has increased exponentially during the past two decades to facilitate groundwater irrigation, energy requirements to operate those pumps have gone up as well. Thus, in the future, groundwater management will increasingly depend upon not only its availability but also availability of energy to pump it up. Also, in those areas where groundwater tables are declining due to overpumping, energy requirements for continuing groundwater use can

only increase steadily. Since groundwater cannot be properly managed without energy, energy availability (including costs) needs to be given increasing attention in the future.

Recharge of Groundwater

How to ensure proper recharge of groundwater has to be an increasingly important consideration in the future. For example, in the monsoon countries of Asia, much of the annual rainfall occurs in less than 30 days (not consecutive). The main water management issue in such countries has to be how to store such torrential rainfall so that it can be used over the entire year. Up to now, the main emphasis has been to construct surface water reservoirs to store such excess water.

One issue for further research is to what extent the aquifers can be used for storing such extra water for future uses, and what techniques can be used cost-effectively to ensure such underground storage. If this is possible, one major loss from reservoirs, due to evaporation, can be significantly reduced. Water contamination could also be less.

Similarly, in Mexico City Metropolitan Area, some parts of the metropolis that are located on the alluvium have been sinking in recent decades because of overpumping of groundwater. Equally, as urbanization has increased, it has not only increased the area's total water requirements, but has also reduced the surface areas through which recharge can take place because the city is getting increasingly covered with concrete and asphalt. This twin events of overpumping of groundwater and the simultaneous reduction of recharge areas, is exacerbating social and environmental costs due to the existing pattern of groundwater use. New ways need to be found to increase the recharge rates of the city's aquifers through accelerated use of storm drainage and use of treated wastewater.

CONCLUSION

It is now fashionable to talk about water crisis in a very similar way to the discussions during the early 1970s on the future resource and environmental crisis. This, of course, is not surprising since human anxieties are an integral part of our evolutionary make-up: we could not be without them.

The world is changing rapidly, and with it the existing water management practices must change as well. However, we must objectively analyze the potential prospects and problems of the future water issues in the light of changes that are expected. We must view it neither with rose-colored glasses nor with dark glasses. In the final analysis, it is our deeds, not words that will be most important to solve the future water problems. We must objectively determine what are the potentials and also what are the problems so that we would know how to handle them efficiently in a timely manner. Success can only be measured by our timely response ability. Yesterday's crystal balls can shed no longer any light on this coming new age of restless environment, which is likely to have diversified interests that are awash in chaos, differing opinions, rapid technological changes, globalization and relentless economic competition.

A major attribute of all pioneers is their determination and will to succeed. They do not run away at the first sign of adversity, nor do they have unrealistic expectations. The field of water resources now needs some pioneers, who can handle successes and failures with equal equanimity. Technology, globalization and information revolution are now collapsing borders and barriers, between disciplines as well as between countries. A main challenge before the water profession in the coming decade would be how best to take advantage of these rapid advances to improve the existing management practices.

As we move into the 21st century, we must have a clear vision of the future, and how this vision can be achieved. We must ensure to bring this vision to life in the best way it serves humanity. We must strive to discern what the societies value most, which will determine and drive their unique vision of the future. Taking these steps in a timely and cost-effective manner will not be an easy task; it will be an essential requirement for the water profession of the future. There is now a revolution taking place, even though most people may not be aware of it. In the wake of this revolution, long-held concepts and models are likely to evolve further in an accelerated manner, and some will even disappear completely. Never before in human history have such profound changes taken place within such a short period of time as to how water should be efficiently managed, as we are likely to witness during the coming two decades. It is essential that the water profession must not only identify those changes, but must also feel them.

Along the way there will be successes and failures, with emotional peaks and valleys. It will probably be essential for the water profession to travel on many trails that are not well-worn. Along theses untrodden paths, there will be discovered undoubtedly some short-cuts, and the profession will face numerous obstacles and bumps. This is to be expected. It comes with the new uncharted territory.

PART I

UNDERSTANDING GROUNDWATER

CHAPTER 1

Essential Concepts For Groundwater Regulators

Stephen Foster*

INTRODUCTION

Groundwater is a very large, often misunderstood, and almost always undervalued, resource. Of 37 million cubic kilometer (Mkm^3) of freshwater estimated to be present on this planet, about 22% occurs below the land surface in the form of groundwater storage. Excluding water locked in polar ice caps, this constitutes some 97% of all freshwater potentially available for human use.

As a result of its drought reliability, low development cost, widespread availability and generally excellent natural quality, groundwater has become immensely important for human water supply in both urban and rural areas of developed and developing nations alike. Countless large towns and many cities derive much of their domestic and industrial water supply from aquifers, through municipal wellfields and/or very large numbers of private boreholes.

Groundwater has also become of greatly increased importance for agricultural irrigation, both to provide insurance against drought for rainfed crops and to afford greater opportunities for more frequent, widespread, and productive cultivation in climatic regions experiencing extended dry seasons. The use of groundwater has often been a key factor in promoting more efficient irrigation water-use.

KEY CHARACTERISTICS OF GROUNDWATER SYSTEMS

Nature of Aquifer Storage

A geological formation that has sufficient water-transmitting capacity to yield a useful water-supply in wells and springs is termed an aquifer. All aquifers have two fundamental characteristics: a capacity for groundwater storage and also for groundwater flow. However, as a result of natural geo-diversity aquifers vary widely in hydraulic properties (permeability and storativity) and reservoir volume (effective thickness and geographical extension).

---

* Assistant Director, British Geological Survey, Nottingham & Wallingford, United Kingdom, and Visiting Professor, University of London. This Chapter is based on widespread international experience of groundwater evaluation, management and protection through projects funded by the (British) Department for International Development (DFID), the World Bank, the World Health Organisation (WHO) and the UN Environmental Programme (UNEP). The Chapter is published by permission of the Director of the British Geological Survey.

Aquifers are underlain by low permeability strata. Similar strata (known as aquitards) may also overlie parts of aquifers confining to varying degrees their groundwater under pressure. Many thicker groundwater systems comprise interbedded layers of aquifers and thin aquitards giving rise to complex flow regimes, with significant upward flow components in discharge areas. Groundwater bodies may also become "perched" on aquitards above the level of the regional water table.

In certain inland geological situations and invariably close to coastlines, aquifers contain saline water. An interface (and associated mixing zone) between fresh and saline water develops according to the freshwater pressure and density contrasts. It should be noted that while this often results in a "lens" or "wedge" of fresh groundwater overlying saline water, in layered aquifer systems salinity inversion is not uncommon with the main freshwater reserve occurring at pressure below shallow saline water.

Aquifers range in geographical extension from less than 10 km^2 to more than 1,000 km^2 or even 100,000 km^2. The difference between their scale and boundaries and those of sociopolitical areas can present a significant impediment to regulation, especially in the context of agricultural irrigation.

The volumes of water stored underground are generally very large and thus the time-scales of (the predominantly horizontal) groundwater flow are very long (Figure 1), with most groundwater remaining in the subsurface for tens or hundreds of years before reappearing at the surface. In some areas, and especially in arid regions, a proportion of groundwater stored in deeper aquifers can be thousands of years old, representing palaeo-recharge that occurred during past eras of wetter climate (in effect "fossil groundwater").

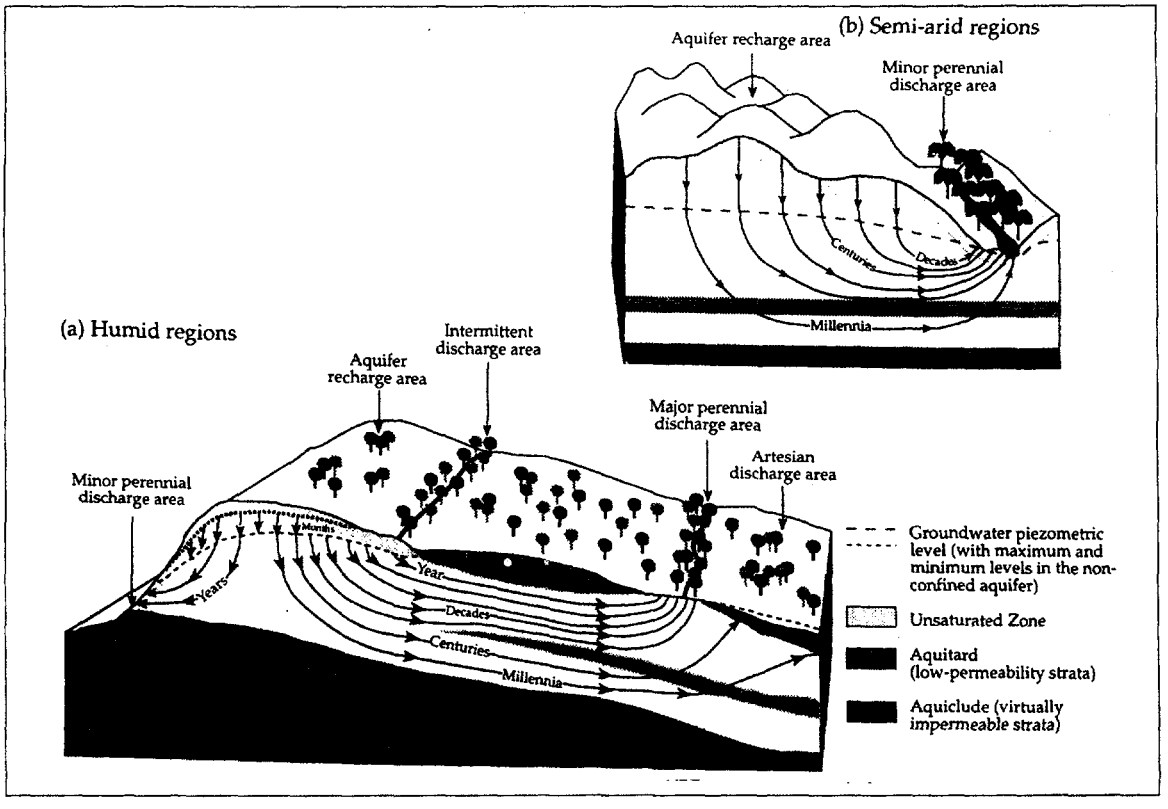


Figure 1: Typical groundwater flow systems

the residence periods indicated are typical order-of-magnitude values from time of recharge to point of discharge

Groundwater Recharge Processes

For the most part, groundwater systems are recharged by rainfall excess to plant requirements infiltrating the land surface, in areas with relatively permeable soil profile. This occurs both directly in a diffuse sense and indirectly (on a more localized basis) from the beds of both ephemeral and permanent watercourses. The latter process becomes more predominant with increasing climatic aridity, where significant recharge episodes can be very infrequent.

It is of great importance to identify the linkages between recharge and land-use. In the more arid regions, a significant proportion of total groundwater recharge may be derived from irrigation canals and/or irrigated fields, a fact that is strongly reflected by its quality (Figure 2). Modifications to canal construction/operation, irrigation technology and cropping regimes can cause marked changes in groundwater recharge rates. The same is true in urban areas, where various facets of the urbanization process radically modify existing recharge mechanisms and introduce new ones. Groundwater recharge from *in situ* wastewater disposal and/or mains water leakage is often much larger than that arising from excess rainfall under natural vegetation conditions.

It normally (but not invariably) takes many years for infiltrating water to find its way down to the water table (level where ground becomes fully saturated), which may occur at shallow depth but can be at up to 100 m or more, depending on topographical and climatic conditions.

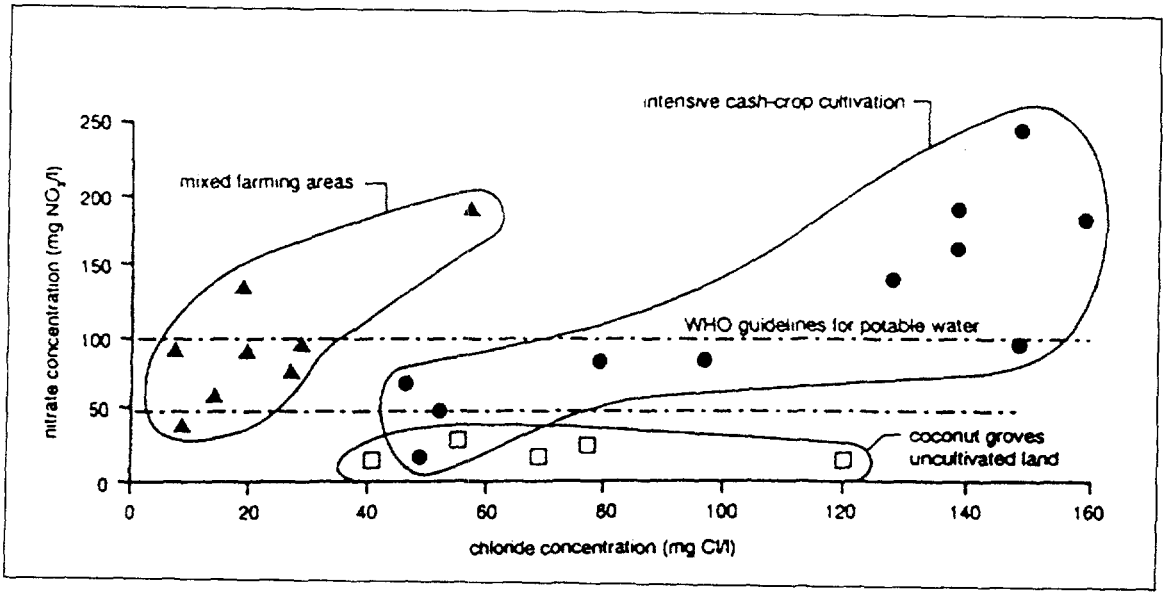


Figure 2: Correlation between groundwater quality and cultivation practices in a shallow limestone aquifer of northwestern Sri Lanka

the introduction of intensive irrigated cash-crop cultivation has resulted widely in groundwater with nitrate concentrations over 100 mg/l

Subsurface Contaminant Attenuation Capacity

Another key characteristic of groundwater systems is that subsoil profiles in recharge areas attenuate many water pollutants. They have, for example, long been considered a potentially-effective system for the safe disposal of domestic effluents. However, as a result of natural geo-diversity, not all subsoil profiles (and underlying hydrogeological environments) are equally effective in pollutant attenuation. Moreover, the level of attenuation will also vary widely with the type of contaminant and the nature of the polluting process in a given environment.

The major concern about groundwater pollution relates principally to the so-called phreatic (unconfined) aquifers, especially where their vadose (unsaturated) zone is thin and their water table shallow. However, significant pollution risk may also be present even where aquifers are semi-confined, if the overlying aquitards are relatively thin and/or permeable.

From the above considerations the concept of aquifer pollution vulnerability follows as an intrinsic characteristic indicating the likelihood of significant contamination reaching an aquifer when discharged or generated at the immediately-overlying land surface. This will vary spatially with the thickness and properties of the strata forming the vadose zone or the confining beds.

Causes of Groundwater Quality Deterioration

The different potential causes of groundwater quality deterioration are summarized in Table 1. This chapter is mainly concerned with those caused by anthropogenic pollution and or excessive abstraction. However, it is necessary to be aware of other processes that may also be operative.

TYPE OF PROBLEM	CAUSES	CONCERNS
Anthropogenic Pollution	Inadequate protection of vulnerable aquifers against manmade discharges and leachates from urban/industrial activities and intensification of agricultural cultivation	pathogens, NO_3, NH_4, Cl, SO_4, B, heavy metals, DOC aromatic and halogenated hydrocarbons
Excessive Abstraction	Saline and/or polluted groundwater induced to flow into freshwater aquifer	mainly Na, Cl, but can also include persistent anthropogenic contaminants
Wellhead Contamination	Inadequate well design and construction allowing direct ingress of polluted surface water or shallow groundwater	mainly pathogens
Naturally-Occurring Contamination	Related to pH-Eh evolution of groundwater and dissolution of minerals (aggravated by anthropogenic pollution and/or excessive abstraction)	mainly Fe, F and sometimes As, Mn, Al, Mg, SO_4, Se, even NO_3 from palaeo-recharge

Table 1: Classification of groundwater quality problems

HYDROGEOLOGICAL FRAMEWORK FOR REGULATION

Groundwater is not confined to pipes or channels, thus its "front-line managers" are municipalities, communities, industrialists and farmers; in essence, the water-user and those who take decisions on land-use planning and waste management. Unless such stakeholders understand the basic concepts of groundwater use and protection, we cannot hope to manage these resources adequately.

The considerable complexity and inherent time-lag on many aquifer flow regimes mean that cause and effect often tend to become "decoupled," both when considering groundwater abstraction and pollution. Promoting the management and protection of groundwater resources, and the water-supplies which derive from them, thus represents a formidable organizational and technical challenge. In essence, the two fundamental requirements are to exercise:

- some control on groundwater abstraction for water-supply;

- some constraint on the generation of subsurface contaminant load due to discharges on, and/or leaching from, the land surface.

Such actions are needed in the interest of avoiding quasi-irreversible aquifer degradation, and of maintaining access to adequate water-supply, whatever institutional (social, regulatory, legal, economic) arrangements appear likely to be most effective.

Issue of Land Surface Zoning

In many countries there will be strong economic arguments for acting selectively in applying such controls to specific priority areas such as:

- resource conservation zones, identified because the existing state of resource exploitation threatens key water-supplies and/or the water environment;

- source protection areas around strategic groundwater supply installations, especially where these are located in areas of high aquifer pollution vulnerability.

A fundamental legal question is the validity of selective land zoning for the imposition of special controls. In the sense that this may imply reduction in land values (blight), because of lost opportunities or increased costs for industrial development or agricultural productivity, the question of legal right to payment of compensation also arises.

Inherent Hydrogeological Data Uncertainty

It must be appreciated that natural geological heterogeneity and meteorological variability result in a relatively high degree of uncertainty in the estimation of key parameters required to characterize aquifer systems. This usually results in substantial error bands on the prediction of the impact of given scenarios of groundwater abstraction or of contaminant loading.

Comprehensive and quantitative hydrogeological surveys are costly, and a blend of rapid preliminary assessments, followed by highly-focused field measurement and well-monitored operational experience, is generally the cost-effective way forward to improve the confidence and precision of predictions needed for resource management and protection.

CONSERVING GROUNDWATER RESOURCES

Key Challenges for Resource Management

The historical perception of groundwater as an unlimited resource represents both a major cause of groundwater management problems and a major obstacle to development of effective management responses.

Groundwaters (like fish) are a resource for which property rights are not obviously defined in the legal sense. Thus, except in those nations where clear rights systems have been implemented, groundwater would still be termed a common-property (or common-pool) resource. In this situation individual users have little ability to conserve groundwater for their own future use, and thus exploitation overall is more difficult to control.

Prediction of Effect of Individual Abstractions

All groundwater exploitation by wells results in a decline in aquifer water-level (piezometric surface) over a certain area. Some reduction can be considered not only necessary but also desirable, since it often improves land drainage and maximizes groundwater recharge rates by reducing "rejected recharge."

With reasonable knowledge of aquifer properties and boundaries, the effect of proposed individual abstractions on neighboring wells can normally be predicted with acceptable accuracy for regulatory purposes, except in cases where exceptional hydrogeological heterogeneity exists. In cases where this is potentially critical, and may be challenged legally or require compensation for interference, trial/test pumping would be required for confirmation.

Groundwater is generally undervalued, especially when exploitation is uncontrolled. In this situation the exploiter of the source, in effect, receives all the benefits of groundwater development, but (at most) pays only part of the cost (usually the recurrent costs of pumping and sometimes the capital costs of well construction), since the costs of the externalities are all too often overlooked.

However, highly-dispersed groundwater abstraction patterns can have significant aggregate impacts, with problems often arising at substantial distance from many users. The migration of a saline-water front, for example, is often due to changes in groundwater flow caused by regional pumping patterns, but the only abstractors affected are those in the specific area where the saline water intrudes. It is thus normally technically difficult to apportion responsibility for external impacts.

Technical Capability of Measuring Abstraction

At first sight measuring abstraction is a necessary basis on which to raise appropriate charges for groundwater use, and does not appear to present a significant

regulatory problem. However, most experience in developing nations suggests that metering is not only costly but ineffective, until such time as the need to control abstraction is fully accepted by local water-users.

Indirect, and often inaccurate, methods for estimating abstraction and charging for groundwater use have normally to be accepted. Moreover, while it is highly desirable to maintain a comprehensive register of all abstractions, in practice it will be necessary for practical reasons to exempt small users from charges.

Issue of Perpetuity of Abstraction Rights

In many informal (social) and formal (legal) codes relating to groundwater abstraction the notion of "prior rights" (for those who came first with respect to those who followed or whose interests were later defined) is a common feature. Such rights are also, in practice, always considered to be held in perpetuity.

Given initial uncertainties about groundwater resource estimates, and over the side-effects associated with their exploitation, this situation presents a significant impediment to efficient resource management. Sooner or later it will normally require legal reform, or rationalization through the introduction of economic instruments.

A classic example is the early exploitation of a major aquifer discharge area by large numbers of shallow (sometimes artesian overflowing) wells. Insistence upon conserving the rights of these low-volume/low-cost users can prevent a major groundwater storage resource from development to meet much larger demands during drought periods.

In many ways the vast storage of many groundwater systems is their most valuable asset and regulatory arrangements need to avoid sterilizing its use in a strategic fashion. The real challenge is to use, but not to abuse, aquifer storage.

In the case of overexploited aquifers, abstraction control will need to include measures to prohibit the construction of new waterwells and to reduce abstraction from existing wells. This also involves the complex legal area of redefining abstraction rights. A pragmatic approach is to declare "groundwater resource conservation areas" in the greater public interest (through some form of local decree), greatly restricting the circumstances under which new wells can be constructed and imposing reduced abstraction rights and/or increased abstraction charges on all operators of existing wells.

Validity of Concept of Aquifer Overexploitation

If the overall abstraction rate in a given area, or aquifer system as a whole, exceeds the long-term average rate of replenishment, there will be a continuous decline in water-level, overdraft of aquifer storage and consumption of aquifer reserves. Essentially, the same can apply to abstraction from a deep semi-confined aquifer in which the limiting factors will be the rate of leakage which can be induced to flow through the confining

beds from overlying shallow aquifers and the rate of replenishment to these shallow aquifers.

Groundwater resource (or aquifer) overexploitation is an emotive, but useful expression, which has entered into the legislative codes of some countries because of its clear political register. However, it is not capable of precise scientific definition, as a result of the need to specify:

- over what period the resource balance should be evaluated, especially in situations where pumping is very unevenly distributed;
- for what period the resource balance should be evaluated, especially in the more arid climates, where major recharge episodes occur as infrequently as once a decade, or even once a century.

In practice, we are more concerned about the consequences of overexploitation than with its actual level. These include reversible interference with other wells and with springs, but can also include quasi-irreversible aquifer degradation due to ingress of saline or polluted water. In reality, there is a wide range of groundwater exploitation-related side effects (Table 2) and it is not always appreciated that differing hydrogeological environments show widely varying susceptibility to such effects.

The more logical definition of overexploitation may, therefore, be an economic one: where the benefits of groundwater use are less than the costs of the consequences of its abstraction. Thus, planned mining of aquifer storage could be acceptable. The way in which overexploitation is interpreted will also vary with the exploitable storage of the aquifer system concerned and its susceptibility to side-effects as a result of short-term over-abstraction. Both will be a function of aquifer type and hydrogeological setting.

Most serious are the quasi-irreversible side-effects, especially those involving the encroachment of saline water, if the hydraulic equilibrium in coastal areas is seriously disturbed. The effects are quasi-irreversible because the saline water, which first invades macropores and fissures, diffuses rapidly into the porous aquifer matrix under the prevailing high salinity gradients. In most cases it will take decades for this saline water to be flushed from the aquifer matrix, even after the flow of freshwater has been re-established.

REVERSIBLE INTERFERENCE	• pumping lifts/costs increase* • well yields decrease* • springflow/baseflow reduction*
	• effect on phreatophytic vegetation (natural, agricultural)
IRREVERSIBLE DETERIORATION	• saline water intrusion/upconing* • ingress of polluted water (perched aquifers, influent rivers)* • aquifer compaction/yield reduction • land subsidence effects

*frequent causes of increased social inequity amongst groundwater users

Table 2: Summary of possible consequences of excessive abstraction of groundwater from aquifers

Limitations to Concept of Safe Yield

The question of the "safe yield" of a groundwater system under exploitation invariably arises, but this is often approached far too simplistically. All natural groundwater flux in an aquifer will be discharging somewhere. A fundamental requisite of groundwater resource evaluation is to define a reliable conceptual aquifer flow model, with quantitative estimates of the rates of aquifer discharge. This will not only provide a cross-check on recharge estimates, but should also reveal key linkages to the surface environment such as:

- discharge to freshwater systems, which may be required to sustain downstream uses, both for water-supply and/or other river interests;
- discharge via natural vegetation, which may include sustaining ecologically and/or economically valuable freshwater wetlands and brackish lagoons;
- discharge to saline areas including coastal waters, salt lakes and playas.

Any attempt to define a "safe yield" for abstraction should (but all too often does not) involve decisions on what are the minimum discharge rates to sustain these interests at an acceptable level. This process will inevitably involve value judgements and may well be highly subjective.

Moreover, the use of groundwater abstracted may be highly inefficient, and thus less beneficial than the functions dependent upon the natural aquifer discharge. These include the inefficient use of water for urban and industrial water supply, and for agricultural irrigation. However, the scope for "real-water savings" (as opposed to "energy savings") may be less than believed at first sight, since it will (in fact) be limited to those water-use practices which lead to a high level of non-beneficial evaporation and/or evapo-transpiration.

PROTECTING GROUNDWATER QUALITY

Proving Responsibility for Pollution

Given the complexity of groundwater flow and contaminant transport, and the potentially large time-lag between the onset of a polluting process and its impact on a groundwater supply source, proving liability for groundwater pollution is technically and legally difficult. Moreover, it is an inadequate basis for resource protection since by the time the impact is felt, serious aquifer degradation will have occurred and remedial action is likely to be extremely costly.

A related legal question which often arises is whether (at the time of the polluting incident) the contamination occurred knowingly or intentionally, or was essentially of an accidental or incidental nature, since in most legal codes this greatly influences the scale of liability.

There is also a marked distinction between well-defined "point source" pollution and that which occurs on a widespread "diffuse source" basis. Moreover, since many pollution incidents have only an incremental effect on groundwater quality, the adequacy of monitoring of background levels and quality trends may also be key for the evaluation of liability.

Land Surface Zoning for Aquifer Protection

A more proactive approach to controlling subsurface contaminant load and protecting groundwater quality is required, and to be cost-effective the vital step is to find a realistic way of integrating groundwater considerations into land-use planning, making cautious use of natural subsurface contaminant attenuation capacity.

To do this, simplification of hydrogeological interpretation must be accepted to facilitate communication with stakeholders. Useful tools are guide maps, which zone the land surface, accompanied by simple matrices which indicate what activities are acceptable in each zone (with a given design level) at a tolerable risk to groundwater.

Aquifer vulnerability mapping is the basis for such an approach. While "a general vulnerability to a universal contaminant in a typical pollution scenario" has little validity in rigorous scientific terms, it is useful to retain the concept of "an integrated intrinsic vulnerability." This is feasible provided that a clear interpretation of the classes of vulnerability is established, such that extreme vulnerability is taken to mean

"vulnerability to most water pollutants with relatively rapid impact in many pollution scenarios," whereas low vulnerability implies "only vulnerable to conservative pollutants in the long-term when continuously and widely discharged or leached."

A sensible balance also needs to be struck between the protection of groundwater resources (aquifers as a whole) and specific sources (boreholes, wells and springs). The logical addition is to define source (wellhead) protection areas around sites of major potable water supply. The two principal zones requiring delineation are the overall source capture area and a perimeter of microbiological protection (normally defined by the mean 50-day saturated zone travel-time).

The source protection area concept is a simple but powerful one which is readily understood by land-use planners, but it has significant limitations where there is seasonally-variable and/or rapidly-growing abstraction, as the problems of pumping interference and transient flow render the establishment of fixed protection areas impracticable.

Impediments to Pollution Control Measures

There are some significant obstacles to the implementation of groundwater protection measures:

- major uncertainty over the transport and persistence of some contaminants in the subsurface, which can lead to very large uncertainties in the definition of aquifer protection requirements;
- modifying activities or practices that pre-date the introduction of the pollution control measures, without offering financial support;
- controlling diffuse pollution generally, especially where this implies changes in agricultural cultivation, as opposed to refining best management practice for existing cropping and husbandry;
- dealing technically, financially and legally with the legacy of past pollution, especially in longer-standing industrialized urban areas.

Paradoxically, the introduction of increasingly rigorous (but not well substantiated) quality standards for drinking water can result in less (not more) aquifer protection, because they only appear achievable through water treatment at point-of-use.

Moreover, it has to be recognized that shallow groundwater in urban areas is often likely to be contaminated (Figure 3) and may continue to be significantly polluted in the absence of comprehensive mains sewerage. However, the following actions will be needed in the interest of protection of potable groundwater supplies:

- prioritizing mains sewerage extension to source protection areas of high aquifer vulnerability;

- restricting the density of residential development served by *in situ* sanitation;
- directing the location of landfill solid-waste disposal facilities to areas of low aquifer vulnerability;
- controlling industrial effluent disposal to the ground through discharge permits and charges, thereby stimulating effluent recycling and waste reduction;
- special handling of persistent toxic chemicals and effluents at any industrial sites located in source protection areas;
- improving the location and quality of wastewater discharge from main sewerage systems after consideration of the potential impacts on peri-urban and downstream municipal wellfields.

In situations of extreme aquifer vulnerability it will be necessary to delineate source protection areas as total conservation zones and avoid most forms of economic development within them. This will only be possible in some peri-urban situations, whilst elsewhere it may be unavoidable to dedicate areas of the subsurface for waste disposal, prohibiting the abstraction of potable or sensitive groundwater supplies.

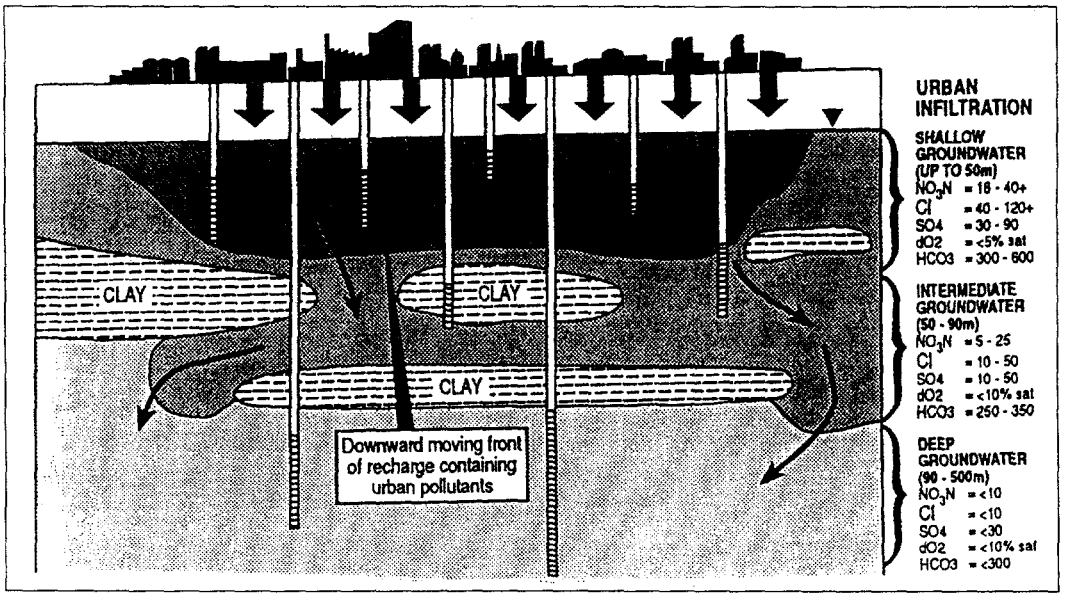


Figure 3: Impact of largely unsewered urbanization on the alluvial outwash aquifer beneath Santa Cruz, Bolivia

the shallow groundwater is most impacted and incipient contamination of deep groundwater has been induced by pumping

CONCLUSION

Groundwater is one of the most valuable natural resources possessed by many nations, supporting public health, economic development and ecological diversity. It is still insufficiently understood, widely undervalued, irrationally exploited and inadequately protected. Without proactive management there is serious risk of resource deterioration on an increasingly widespread basis.

Groundwater quality deterioration, whatever its cause, is insidious and expensive: insidious because it takes many years to show its full effect in the quality of water pumped from deep wells, expensive because by this time the cost of remediating polluted aquifers will be extremely high.

In developing strategies for groundwater protection, the issues of quantity and quality cannot be divorced because of the hydraulic complexity of aquifer response to abstraction and the slow response times of aquifers to changes in recharge quality. An integrated approach to this, and to the interrelation with surface water systems, must be adopted.

The implementation of groundwater management measures must vary quite widely with hydrogeological and socioeconomic diversity, but raising awareness, broadening participation and constraining demand will always be critical elements.

BIBLIOGRAPHY

CLARKE, ROBIN ET AL., GROUNDWATER: A THREATENED RESOURCE (UNEP Environment Library No. 15, 1996).

FOSTER, STEPHEN ET AL., GROUNDWATER IN URBAN DEVELOPMENT - ASSESSING MANAGEMENT NEEDS AND FORMULATING POLICY STRATEGIES (World Bank Technical Paper No. 390, 1998).

FOSTER, STEPHEN ET AL., GROUNDWATER IN RURAL DEVELOPMENT - FACING THE CHALLENGES OF SUPPLY AND RESOURCE SUSTAINABILITY (World Bank Technical Paper, forthcoming).

FOSTER, STEPHEN ET AL., GROUNDWATER POLLUTION RISKS: AN EXECUTIVE REVIEW OF THE LATIN AMERICAN-CARIBBEAN SITUATION IN RELATION TO PUBLIC WATER-SUPPLY (WHO-PAHO-CEPIS Publication, 1987).

Foster, Stephen & Lawrence, Adrian, *Groundwater Quality in Asia: An Overview of Trends and Concerns*, UN-ESCAP WATER RESOURCES JOURNAL C 184, 97-110 (1995).

FOSTER, STEPHEN & SKINNER, A. C., GROUNDWATER PROTECTION - THE SCIENCE AND PRACTICE OF LAND SURFACE ZONING 471-482 (IAHS Publication 225, 1995).

CHAPTER 2

Groundwater and Society: Problems in Variability and Points of Engagement *

Jacob Burke, Marcus Moench,
and Claude Sauveplane**

INTRODUCTION

The physical problems associated with groundwater development and management are increasing in scale and complexity. While the scope of these physical problems is readily acknowledged by the scientific and technical community, the range and complexity of socioeconomic responses to such physical problems are not immediately recognized. This is surprising, given mankind's intimate and intense engagement with groundwater from the early use of springs and seeps to the wholesale abstraction of deep aquifers and the injection of hazardous wastes. In general, it is possible to observe a failure to identify and articulate the public interest in groundwater until it is too late, and groundwater resources are depleted and degraded beyond physical or economic recovery. In addition, the public institutions responsible for the regulation of groundwater have lacked the mandate and the capacity to engage the millions of individual users of the resource in a process of sustainable development. What is disturbing is that most of the major aquifer depletion and degradation has occurred in a very short space of time – over the past 50 years, essentially between the 1960s and the 1980s. It is therefore interesting to observe that in the same period many advocates of "integrated water resource management" have adopted numerous statements and resolutions in which groundwater tends to get added almost as an afterthought. Is it the specific character of the resource base that poses the problems or the way in which groundwater users choose to organize themselves around it that inhibits management approaches? Some general considerations are outlined in this Chapter and some examples presented to illustrate the various levels of complexity that apply and to indicate the need for certain styles of regulation.

---

* This Chapter draws upon the summary and conclusions of the joint UNDESA/ISET Publication *Groundwater and Society: Resources, Tensions and Opportunities. Themes in Groundwater Management for the 21st Century*, due for publication in 1999 with principal authors Marcus Moench, Jacob Burke and Claude Sauveplane. This source text should be referred to for its presentation of evidence, case studies and full bibliography.

** Jacob Burke and Claude Sauveplane are Technical Advisers, Groundwater Resources, United Nations Department for Economic and Social Affairs (UNDESA); Marcus Moench is with the Institute for Social and Economic Transition (ISET).

THE ROLE OF GROUNDWATER IN SOCIETY

For several thousands of years groundwater has provided a uniquely reliable source of high quality water for human use. Surface seeps and springs have always been a treasured source of potable water, even in humid environments.

In contemporary settings, groundwater is an important input to economic activity and social well being through the range of extractive and *in situ* services (including environmental services) it provides by virtue of its circulation in aquifer systems and its general ubiquity. Reliable water supplies, directly or indirectly derived from groundwater, carry a special premium since the reliability is a key parameter influencing the sustainability of essential activities. As the reliability of water supplies declines, risks for users dependent on it increase. From small investment decisions by poor farmers regarding the purchase of fertilizer or seeds to major investments by companies or governments, economic returns (and in some cases survival) depend on whether or not water is available when needed. In many areas, the assurance provided by groundwater is a key foundation for socioeconomic development.

While it is essential to recognize the role groundwater plays as a basis for socioeconomic development, it is equally important to recognize that its uses have negative impacts upon the resource base. Most uses of groundwater are consumptive or involve a degradation of water quality when returned to the system of shallow groundwater circulation. The stock of groundwater is generally reduced and the subsequent quality in the all-important shallow aquifers is degraded. In the longer term, prolonged abstraction beyond the rates of recharge will involve fundamental changes to the dynamics of aquifer systems. This interdependency of uses and impacts is fundamental and should be kept in mind throughout subsequent discussions of the key services groundwater produces and the problems facing sustainable management of these resource bases.

Groundwater resource conditions directly affect the opportunities and risks people face and the environment they inhabit. Furthermore, the keys to groundwater management generally lie in the local hydrological realities and the sociocultural patterns of water use. The details of how people use groundwater are particularly important, more so than for surface water, because of the direct and intimate physical links that are developed and because of the particular administrative and institutional responses this use has invoked.

The distinction between surface water and groundwater in a socioeconomic context is deliberate. While the links between the two sources of water are very close, the management of groundwater presents a separate, and, arguably, more complex challenge. Surface waters are naturally integrated in watercourses where abstraction structures are visible and amenable to "lumpy," high profile public investment and regulation. Groundwater occurrences on the other hand, are generally exploited by a highly distributed and numerous set of low intensity investments that are not necessarily amenable to the types of economic and environmental regulation used to control surface water abstraction and use.

The broader aspects of integrated water resources management are discussed elsewhere, but even in these accounts, the discussion of groundwater management is conspicuous by its absence. Furthermore, groundwater has a number of special characteristics that are distinct from those addressed in general discussions of integrated water resources management. The advent and spread of energized pumping technologies in the 20th century has enabled rapid groundwater development and the emergence of socioeconomic systems dependent on its reliability. The development of groundwater is predicated upon the perceived advantages of groundwater and the general assumption that the resource, as with surface water systems, will be replenishable or the reserves so great that one generation's impact will be insignificant, or that depleted groundwater can be substituted by man-made capital. Development has, however, occurred without an adequate understanding of the complex and vulnerable nature of groundwater systems. Aquifer characteristics and groundwater flow properties vary laterally, vertically and temporally. These combine to create dynamic, interdependent systems that can be disrupted in ways that are difficult to predict as a result of rapid development. What is remarkable is the rate at which aquifer systems have been depleted and degraded through over-abstraction and pollution in the last 50 years. To illustrate this, figure 1 demonstrates the stages of groundwater development that have been identified in India.

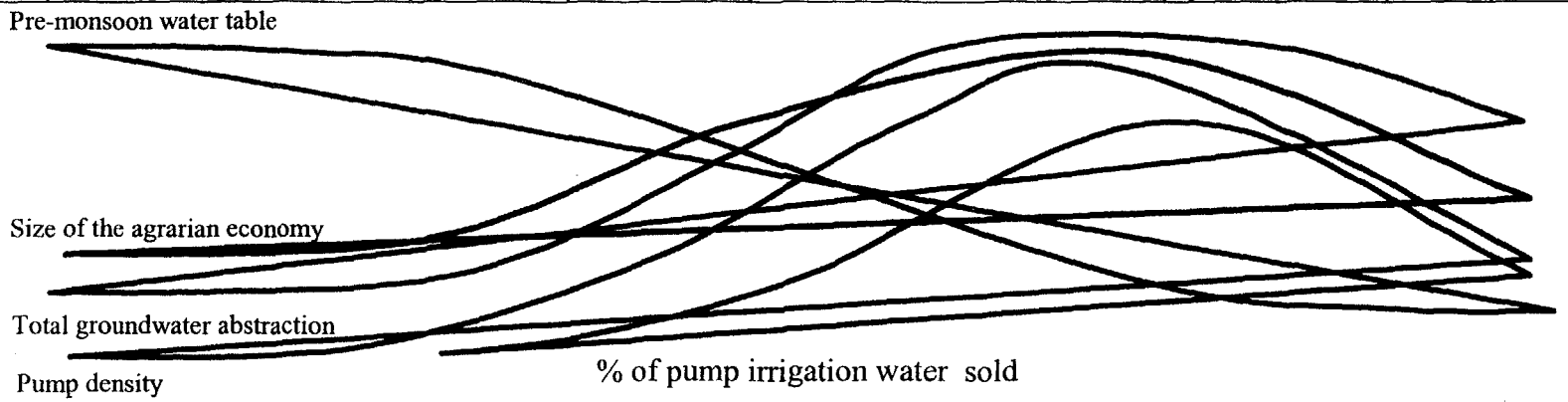
	Stage I	Stage II	Stage III	Stage IV
Stages:→	Popularization of Green Revolution and Tubewell Technologies	The Rise of the Groundwater-based Agrarian Economy	Early Symptoms of Groundwater Over-draft	Decline of Groundwater availability with impacts on local economy and quality of life.
				
Example Regions: →	North Bengal and West Bengal	• Eastern Uttar Pradesh • Western Goadavari • Central Gujarat	• Haryana • Western Uttar Pradesh • Combatore and Madurai, Tamil Nadu	• North Gujarat • Coastal Tamil Nadu • Coastal Saurashtra • South West Bengal
Characteristics→	• Subsistence agriculture • Protective Irrigation • Traditional crops • Concentrated rural poverty • Traditional water lifting devices using human and animal power	• Pump ownership skewed • Access to pump irrigation prized • Rise of primitive pump irrigation "exchange" institutions • Decline of traditional water lifting technologies • Rapid growth in agrarian income and employment	• Diversification of agrarian economy • Long-term decline in water tables • The groundwater-based "bubble economy" continues booming • Tensions between economy and ecology begin to surface as pumping costs increase and water markets become oppressive • Private and social costs of groundwater use finally part ways	• The "bubble" bursts; agricultural growth decclerates and then declines • Out migration and poverty increase. In some cases, villages are abandoned. • Water quality problems assume serious proportions. • The well-off and the "smart" began moving out long before the crisis deepened; the poor are the last to leave and the hardest hit.
Public Policies and other external Interventions:	• Targeted subsidy for pumps • Public tubewell programs • Electricity subsidies and flat tariff	• Subsidies and institutional credit for wells and pumps continue • Donors augment resources for pump capital • NGOs promote small farmer irrigation as a livelihood program	• Subsidies, credit, donor and NGO support continue • licensing, siting norms and zoning system are created but weakly enforced • Groundwater irrigators emerge as powerful vote-bank	• Subsidies, credit and donor support go • NGOs and donors emphasize conservation • Zoning restrictions begin to be enforced • Water imports begin for domestic needs • Public and NGO sponsored ameliorative action starts

Figure 1: Stages in the Rise and Decline of Groundwater Socioeconomic Systems: The Indian Experience. Source: TUSHAAR SHAH, GROUNDWATER MARKETS AND IRRIGATION DEVELOPMENT - POLITICAL ECONOMY AND PRACTICAL POLICY (1993).

Unlike surface water systems, much of this loss is irreversible and therefore much more critical. Development has occurred with little appreciation of how societies and economies organize themselves to take advantage of the opportunities groundwater presents and to respond to management needs as they emerge. Understanding the sociopolitical economy (and culture) surrounding groundwater and the management mechanisms that may apply is as important to management as understanding the physical systems. There are very few published accounts of this important aspect. Messrs. Shah[1] and Barraqué[2] discuss such issues in relation to India and Europe, but those issues apply globally. Clearly, there is a special form of engagement with the groundwater resource base, and a need for participation in groundwater management by those who have a direct interest in the resource.

Developed and developing countries alike are attempting to frame approaches to the sustainable development of their sovereign and shared water resources. In many cases the socioeconomic and hydro-environmental imperatives do not leave much room for maneuver. This is particularly true for groundwater, where expansion of agricultural production, industrial activity and, to a lesser extent, domestic water supply systems have induced unsustainable patterns of groundwater use. This Chapter argues that social, institutional and political factors are the primary obstacles to sustainable management of the world's groundwater resources. Technologies for groundwater exploration and extraction are developing all the time, together with sophisticated techniques for understanding flow dynamics within complex aquifer systems.[3] Equally, hydrogeological tools are being added to the repertoire of conjunctive use and water conservation. However, understanding the social, economic, institutional and political dimensions essential for effective management lags far behind.

---

[1] TUSHAAR SHAH, GROUNDWATER MARKETS AND IRRIGATION DEVELOPMENT – POLITICAL ECONOMY AND PRACTICAL POLICY (1993).

[2] B. Barraqué, (i) EUROWATER. WATER RIGHTS AND ADMINISTRATION IN EUROPE (EU D.G. XII Horizontal Report No. 8, 1996); (ii) LES AGENCES DE L'EAU ET LA QUESTION DU PATRIMOINE COMMUN EN FRANCE ET EN EUROPE, COMMISSARIAT GÉNÉRAL DU PLAN, SERVICE ENERGIE ENVIRONMENT/AGRICULTURE SECTEUR TERTIARE (1997); (iii) GROUNDWATER MANAGEMENT IN EUROPE: REGULATORY, ORGANISATIONAL AND INSTITUTIONAL CHANGE. HOW TO COPE WITH DEGRADING GROUNDWATER QUALITY IN EUROPE (FRN-NFR MAB-UNESCO-IHP, 1997).

[3] Current scientific research on groundwater, which now includes numerical and analytic models from petroleum reservoir engineering, is advancing knowledge regarding the physical dynamics of groundwater systems. The fundamental issues of aquifer heterogeneity are well appreciated by the authors both through practical experience and state of the art reviews of groundwater research and development. The contributions of geologists, geophysicists and sedimentologists are of fundamental importance to understanding aquifer parameters and identifying management options. The process by which this improved understanding can translate into practical groundwater management practice is one of the central concerns of this Chapter.

THE NATURE OF GROUNDWATER FLOW SYSTEMS AND AQUIFERS – PROBLEMS IN FINDING 'SOLUTIONS OF CONTINUITY'

Groundwater flow systems comprise sets of geologically defined and saturated sediment or rock. If a specific geological formation is capable of producing useable amounts of water, it is generally recognized as an aquifer. A key notion is that an aquifer system is a "...natural, continuous flow domain that converts a variable impulse (input) into a variable response (output) ...."[4] It is clear that the optimal use of groundwater from an aquifer system requires both the physical understanding of the system (boundary conditions and flow parameters) and the knowledge of the projected abstractions and uses – their magnitude and duration. All inputs (abstractions and injections) to the system will have an effect over time so that it is irresponsible to assume that management actions can be deferred.

The distinction between renewable (flux) and non-renewable (stock) groundwater resources is important since exploitation of non-renewable groundwater resources contained in aquifer systems de-coupled from contemporary recharge is already significant in both humid and arid environments. Such extensive systems are generally thicker, deeper and complex, frequently multilayered, and often faulted or intruded. They represent large volumes of groundwater that can be exploited in the form of a "mined" resource. However, given the expense of research and monitoring at depth, the stock is only known with a low degree of precision. Even when controlled depletion of non-renewable resources is carefully planned, changes in compaction (with risk of land subsidence), storage and leakage conditions require continuous re-assessment of the groundwater asset – its quantity and quality - i.e. the admissible damage to the stock needs to be treated strategically and with care. The same is true of planned recovery, particularly when sediments exposed to aerobic conditions are re-saturated. Equally, recharge processes are rarely understood or monitored to a sufficient degree of precision to enable accurate projections of aquifer replenishment to be made.

Figure 2 illustrates the general non-conformance between groundwater flow domains and the essentially "public" domains in which decisions are made about the allocation and protection of groundwater.

---

[4] Claude Sauveplane, Analytical Modeling of Transient Flows to Wells in Complex Aquifer Systems (1987) (unpublished Ph.D. dissertation, Department of Civil Engineering and Water Resources, Edmonton, Alberta).

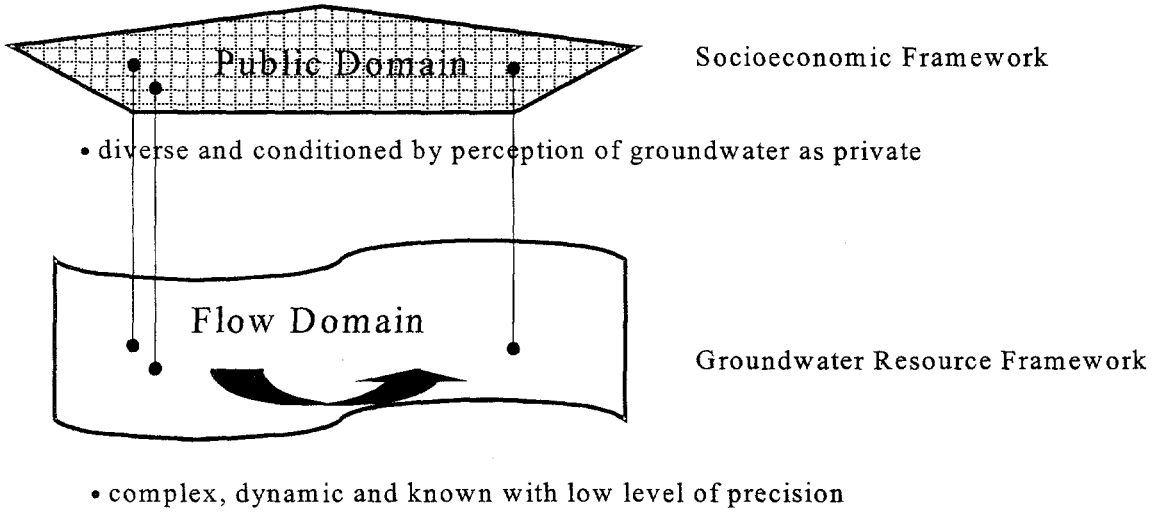


Figure 2: Physical and socioeconomic domains for groundwater

The essential feature in Figure 2 is the lack of clear, steady boundaries in the flow domain that can conform with the generally precise administrative and jurisdictional bounds in the public domain – the so called "solutions of continuity." While hydrogeologists are always seeking to define physical boundary conditions, these boundaries are, by their nature, dynamic - changing over time and space - and are not generally closely monitored. Therefore, the typical "solutions of continuity" that would apply in the regulation of watercourses (catchments and basin boundaries) and the "natural monopoly" conditions that apply in the provision of water services from single sources, such as rivers or dams, are not easily validated for aquifer systems and their multiplicity of users. Equally, if the effects of all groundwater abstractions fell within accepted and precise administrative solutions (for example "rules of capture" related to property boundaries) there would be no problem, but this circumstance can rarely be proved to apply.

Therefore, finding a degree of acceptance and precision in this manifestly confusing arrangement requires establishment of both an appropriate resource framework and the overarching socioeconomic framework. Linkages between the two frameworks can be identified and groundwater management strategies developed on this understanding. Equally, it should be possible to examine the scope for regulation of economic and environmental externalities within this integrated perspective. As will be argued later in this Chapter, the understanding of the resource framework is generally accepted, but the relevance of compatible socioeconomic frameworks that relate specifically to the variability of groundwater resources is rarely appreciated. Under such complex management conditions, the ability to integrate the physical and socioeconomic frameworks and the need for flexibility in applying management options are fundamental principles.

INSTRUMENTAL VALUE OF GROUNDWATER AND THE "COMMON POOL" NATURE OF THE RESOURCE BASE

The value of groundwater – as distinct from surface water sources – is enhanced by virtue of its highly distributed occurrence. This occurrence reinforces groundwater's instrumentality (its value to others) in many complex and subtle ways. In confined systems, for example, the aggregate impacts of abstraction may not necessarily be experienced by users in the immediate vicinity of the abstraction, but can be experienced at remote locations where critical changes in piezometric head conditions have been induced.

Groundwater is, in most situations, a common pool resource[5] with extremely high use value. It is also inherently vulnerable. Disposal of waste to aquifers and groundwater extraction affect neighboring users in ways that are often difficult to predict and quantify. Conditions vary greatly between locations, and data, information and understanding are often lacking or in a form that cannot be readily understood by non-specialists - who make up the bulk of the immediate users. As a result, there is little public awareness of groundwater, the benefits it confers and the limits under which it is available.

Lack of awareness and understanding of aquifer systems combined with the common pool nature of the resource perpetuates chronic under-valuation of the resource base. Because few understand the complex nature of groundwater flow and contamination, the vulnerability of the resource base to irreversible damage through unconstrained use or waste disposal is rarely appreciated. At the same time, because the groundwater resource base common to large areas can easily be tapped through wells on small individual land holdings, its condition is dependent on the actions of many users. Unless each individual can be assured that others are behaving in ways that protect the resource base, the *in situ* value of the resource to individuals is low. Finally, because the full value of the resource is rarely reflected in the costs individuals face when using services derived from groundwater, they are rarely aware of that value. As a result, individuals are often indifferent to the source of the water they are using and the natural systems to which they dispose waste.

Very few formal attempts have been made to estimate both the immediate use and *in situ* values of groundwater. Economic or legal mechanisms through which *in situ* values could be communicated to groundwater users have yet to be systematically realized. Indeed, the first major publication on the issue has only recently been published.[6] One of the reasons valuation issues are complicated is because many of the

---

[5] The term "common pool" refers to the status of groundwater as a resource to which all overlying landowners generally have access to – i.e. the resource is non-exclusive, but it is "rival." The term is not intended to reflect the legal status of groundwater (which varies greatly) as "public," "common," or "private" resource.

[6] NATIONAL RESEARCH COUNCIL, VALUING GROUNDWATER: ECONOMIC CONCEPTS AND APPROACHES, COMMITTEE ON VALUING GROUNDWATER (1997).

services provided by aquifer systems (such as base flow in rivers) depend on *in situ* system characteristics and not just the volume in storage or uses involving groundwater extraction. While there is scope for the direct use values to be documented through economic studies or communicated to users through the operation of markets, documentation of the *in situ* values associated with groundwater systems is much more complicated and these values are rarely reflected in market transactions.

It is important to recognize, however, that overdraft and water level declines typically affect the sustainability of uses that are dependent on groundwater long before the resource base itself is threatened with physical exhaustion. Many uses and environmental values depend on the depth to water – not the volumetric amount theoretically available. Depth to water affects the economics of groundwater extraction and declines can exclude the poor from access long before they exclude the rich. Water level declines can also cause wetlands and stream flows to dry up even when the total amount of groundwater stored in a given basin remains huge. In many ways, the sharpest points of competition between uses may have to do with the objectives of management, not with allocation of the volumes of water available. This consideration leads to an even stronger definition of groundwater as a form of "critical capital"[7] and further heightens groundwater's instrumentality with respect to surface water.

The development of formal water markets has been a focus of experimentation and analysis in countries such as the United States. In many other countries, however, informal markets and trading in groundwater have developed apace with the emergence of mechanized wells.[8] While these markets often at least partially reflect use values, market development has generally occurred in the absence of any regulatory or physical planning framework.[9] In many cases this is entirely understandable since the majority of groundwater abstraction points are privately owned and furnish private services with any surplus transacted on the margin. Even where emerging problems are recognized resource agencies generally lack the mandate or capacity to control use and extraction directly. These underlying factors have allowed extraction and pollution to proceed unchecked as demands grow and pumping technologies spread.

Patterns of Groundwater Use: Issues For Sustainability

A large proportion of the world's population relies on groundwater as a primary source of supply for drinking and domestic uses. Indirectly and often unknowingly, their survival depends on it as a key input for sustainable food production. Agricultural economies in arid, semi-arid and humid zones have expanded through exploitation of the

---

[7] W. R. Dobourg, *Reflections on the Meaning of Sustainable Development in the Water Sector*, 21(3) NATURAL RESOURCES FORUM 191 (1997).

[8] SHAH, *supra* note 1.

[9] Miguel Solanes, *Institutional and Legal Issues Relevant to the Implementation of Water Markets: Report to the Secretary-General*, Committee on Natural Resources, U.N. ESCOR, 3rd Sess., U.N. Doc. E/C.7/1996/3 (1996).

groundwater resource base. Reliance shifts to dependency in drought years when groundwater plays its critical role in buffering water supply availability. The regular replenishment of aquifers through direct recharge processes from rainfall and indirect recharge from surface watercourses and bodies is vital in sustaining shallow groundwater systems and maintaining the piezometric heads of deeper flow systems. This input is highly variable, particularly in arid and semi-arid zones where there is greater dependence upon groundwater. Direct human uses, however, comprise only a small fraction of the values dependent on groundwater. Base flows in streams, wetlands and surface vegetation are in many cases dependent on piezometric heads, and discharges. Change in those levels or changes in groundwater quality induce ripple effects through terrestrial and aquatic ecosystems. In some cases, marine ecosystems, such as those associated with submarine springs, may be supported by groundwater outflows from adjacent landmasses.

In many countries, groundwater extraction has increased exponentially with the spread of energized pumping technologies for irrigation in agriculture. In India, for example, the number of diesel and electrical pumps jumped from 87,000 in 1950 to 12.6 million in 1990.[10] Expansion of pumping technology has often resulted in dramatic declines in the water table in areas of low or zero recharge. Competition among agriculture, domestic and commercial water users over access to limited groundwater resources is growing. Perhaps more seriously, pumping changes flow patterns often resulting in migration of pollutants and low quality water into fresh aquifers. Pollution has also been caused by rapid growth in the use of agricultural chemicals and by the all too common practice of discharging untreated industrial and domestic wastewater directly into the ground. Furthermore, even minor spills of some industrial chemicals, such as organic solvents, can cause large-scale groundwater pollution. Once polluted, aquifer clean-up can be technical impossible or simply uneconomic.

Pollution and declining water levels represent direct threats to the sustainability of environmental, domestic, agricultural and industrial uses dependent on groundwater. In addition, as demands grow and the limits of sustainable extraction become evident, competition between agricultural and other users is increasing rapidly. Competition over shared aquifers between countries is also becoming apparent, but finding equitable means of allocation are hampered as much by economic asymmetry as the problems in defining hydrogeological boundary conditions – the "solutions of continuity" in the shared groundwater system flow domains. The result of these types of competition for groundwater in generally a "race to the pumphouse." Users extract as much groundwater as possible in order to maintain their rights and capture benefits for themselves before the resource is exhausted. The net result can be a spiral of growing demands and decreasing availability.

---

[10] CENTRAL GROUND WATER BOARD, MINISTRY OF WATER RESOURCES, GOVERNMENT OF INDIA, BACKGROUND NOTE, COLLOQUIUM ON STRATEGY FOR GROUND WATER DEVELOPMENT, NEW DELHI, at 9 (1996).

The proximate causes of groundwater depletion and pollution, indicated above, are rooted in population growth, economic expansion, the distorting impacts of subsidies and financial incentives, and the spread of energized pumping technologies. These immediate causes mask deeper forces. In most regions, groundwater is not an inherently scarce resource. Emerging problems relate more to management issues – use efficiency, allocation and understanding – than to the ultimate sustainability or carrying capacity of the resource base. This in no way reduces the severity of emerging problems or the impacts they can have on society and the environment. It does, however, point toward the complications society faces in organizing management responses. To be effective, approaches have to respond to the deeper factors underlying emerging problems, not just to the proximate causes.

Integration of Physical and Socioeconomic Systems

The above context suggests that emerging groundwater problems need to be addressed through integrated management approaches designed to change the way people view and use the resource. This involves an appreciation of three effective levels of integration, integration within the hydrologic cycle (the physical processes), integration across river basins and aquifers (spatial integration) and integration across the overall social and economic fabric at national and regional levels.

Aquifer systems and sub-systems are intimately connected with other portions of the overall hydrologic system and are best understood within broad physical frameworks upon which hydrologic and hydrogeologic processes are set.[11] Similarly, the patterns of groundwater uses are interconnected and often sequential. Taken together, hydrogeology and use patterns form interdependent systems linked by the way water flows through the resource base and through each use. This meshing of physical and socioeconomic frameworks is key to understanding patterns of resource use and management options. It is also often a complicating factor because the lack of congruence between natural boundaries and social or administrative/political boundaries often impedes "holistic" approaches. Again, the more opaque solutions of continuity that apply in groundwater flow domains (as opposed to the more transparent solutions in surface water systems) make the integration of groundwater into national economic and administrative frames even more challenging. In any event, there are very few instances where this type of natural resource based integration has taken place. The "Water Resource Master Plans" developed in Africa, for example, during the 1980s give some indication of the type of spatial "overview" of physical and socioeconomic systems that have been used to develop drinking water supply, sanitation and irrigation programs (e.g.

---

[11] *See*, Jacob Burke: (i) *Approaches to Integrated Water Resource Development and Management: the Kafu Basin, Zambia*, 18(3) NATURAL RESOURCES FORUM 181 (1994); and (ii) *Hydrogeological Provinces in Central Sudan: Morphostructural and Hydrogeomorphological Controls, in* T. Brown ed., GROUNDWATER AND GEOMORPHOLOGY (1996). See also, M. J. Jones, *The Weathered Zone Aquifers of the Basement Complex Areas of Africa*, 18 Q. J. ENGL. GEOL. 35 (1985).

Norconsult,1982;[12] UN DTCD, 1990[13]). The degree to which these initiatives, dependent primarily on "top-down" approaches, have been absorbed and used to drive sustainable approaches to groundwater development has been variable. More recent approaches to groundwater resource development and management have sought closer integration with local socioeconomic groupings. The *gestion des terroirs* approach in Burkina Faso and the use of public "water forums" in groundwater and surface water planning and development at sub-catchment and basin scales are cases in point.[14]

The interdependent nature of hydrologic, hydrogeologic and water use systems makes the continuum between data, information and knowledge of particular importance. Understanding systemic interactions is essential as a basis for identifying management options and generating sufficient social consensus to implement them. Developing this understanding requires a steady flow of hydrologic data and data on water use. It also requires continuous refinement of the scientific foundations, both physical and social, upon which management solutions rest. There are few examples of this type of progressive approach to groundwater information and societal needs. The UK Groundwater Forum[15] and the Groundwater Foundation in the USA represent initiatives designed to address, respectively, groundwater research needs and public education in developed countries. The Integrated Resource Planning process recently undertaken by the Metropolitan Water District of Southern California represents one of the few large scale examples where organizations have attempted to implement this type of approach in specific planning contexts.[16]

The more pressing needs for this approach, however, are in developing countries where sophisticated professional associations, well organized user groups, appropriate government agencies and information flows are often absent. Problems are particularly severe where well-organized special interests promote self-serving policies in the absence of the transparent governmental and information systems essential for other stakeholders to counterbalance their influence. The negative environmental and social impacts of rent-seeking stakeholders benefiting from privileged access to the decision-making process are poorly documented but probably pervasive. A body of experience at "catchment council" level is being built up in which basin institutions are primarily representational. Examples include Niger, Swaziland, Zimbabwe and Yemen. However,

---

[12] NATIONAL RESEARCH COUNCIL, VALUING GROUNDWATER: ECONOMIC CONCEPTS AND APPROACHES, COMMITTEE ON VALUING GROUNDWATER (1997).

[13] U.N. D.T.C.D., *Schema Directeur de Mise en Valeur des Ressources en Eau du Mali, Rapport*, MLI/84/005 (1990).

[14] *See* U.N. DDSMS/DEMSD/NREMPMB, A REVIEW OF THE ADVERSE EFFECTS OF WATER RESOURCES DEVELOPMENT AND USE ON GROUNDWATER AND AQUIFERS (1995).

[15] *See* David Grey et al., *Groundwater in the United Kingdom - A Strategy Study: Issues and Research Needs*, *in* Foundation of Water Research, Marlow, UK, GROUNDWATER FORUM REPORT FR/GF 1 (1995).

[16] *See* METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA, LOS ANGELES, INTEGRATED RESOURCES PLAN – PUBLIC PARTICIPATION, COMPREHENSIVE WATER RESOURCE MANAGEMENT STRATEGIES FOR SOUTHERN CALIFORNIA (1995).

even widespread public participation is no panacea, even in well developed settings. Hydrogeologic complexity and poor public understanding of groundwater systems has, in the case of Tuscon, Arizona, led to widespread public support for – and the implementation of – management approaches that are technically unworkable.[17]

Interdependency also makes integrated approaches to management essential. Management depends on the availability of political and socioeconomic frameworks that are capable of responding sensibly to the resource's physical structure and dynamics. Such frameworks consist of the legal, institutional, and regulatory structures that enable or obstruct different forms of organization or types of action.

Finally, it is essential to recognize the influence of economic factors. Formal and informal markets are often major mechanisms for water allocation. Prices established in these markets can encourage or discourage use efficiency. Indirect policies, such as those affecting energy prices and the prices of agricultural products, can also significantly affect groundwater use incentives. Under these circumstances it should be clear that frameworks and processes that enable integrated packages of participatory, regulatory, economic and other interventions to be developed and implemented are essential. These frameworks and structured interventions are fundamental to the sustainable development of all regions dependent, even partially, upon aquifer systems.

Variability in Resource Characteristics, Social Conditions and Management Options

Responses to emerging groundwater problems are complicated by variation in resource characteristics and social conditions. Such variations limit the ability of governments or other entities to develop standardized approaches to management. The socioeconomic circumstances that condition the levels and patterns of the demand for groundwater abstraction and the subsequent level and pattern of the disposal of waste water exhibit highly localized variability. It might be argued that this is no more the case for groundwater as it is for surface water. Surface waters are naturally integrated at specific points, however, where "solutions of continuity" an be applied and from which conditions of "natural monopoly" are expected. Consequently, it could be argued that water management has, in general, been more comfortable with dealing with surface water than with groundwater.

Three types of variation have major implications for groundwater management: climatic, hydrogeologic, and social.

Natural variation in climatic conditions is fundamental since precipitation characteristics greatly influence management options for renewable groundwater resources. The propensity of aquifers to be replenished by direct recharge from rainfall

---

[17] L. G. Wilson et al., *Hydrogeologic Uncertainties and Policy Implications: The Water Consumer Protection Act of Tucson Arizona, USA*, 6 HYDROGEOLOGY JOURNAL 3 (1998).

and indirect recharge from runoff, depends heavily on the intensity and duration of precipitation events. However, in many parts of the world, estimates of the amount of water available for direct use or recharge are based on monthly or even annual averages. Management approaches need to respond to this variation by incorporating near real-time approaches to recharge assessment and systematically analyzing recharge events using piezometric fluctuations in the monitoring network.

Hydrogeologic variation relates to the great changes in groundwater resource dynamics that exist both between and within aquifer systems. It is essential to recognize, however, that the great natural variation in groundwater conditions affects actual management needs and options as well as perceptions. In many cases, variation between areas necessitates highly localized approaches to management; in other cases, regionally based approaches are sufficient. Strategic abstraction of non-renewable groundwater resources is conditioned by this hydrogeological reliability.

Social and cultural variation is often as great as hydrogeologic or climatic variation and may present even greater challenges to the development of groundwater management systems. In the United States, for example, groundwater rights systems vary greatly between States. This reflects different histories, community characteristics, traditions and water management needs. In many rural areas throughout the world, different communities use water in different ways. Pastoral groups relying on animal husbandry for their income have different sets of groundwater needs from communities engaged in irrigated agriculture. Urban areas differ from adjacent rural areas both in demographic and sociologic make up and institutional responses to water use. In rural areas, where traditional codes and customs prevail, regional institutions representing classes of water users are often weak or absent. Urban areas, in contrast, are generally served by municipal water supply organizations that represent a large class of users. In the urban case, water management initiatives may be able to draw on existing institutional structures and standard management approaches. However, aquifer pollution by human and industrial waste complicate the issues since they directly threaten water supply sources. In rural areas, similar initiatives may need to focus far more heavily on individual users and their particular engagement with their local groundwater resource base.

The different types of variation have fundamental implications for groundwater management. Institutions and approaches need to be closely tuned to local conditions. Flexibility is essential. Solutions that work in one area may be inappropriate in adjacent areas. This creates major challenges for the development of management institutions. Solutions based on models developed in pilot management areas cannot easily be replicated in other areas. Centralized approaches are often confounded by the great variation in conditions, problems and management options that characterize local areas. This reduces the ability of governments to manage groundwater resources solely through the apparatus of the state. It also emphasizes the importance of involving local communities (those who are most familiar with local conditions and most directly affected by groundwater problems) in the management of groundwater resources. This having been said, care has to be taken to ensure that all public interest matters are

invested somewhere. The participation of interest groups alone is no guarantee that wider public interest matters will be addressed since such groups invariably have a degree of self-interest.[18] There is also the need to ensure that patterns of local consumption do not impose onerous externalities on the aquifer system as a whole. This reinforces the call for clearly established and accepted management frameworks.

PUBLIC INTEREST AND GROUNDWATER: A PROBLEM OF ENGAGEMENT AND LIMITS TO REGULATION

Publicly owned and operated boreholes are the exception rather than the rule. Municipal well fields are, in general, the only easily identified public utility that can be regulated with an expectation of discernible impact. With the legacy of private use, it is difficult to identify and mobilize the public interest in relation to groundwater. Precisely who should be responsible for maintaining the public interest in the status of local aquifers, and how that interest should be implemented, are questions that are not easily answered.

The continued decline and degradation of groundwater resources would indicate that earlier initiatives to manage groundwater have been proved largely ineffective. Governments often lack the political or enforcement instruments to control groundwater use and abstraction directly. Furthermore, the complexity of aquifer systems and the large number and dispersed nature of groundwater users can limit conventional forms of regulation. Moreover, the economic assumptions that underpin them[19] may be difficult to apply. One interpretation of this apparent failure is that access to the resource is so linked with land and reliance upon common law that orderly management of the resource base – strictly as a water resource – is resisted. It is also not easy to reconcile enabling the use of the resource with an expectation that users will conserve the resource base and maintain its productive integrity. These dilemmas relate to the circumstances of the engagement with the resource – millions of highly distributed but low intensity investments – and the subsequent attempts by institutions, mandated to regulate the use of groundwater, to lock on to this diverse set of users.

What is clear is that community participation in developing groundwater management solutions needs to be widespread given the highly distributed nature of groundwater resources. Physical management options vary greatly at a local scale. Legal and institutional frameworks need to reflect this by enabling different types of community action in response to differences in physical management options and needs. The importance of participation should not reduce the role of regulatory or legal rights systems or limit the role of scientific understanding since these also govern groundwater access and use. Information, rights, regulation, participation and education all represent

---

[18] KARIN E. KEMPER, THE COST OF FREE WATER: WATER RESOURCE ALLOCATION AND USE IN THE KURU VALLEY, CEARA, NORTHEAST BRAZIL 195 (Linkoping Studies in Arts and Sciences 137, 1996).

[19] A. I. OGUS, REGULATION: LEGAL FORM AND ECONOMIC THEORY (1994).

different dimensions of a single equation. Individuals are often unwilling to participate unless regulatory or legal structures are available to control those who may be less willing to cooperate. At the same time, regulation is often resisted unless the need for it is understood and accepted and unless individuals are assured that regulatory approaches reflect fundamental rights. Frameworks for groundwater management, as a result, need to contain mechanisms that both enable regulation or legal controls over groundwater while explaining the necessity for those controls. Culture and local traditions are also important factors. In some areas these provide a sufficient basis for development of decentralized participatory institutions; in others more centralized systems are viable. But both need to respect the integrity and scale of the aquifer systems upon which they depend and accept the need for good-quality, regular information on the status of the aquifers.

Not surprisingly, monitoring groundwater use is much more difficult than monitoring the use of, for example, land or forest resources. However, the ability to monitor resource use is often critical for the development of "common pool" management institutions. Metering provides the highest level of assurance in monitoring abstraction. Large numbers of users and dispersed use locations can, however, make metering both difficult and expensive. In many countries groundwater abstraction is monitored through indirect measures – such as pump electricity consumption or the size of irrigated areas. Even these indirect measures can be problematic. In India, for example, electricity meters on agricultural pumps were eliminated in the mid-1980s due to conflicts between farmers and meter readers and metering costs. At present, most agricultural electricity consumption is not metered and there is substantial political opposition from farmers to any return to metered systems. Equally, the ability to control "free riders" is commonly emphasized in the common pool resource literature as essential for effective management. In the case of groundwater, management activities such as the adoption of efficient irrigation technologies and agreed-on reductions are often essential to address emerging problems, but ensuring that all individuals within a management area comply with management decisions of this type is not a straightforward exercise.

The difficulty with applying direct regulation, such as metering, leaves little option but to resort to indirect methods which rely on public awareness to promote conservation, curb over-abstraction and limit the returns of polluted water. All this has to happen against variable physical environments and within complex socioeconomic and sociocultural settings. Formal regulation can only be expected to be successful when the need is apparent (rapid depletion or comprehensive pollution) and at a stage when there is clarity in groundwater rights. Equally, informal mechanisms of regulation, through customary practice, may be effective enough so long as pressures for development do not accelerate significantly. In either case deciding when and how to regulate has to be done in the knowledge of users behavior. It is hard to envisage any circumstance where detailed groundwater regulation could be accepted without first explaining rights in use or understanding existing, and often well established, methods of self-regulation.

The range of fundamental socioeconomic circumstances that determine how groundwater is used and abused in practice is given in the following box. These are observations from the authors' direct experiences and serve to illustrate the practical socioeconomic conditions under which groundwater management has to be conducted.

EXAMPLES OF THE SOCIOECONOMIC "CONDITIONING" OF GROUNDWATER USE

Some contemporary examples of the socioeconomic "conditioning" of groundwater use are given here. These examples are drawn from countries not usually associated with groundwater problems but here serve to illustrate local complexity of groundwater use and the implications for the resource base, investment and the scope for regulation.

An Example of Lost Opportunities: Kafue Basin, Zambia

Despite the detailed hydrogeological work done in the 1930s, the immediate post-independence years (late 1960s and early 1970s), the Kafue basin's development is based on a very limited understanding of the basin's overall resources. It is apparent that past approaches to water resource development of the basin failed to view the basin as an integrated system with distributed inputs, outputs and storage elements set within a well defined hydrogeological framework. Water supply schemes have generally concentrated on stored surface water or run of river solutions and ignored the potential of some very prolific and ideally located aquifers. Measures to protect the open dolomitic aquifers from urban, industrial and mining pollution sources have been progressively bypassed.

The role of traditional practice: Eritrea

The Basalt plains south of Asmara are highly productive and reliant for agriculture upon aquifers for intensive seasonal irrigation and all domestic uses that are annually recharged through a combination of direct and indirect recharge mechanisms. Land is owned collectively and groundwater rights accrue to traditional landholders. When drought conditions occur, or at the end of the dry season recession, a system of well guardians and allocation goes into place to conserve the resource and allocate between irrigation use and potable use. This state of affairs is generally sustainable under current abstraction regimes, but may soon change as a result of a very active program of upstream irrigation dam construction which will significantly alter the indirect recharge regime.

The Case For Public Land: Yap and Chuuk, Federated States of Micronesia

The surface water resources in both islands have been developed to the limit, certainly with respect to mobilizing more surface water storage. The recently commercialized public utilities are going to be completely dependent upon groundwater to maintain the reliability of the reticulation system and ensure levels of service. These levels of service are critical if the utilities are to advocate cost recovery. The current statute in both States has no provision for groundwater so that common law – or customary practice - applies. In both cases all land is privately owned. The two islands have adopted two very different responses to groundwater exploitation. In the case of Yap, the prime aquifer is off-limits to the utility. The incumbent communities use a fraction of the aquifer's resource, but do not want to see a utility exploit their groundwater "heritage." In the case of Chuuk, the legacy of previous administrations (Japanese and American) did not involve any public land. Hence the utility is obliged to buy leases from private landholders for any borehole installation - $15,000 for a 30 year lease - and has no power to protect the resource.

Contrasting access to groundwater: Namibia

Namibia has no internal perennial watercourses. It therefore relies upon groundwater to provide 60% of its bulk water. This is not matched by a commensurate level of investment in groundwater research, infrastructure and development; the bulk of investment in raw water procurement has been in surface water schemes to service the central area of the country. The majority of Namibia's poor live in communal areas in the northern quarter of the country. In many communities remote from the Okavango and Cunene watercourses on the Angolan border, access to potable groundwater is marginal at best. High salinities and low transmissivities in the Kalahari sediments make development of the resource difficult, but many of Namibia's rural poor are completely dependent upon groundwater in these areas. With the exception of the municipal zones, the remaining three-quarters of the country is fenced off – owned by commercial farms and mineral companies. The country has no hydrogeological map, and the Water Act dates back to 1956. The latter continues to support a system of riparian rights in which groundwater is essentially relegated to a "private" status. An active program of decentralized groundwater supply to Namibia's poor is predicated on cost recovery while commercial farmers enjoy effectively unrestricted access to non-renewable aquifer systems for highly subsidized irrigated agriculture.

CONCLUSION

From this brief analysis and the set of examples in the Box, it can be seen that trying to exercise a measure of equity and control over abstraction and protection of the resource base continues to be thwarted by the perception and treatment of groundwater as a private resource – despite the evident common pool properties of groundwater. These perceptions are deeply rooted in custom, culture and, sometimes, law.

Arguably, the failure to anticipate the public interest in groundwater and make the appropriate policy, legislative and institutional responses has compromised the asset value of the resource to such a degree that it may be too late to do any effective regulation, in the formal sense. But would this have been a solution anyway? Collective action over local and regional groundwater resources and the willingness to place local groundwater into a public domain will become increasingly difficult as reliance shifts to dependency. Why should adjacent groundwater users trust each other not to pump or not to pollute, particularly if the impact of one individual is not discernible in terms of the aquifer as a whole? More significantly, what are the incentives for users to curb their groundwater use if the practice is highly productive and externalities are easy to hide?

The fact that the aggregate impact of a large number of groundwater abstractors and polluters is significant will always provide a rationale for intervention in the public interest on the basis of a common pool resource. Legislation may even be passed and detailed regulations formulated, but unless the mandated institutions are capable of leveraging compliance on individual users at the local level, these efforts will be wasted. In many senses, the primary challenge for groundwater institutions and agencies lies not so much in formal regulation of use, but in being able to communicate with a diverse array of groundwater users to encourage sustainable use of the resource base.

Therefore, being able to integrate the physical characteristics of the groundwater resources base across socioeconomic settings to a sufficient degree of precision and then being able to apply management options in a flexible fashion are essential principles. These may appear rather fuzzy requirements, but given the physical nature of groundwater and the diversity of sociocultural perceptions and modes of groundwater use, effective frameworks for groundwater management will need to be structured to cope with more variability and risk, not less.

BIBLIOGRAPHY

BARRAQUÉ, B., EUROWATER. WATER RIGHTS AND ADMINISTRATION IN EUROPE (EU D.G. XII Horizontal Report No. 8, 1996).

BARRAQUÉ, B., LES AGENCES DE L'EAU ET LA QUESTION DU PATRIMOINE COMMUN EN FRANCE ET EN EUROPE, COMMISSARIAT GÉNÉRAL DU PLAN, SERVICE ENERGIE ENVIRONMENT/AGRICULTURE SECTEUR TERTIARE (1997).

Barraqué, B., GROUNDWATER MANAGEMENT IN EUROPE: REGULATORY, ORGANISATIONAL AND INSTITUTIONAL CHANGE. HOW TO COPE WITH DEGRADING GROUNDWATER QUALITY IN EUROPE (FRN-NFR MAB-UNESCO-IHP, 1997).

Burke, Jacob, *Approaches to Integrated Water Resource Development and Management: the Kafu Basin, Zambia*, 18(3) NATURAL RESOURCES FORUM 181 (1994).

BURKE, JACOB, *Hydrogeological Provinces in Central Sudan: Morphostructural and Hydrogeomorphological Controls, in* A. G. Brown ed., GEOMORPHOLOGY AND GROUNDWATER (1995).

CENTRAL GROUND WATER BOARD, MINISTRY OF WATER RESOURCES, GOVERNMENT OF INDIA, BACKGROUND NOTE, COLLOQUIUM ON STRATEGY FOR GROUND WATER DEVELOPMENT, NEW DELHI (1996).

Dobourg, W. R., *Reflections on the Meaning of Sustainable Development in the Water Sector*, 21(3) NATURAL RESOURCES FORUM 191 (1997).

Grey, David et al., *Groundwater in the United Kingdom - A Strategy Study: Issues and Research Needs, in* Foundation of Water Research, Marlow, UK, GROUNDWATER FORUM REPORT FR/GF 1 (1995).

Jones, M. J., *The Weathered Zone Aquifers of the Basement Complex Areas of Africa*, 18 Q. J. ENGL. GEOL. 35 (1985).

KEMPER, KARIN E., THE COST OF FREE WATER: WATER RESOURCE ALLOCATION AND USE IN THE KURU VALLEY, CEARA, NORTHEAST BRAZIL 195 (Linkoping Studies in Arts and Sciences 137, 1996).

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA, LOS ANGELES, INTEGRATED RESOURCES PLAN – PUBLIC PARTICIPATION, COMPREHENSIVE WATER RESOURCE MANAGEMENT STRATEGIES FOR SOUTHERN CALIFORNIA (1995).

MITCHELL, B., INTEGRATED WATER MANAGEMENT: INTERNATIONAL EXPERIENCES AND PERSPECTIVES (1990).

NATIONAL RESEARCH COUNCIL, VALUING GROUNDWATER: ECONOMIC CONCEPTS AND APPROACHES, COMMITTEE ON VALUING GROUNDWATER (1997).

NORCONSULT, RUKWA WATER MASTER PLAN, VOLUME 2, WATER DEVELOPMENT ATLAS (prepared for Norwegian Agency for International Development NORAD, Oslo) (1982).

OGUS, A. I., REGULATION: LEGAL FORM AND ECONOMIC THEORY (1994).

Sauveplan, Claude, Analytical Modeling of Transient Flows to Wells in Complex Aquifer Systems (1987) (unpublished Ph.D. dissertation, Department of Civil Engineering and Water Resources, Edmonton, Alberta).

SHAH, TUSHAAR, GROUNDWATER MARKETS AND IRRIGATION DEVELOPMENT - POLITICAL ECONOMY AND PRACTICAL POLICY (1993).

Solanes, Miguel, *Institutional and Legal Issues Relevant to the Implementation of Water Markets: Report to the Secretary-General*, Committee on Natural Resources, U.N. ESCOR, 3rd Sess., U.N. Doc. E/C.7/1996/3 (1996).

U.N. DDSMS/DEMSD/NREMPMB, A REVIEW OF THE ADVERSE EFFECTS OF WATER RESOURCES DEVELOPMENT AND USE ON GROUNDWATER AND AQUIFERS (1995).

U.N. D.T.C.D., *Schema Directeur de Mise en Valeur des Ressources en Eau du Mali, Rapport*, MLI/84/005 (1990).

Wilson, L. G. et al., *Hydrogeologic Uncertainties and Policy Implications: The Water Consumer Protection Act of Tucson Arizona, USA*, 6 HYDROGEOLOGY JOURNAL 3 (1998).

WINPENNY, J., MANAGING WATER AS AN ECONOMIC RESOURCE (1994).

PART II

THE REGULATORY FRAMEWORK FOR GROUNDWATER

CHAPTER 3

National Regulations for Groundwater: Options, Issues and Best Practices

Stefano Burchi*

INTRODUCTION

Groundwater is in general a high-value resource and is especially important as a source of drinking water. In Europe, for instance, 75% of drinking water supplies come from groundwater sources, with peaks of up to 98% in Denmark. In the United States, groundwater is the source of approximately 50% of all drinking water, and 97% of that used by the rural population. Although in many countries the most important use of groundwater is for drinking water supply, in other countries or regions other uses may dominate. In Australia, for instance, groundwater accounts for only 14% of water use. However, it is an important source of irrigation water and as a water supply for livestock. In India, 50% of the water which is used in irrigation come from under the ground. Groundwater is also important in maintaining the flow of rivers (known in hydrologic parlance as "base flow") in dry periods and in contributing to the water balance of lakes and wetlands.

The sustainable management and use of groundwater resources as a source of drinking water supplies, for irrigation and for other consumptive uses as well as a supplementary source of surface river flows and of wetlands and wildlife habitats, calls for increasing attention to two major and interdependent sources of concern, namely, depletion and pollution. The former is linked to the extraction and use of groundwater, the latter to the contamination of available groundwater supplies from point and non-point (or diffuse) sources. To the extent that either or both (depletion and pollution) threaten the long-term viability of available supplies and the sustainability of their development and use and may become, as a result, the source of social tension and conflict, the legal systems have been prompted to respond with a view to defusing such tension and the potential for conflict. National regulation of groundwater extraction and use and of polluting activities has largely - but not entirely - supplanted private legal remedies available to injured plaintiffs. The comparative review and analysis of available national groundwater legislation illustrate the choice of mechanisms - regulatory and otherwise , or options, available to the lawmakers in the framing of responses to the challenges posed by groundwater depletion and pollution. The same review and analysis show at the same time emerging trends or a crystallization of best practice approaches, and disclose the issues which available options and emerging best practices raise.

---

* Senior Legal Officer, Development Law Service, FAO.

This Chapter will review and analyze national legislation believed to be representative of the available choice of mechanisms or options and illustrative of emerging best practices and attendant issues. It is worth noting that the countries whose legislation has been reviewed for the purposes of this Chapter are representative of a variety of climates - from humid England to arid Niger - and of different legal systems, notably, common law and civil law.

REGULATION OF WELL DRILLING AND OF GROUNDWATER EXTRACTION

Private Ownership of Groundwater

Traditionally and in accordance with basic principles of Roman law, groundwater has been regarded by law as the property of the owner of the land above. Countries following the Napoleonic Code tradition, as well as countries following the Anglo-Saxon Common law tradition, equally subscribe to the same principle. The Moslem tradition, instead, regards water as a public or communal commodity, a gift of God which cannot be owned. Only wells can be owned, whereby exclusive or priority user rights in the water accrue to the well-owners. Furthermore, the ownership of wells entails ownership of an area around the well in which new wells cannot be dug.[1]

Private ownership of land and of groundwater under it entails the accrual of unrestricted enjoyment and user rights, including the right to prospect on one's land for the resource, and to extract and use it, limited only by the equal rights of the neighboring landowners.[2] If conflicts erupt between adjoining landowners, the disputes are settled through formal and informal mechanisms, notably in the courts of law. Inasmuch as they apparently are meant to react to conflict, these traditional rules of groundwater ownership and use are increasingly at odds with the growing pressure on finite and fragile stocks of resources brought about by the growing demand for good-quality water from competing sectors of economic and social development and well-being. To make matters more worrisome, ever more sophisticated, potentially destructive drilling and extractive technologies have become available. Already in reaction to these threats, the American courts tried to put some fetters on the landowners" unrestricted groundwater withdrawal privileges by imposing a reasonableness requirement on groundwater extraction and use. Under the rule, the landowner is only entitled to use as much water as can be reasonably consumed on the overlying lands. Waste of water and use on non-overlying lands is prohibited. Still, the doctrine allows landowners to withdraw and use groundwater in whatever quantities they need for reasonable and beneficial purposes until the underlying groundwater supply is exhausted. It does not restrict the landowner to the use of a

---

[1] *See* generally DANTE A. CAPONERA, WATER LAWS IN MOSLEM COUNTRIES (FAO Irrigation and Drainage Paper No. 20/1, 1973).

[2] *See* STEFANO BURCHI, PREPARING NATIONAL REGULATIONS FOR WATER RESOURCES MANAGEMENT – PRINCIPLES AND PRACTICE 109 (FAO Legislative Study No. 52, 1994).

particular quantity of water nor does it guarantee the landowner that the groundwater supply under his land will be preserved from depletion by the withdrawals of others.

From Private Ownership to Regulation: Scope of Regulation

The challenge nowadays is to prevent expensive and time-consuming conflict or to minimize opportunities for it and, at the same time, to ensure that groundwater reserves are (a) directed to the uses society, or the public, value the most and (b) conserved for future use. In response to this challenge, legal systems, particularly, but not exclusively in water-short countries, have increasingly brought the digging and drilling of boreholes, the construction of wells and the extraction and use of groundwater resources under the direct control of the Government. As a result, if one wants to dig or drill bores to prospect under one's own land - or under somebody else's land - for groundwater, the Government must be first approached and a permit or authorization obtained from it, subject to terms and conditions. Groundwater pumping tests may also attract separate permit or consent requirements, as under the legislation of England and Wales.[3] Equally, if, following successful tests, one wants to construct a well and put it into production and start extracting and using groundwater, the Government must be first approached and a permit, license, concession or the like instrument obtained from it, subject to terms and conditions.

For ease of administration, regulatory restrictions and requirements tend to be relaxed in relation to the digging of bores and wells by hand and/or up to a maximum depth, and to the extraction and use of groundwater not exceeding certain volumes and/or for the abstractor's domestic and other household needs. The relaxation can consist of a total waiver of permit or other similar requirements (under the legislation of England and Wales, domestic abstractors of groundwater extracting up to 20 m^3 per day are totally exempted from requirements, with thought being given to extending the waiver to extractions for any purpose). Under the recently (end 1998) amended legislation of Niger, the extraction of groundwater for whatever purpose of use attracts simpler "declaration" requirements if the volumes which are extracted do not exceed 40 m^3 per day.

The Transition From Private Ownership to Regulation

The governmental assertion of control of groundwater prospection, extraction and use rests on the public property status accruing to groundwater from the statutory vesting of the resource in the public domain of the State (this is the approach reflected in the legislation adopted in Spain and in Italy, respectively, in 1985 and in 1994). Governmental assertion of control can also accrue from the statutory vesting in the State of superior user rights (this is the approach followed by the state of Victoria, Australia, as reflected in the Water Act of 1989). Governmental assertion can also accrue from the statutory vesting in the State of a public trust in the resources on behalf of the people, as

---

[3] The dewatering of quarries tends also to attract regulatory requirements. Requirements to this effect have been proposed for introduction in the legislation of England and Wales.

reflected in South Africa's 1998 National Water Act. Furthermore, it can also accrue from the pronouncements of the courts of law, as with the "public trust" doctrine developed by the courts in the Western United States after the declaration of the Supreme Court that the land underlying navigable waters is owned by the states. A critical issue arising in this connection is whether the former owners of groundwater are entitled to compensation from the Government for what could be construed as a taking of constitutionally protected private property rights. Court challenges on these grounds have been experienced in Arizona and New Mexico, United States, and in Spain, in reaction to legislation which vested all groundwater resources in the State and divested landowners and well owners of private ownership rights in groundwater. The challenges and the attendant compensation claims, however, have been consistently rejected by the United States courts and by the Spanish Supreme Constitutional Court alike, and the new legislation upheld, essentially on the grounds that such vesting was justified by the superior common good pursued by the legislation and that reasonable mitigating measures had been provided for in the legislation to mitigate the impact of the vesting provisions on landowners and well owners.

Main Features of Regulated Groundwater Rights

As a result of groundwater being public property - or being held by the State in trust for the public, only user (or usufructuary-type) rights accrue to the owners of overlying land - or to the developers of the resource, if other than the landowners. Such rights are granted by Government (sometimes by the courts, as in some Western states of the United States), following appraisal by Government of an application, and subject to terms and conditions. Among these, terms and conditions as to the duration of the right and as to the quantity and rate of extraction play a critical role in regulating groundwater use. Of note in regard to the former, Iowa legislation restricts the duration of groundwater extraction permits to less than ten years if the aquifer capacity is uncertain. With regard to terms and conditions regarding extraction, Arizona's groundwater regulator affirmatively limits the amount of groundwater which can be used by each class of water user. Furthermore, that state's legislation sets the maximum water duty or allotment on each farm, based upon the crops historically grown and assuming increasingly stringent measures for the efficient application of irrigation water such as lining irrigation canals and using laser leveling fields.[4]

Groundwater rights obtained from the Government (or from the courts) are granted subject to loss for non-use of the water, for failure to comply with the law in general and with the terms and conditions attached to the right in particular, or if the water needs to be re-allocated to some other use and to another user. In this particular case, however, compensation is payable to the user who is dispossessed of his water right - through no fault of his. Rights are also subject to review, and to variation or adjustment

[4] The 1980 Arizona Groundwater Management Act contains a further provision that beginning twenty years after enactment of the Act in 1980, the Department of Water Resources may reduce the highest 25 %of water duties by up to 10%.

downwards by Government if the circumstances so warrant. Also in this case, compensation is payable to the user on account of the diminution suffered in his right.[5] Rights can also be suspended as a penalty for non-compliance, or in emergencies, in neither circumstance compensation being payable for the damage the right holder may suffer.

The appraisal of an application for the grant of a groundwater extraction permit or the like instrument plays a critical role in the informed allocation by Government of available groundwater resources. The determinations of water resources plans, if available (see below), and the views and objections of affected water users and of other legitimate affected interests, will provide valuable parameters for the appraisal of applications - in addition, of course, to the data and information on record. Increasing recourse is also being made in this regard to formal Environmental Impact Assessment (EIA) requirements of applications. Under European Union legislation (Directive) adopted in 1997, from March 1999 an EIA will be required of all proposed groundwater extractions giving rise to significant environmental effects as defined in the relevant Directive. Similar requirements had been introduced in France by the 1992 Water Act in respect of water abstraction projects in general, and are being contemplated, also with regard to water abstraction projects in general, in Spain under the guise of amendments to the 1985 Water Act.

Recourse from Government's decisions on applications and on existing permits is generally available before the courts of law or the Government itself.

Regulation of Groundwater "Mining"

Where the circumstances of groundwater extraction and use result in the accelerated depletion of the resource - known also as groundwater "mining" - the legal systems tend to respond through legislation providing for the establishment of control areas or districts where stricter regulatory restrictions become applicable or where the mechanisms described above, unavailable elsewhere on account of paramount constitutional limitations, become available inside the declared areas or districts. In Texas, for instance, permitting, well spacing and setting extraction limits, all unavailable in principle due to that state's subscribing to the rule of private ownership of water by the owner of the land above, become available inside areas which have been declared Groundwater Conservation Districts. Restrictions, however, are not mandatory as most of the districts which have been established have worked to get landowners to implement conservation measures voluntarily through educational programs and by providing data on available supply, annual withdrawals, recharge, soil conditions, and waste. In Wyoming, where groundwater extraction and use are governed by prior appropriation,

---

[5] This principle, sanctioned by the 1991 Water Resources Act of England and Wales, has been the subject of a recent non-judicial test involving the Government-initiated downwards variation of a groundwater extraction license which was threatening the ecology of a river. In the event, however, the test did not address the issue of compensation.

"control areas" can be established where new applications for new groundwater extraction permits are no longer granted as a matter of course, but may be approved only after surviving a string of tests, hearings and reviews. The control area mechanism is provided for by the legislation in force in the majority of the Western states of the United States. In Spain, among several other amendments to the 1985 Water Act the Government is contemplating, one in particular provides for the declaration by the competent River Basin Authority of groundwater mining areas wherein the Authority may restrict groundwater extractions until a plan for the recovery of the aquifer is made and adopted. The plan will regulate groundwater extraction, including the replacement of individual extractions and the relevant rights, by a "communal" extraction and right.

Regulation of the Well Drilling Trade

In addition and as a complement to the digging and/or drilling of bores, the construction of wells and the extraction and use of groundwater, also the exercise of the trade of well-driller tend to attract regulatory restrictions meant to scrutinize the professional competency of the individuals performing well drilling operations. This is so in most Western states of the United States,[6] in Kenya, in The Philippines, in Oman, and in Jamaica. With a view to strengthening the provisions laying down professional licensing requirements for well drillers, New Mexico (United States) legislation[7] requires one to contract with duly licensed drillers only.

CHARGING FOR GROUNDWATER EXTRACTION AND USE

Charging for water abstraction in general, and for the extraction of groundwater in particular, seeks to influence the demand for water and constitutes the chief non-regulatory mechanism available to control water abstraction and use. It is generally practiced in combination with the regulatory mechanisms described above. In Belgium, charges are levied on the extraction of groundwater for purposes other than drinking water, with the revenue accruing to a fund for the protection of groundwaters. Belgium is one of the few countries that make no differentiation in the charge level according to the type of use: still, the charge varies according to the volume extracted. In France, water abstraction charges vary according to volume, area, location and source - with groundwater extraction being charged at 2 to 3.5 times higher than surface water abstractions. Also in Germany charge rates vary according to use and tend to be higher for groundwater extraction. In The Netherlands, a groundwater extraction charging mechanism has been in effect since 1995, with the revenue used in part to fund research into developing groundwater policy plans and the remainder paid to the Finance Ministry as part of general taxation. In England and Wales, no charges are levied on groundwater

---

[6] Such as New Mexico, where it is unlawful to drill a well without a license and the State Engineer is empowered to determine the necessary qualifications for the grant of a license.

[7] In the United States in general, regulations qualifying the exercise of the trade of well driller, and regulations making it unlawful for a contractor to contract with an unlicensed well driller, have been upheld as a legitimate exercise of the police power of Government.

extractions of 20 m^3 a day or less for agricultural purposes. All other groundwater extractions are charged and the proceeds from all water abstraction charges are used to cover the costs to the Government of performing its function of water custodian. The levels and rates of charges are set accordingly and ostensibly do not seek to influence the behavior of water abstractors. In Arizona, a tax is levied on all users of groundwater according to the volume which is consumed. The proceeds from this tax are directed to purchasing existing water rights and retiring them from use, to conducting water augmentation programs and to sponsoring research on water conservation.

CONTROLLING POLLUTION OF GROUNDWATER

From Private Law Remedies to Statutory Law

Historically, private remedies have been utilized to address water pollution in general, and groundwater pollution in particular. Tort concepts involving negligence, nuisance and strict liability have been resorted to by injured plaintiffs, in Common law and Civil law countries alike, to seek compensation for the damages suffered as a result of groundwater contamination. These remedies continue to play a role in providing redress for groundwater pollution. However, they are available only after pollution has occurred, and their successful fruition by injured plaintiffs is not without difficulty. Furthermore, it is very difficult to clean up an aquifer once it is polluted. Because of this and also of the proliferation of the sources of pollution and of their heightened pollutive potential, the legal systems virtually everywhere have been emphasizing the prevention of new pollution and the gradual abatement of existing pollution through the enactment of water pollution control legislation. With specific regard to groundwater pollution, the available legislation tends to reflect any one or any combination of the following approaches: (a) regulation of the discharging of wastewater and other wastes on and under the ground, (b) charging for these same activities and/or (c) regulation of land use. The first two are used in connection with pollution of groundwater from "point"-type sources of pollution, notably industrial outfalls and the outfalls of municipal sewerage systems. The third approach has been resorted to to address the "diffuse" pollution from underground storage facilities and from above-ground waste dumps and landfills, and to address pollution from "diffuse"-type sources, notably the runoff and drainage of pesticides- and fertilizer-laden cultivated land.

Prevention and Abatement of Point-Source Pollution

The hallmark are government permits, licenses or authorizations to discharge wastes on or under the ground, including into groundwater aquifers, subject to terms and conditions as to, notably, the composition and quality of the effluent being discharged and the treatment required prior to it being discharged of most regulatory legislation in effect. However, direct discharges into groundwaters can be forbidden outright, particularly if the discharge involves dangerous substances. A two-track system combining permits and strict prohibitions has been adopted already in 1979 by the European Union, with mandatory effect on all Union member countries. Belgium, however, has gone further and banned altogether all direct discharges into groundwaters.

Prevention and Abatement of Diffuse Pollution

Admittedly, the most insidious threat to groundwater, particularly in the long run, comes from the leakage and percolation under the ground of substances stored or handled in factories, other facilities, waste dumps or landfills; and from percolation under the ground of the runoff and drainage of cropland carrying pesticides and fertilizers. The former threat tends to attract licensing and monitoring requirements in respect of the siting of waste dumps (as, for example, under a statute adopted to this specific effect already in 1982 by Italy). A contemporary statute adopted by the Swiss Confederation restricts the siting, construction and operation of designated facilities handling liquid substances which may adversely affect water resources in general. Under such statute, the Cantons (or states of the Swiss Confederation) are to zone their respective territory into four different classes of water protection areas, calling for restrictions of increasing severity. In more recent times, under a statute - technically, an amendment to the 1959 Water Rights Act - adopted in 1997 by Austria, most landfills will require a permit under the 1959 Act. The operator must provide adequate security, in particular, he must provide for future precautionary measures. If the precautions taken prove insufficient, the Government may impose additional or other requirements. In extreme cases, the disposal of waste can be suspended temporarily or the landfill can be even closed. Furthermore, the Government may appoint a monitoring body at the expense of the license holder. The license holder must submit annual reports indicating the type, quantity and origin of wastes deposited in the preceding year and the results of his monitoring program. In Spain, among several other amendments to the 1985 Water Act being contemplated by the Government, the River Basin Authorities would be empowered to declare an area experiencing groundwater pollution or the risk of it as a "protected aquifer area." In such areas, the Authority's prior consent will be required of the siting of facilities, the extraction of inert materials or any other activity potentially impairing the quality of the water underground.

Cultivation practices have been increasingly attracting regulatory restrictions aimed at preventing, abating or minimizing pollution of groundwater from, in particular, nitrates employed in agriculture. At the end of 1991 the European Union has adopted legislation directing member States to designate nitrate-sensitive (or nitrate-vulnerable) areas,[8] and to draw up a code or codes of "good agricultural practice." Within the designated areas, the provisions of such code or codes become mandatory for the affected farmers. A delicate issue, raised by the farming community in England and Wales, has recently arisen in connection with the designation of nitrate-vulnerable areas. In a challenge before the courts of law to the designation of specific areas under the Union legislation, the farmers plaintiff have contended that it is unlawful for the Government to

[8] The Netherlands, Denmark and Germany have opted for the whole of their territories to be subject to the mandatory controls specified in the European Union legislation. In France, about one-third of the country has been classified as Nitrate Vulnerable Zone. According to some commentators, the United Kingdom has taken a more conservative approach and a much smaller area of the country than anticipated has been designated pursuant to the Union legislation.

designate an area wherein non-agricultural sources contribute to pollution from nitrates. The case is significant in that it raises two fundamental issues of environmental protection law as this has evolved in the last twenty-five years, namely, (a) the legitimacy of precautionary measures taken in conditions of scientific uncertainty; and (b) the causation link and the proper relationship between environmental protection and economic - in this case, farming - interests. In the event, the court declined to rule on the issue as it hinged on the interpretation of Union legislation and referred it to the European Court of Justice.

Outside the European Union, the application of animal manure is strictly regulated by statute in, for instance, Estonia.

OTHER MECHANISMS AND APPROACHES FOR THE CONTROLLED DEVELOPMENT, USE AND PROTECTION OF GROUNDWATER

Planning

In response to the growing concern for the long-term viability of available water resources, countries around the globe have been resorting to planning as a preferred mechanism for informed, forward-looking and participatory decision-making with regard to the management and development of water resources in general, including their protection from pollution. While the legislation regulating the water resources planning process does not provide separately for groundwater planning, the aquifer can be singled out as the basic ambit of groundwater planning, on a par with the hydrographic basin. This is so in France, for instance, where the 1992 Water Act introduced and regulated a complex water resources planning system based on General Water Plans (*Schémas directeurs d'aménagement et de gestion des eaux - SDAGE*) covering one or more basins, and on Detailed Water Plans (*Schémas d'aménagement et de gestion des eaux - SAGE*) covering one or more sub-basins or an aquifer. With specific regard to the latter, a number of *SAGE*s are under preparation, covering designated aquifers. The aim of these instruments in preparation is, in general, the reservation of good-quality groundwater to the satisfaction of the drinking water needs of the population, or the apportionment of the available groundwater to the competing user groups on a quota basis. A distinctive feature of the French water planning system is the participation of civil society in the formation and adoption of the plans. Another salient feature is the binding effect of planning determinations on governmental water abstraction and groundwater extraction permitting. In other words, if a groundwater extraction permit is granted by Government which is at variance with the determinations of a *SAGE* or also of a *SDAGE*, it can be challenged in the courts of law and quashed. This has actually been done in connection with the grant of a permit for the extraction of groundwater for industrial use from an aquifer which the relevant *SDAGE* (for the Seine-Normandie region) had reserved for drinking water use. The decision was quashed by the court and the permit withdrawn. As a French commentator has put it, the planning instruments available under the French legislation constitute the "best tool for the conservation and protection of aquifers which is available under French law."

Also in Texas, legislation passed in 1997 instituted a complex water planning system at regional and at the state level and gave the planning determinations a binding effect which they did not use to have under previous legislation. As a result, actions by, among others, the Groundwater Conservation Districts must conform to the adopted plans. However, as noted earlier, the regulatory authority of such Districts - and of Government outside such Districts - in relation to groundwater extraction and use is severely restricted by the prevailing Common law rule of capture. As a result, the impact of planning determinations on the allocative decisions made by the landowners is speculative at best.

Users' Participation in Decision-Making

The participation of concerned water users in the making of decisions which affect them is widely seen and practiced as an effective vehicle to build support for, and eventual compliance with, unpopular decisions. The water resources planning mechanisms and processes briefly recalled above all provide ample opportunities for water users' participation in the formation and adoption of plans, directly and through their elected representatives to the committees tasked accordingly. Under the 1997 Texas legislation, Regional Water Planning Groups consisting of, among others, representatives of a wide variety of water users' categories, are to prepare and submit to the state Government a Regional Water Plan for their area. In the French water planning system, the *SAGE*s are formed and adopted by an *ad hoc* Local Water Commission, one-fourth of whose members consist of representatives of water users. Water users participate also in the adoption of the *SDAGE*s through their one-third share in the membership structure of the Basin Committees (*Comités de bassin*).

Users' participation is further fostered by legislation governing the direct involvement of water users in the management of groundwater resources in areas which experience particular problems, notably, accelerated groundwater depletion and/or severe groundwater pollution. In Texas, Groundwater Conservation Districts, traditionally formed on petition and vote by affected property owners, tend now to be formed also at Government's instigation of a property owners' election to create a district in so-called "critical areas", i.e. areas experiencing overdraft, insufficient supply, or contamination, based on studies conducted by Government. As noted earlier, whereas these Districts have varied powers including permitting, well spacing and setting the amount of withdrawals, most of them have deferred to the rule of capture and have not imposed mandatory restrictions on the affected landowners' rights to pump and on the amount of water extracted. Most have opted, as a result, for voluntary self-restraint and educational programs. In Spain, the proposed amendments to the 1985 Water Act mentioned earlier provide, among others, for the compulsory formation of Water Users' Groups from among the users of an aquifer, in particular when the aquifer is, or is at risk of becoming, overexploited. These groups are to share in the groundwater management responsibilities of the River Basin Authorities and, in particular, in the management and policing of groundwater extraction rights.

Conjunctive Use of Surface and Groundwater Resources

The term "conjunctive use" of surface and groundwater has several different meanings but basically stands for maximizing the beneficial use and economic benefits of both surface water and groundwater through coordinated use. Methods include augmentation of supplies, allocation of costs, groundwater recharge and storage of surface water, and the coordination of rights reflecting the interconnection between the two kinds of sources.

The western states of the United States apply the rule of prior appropriation to interconnected surface and groundwater. As a result, priorities of rights to the use of interconnected waters are correlated and subject to a single set of priorities that encompasses the whole common water supply. In practice, (a) new permits can be refused in the area, (b) permissible total withdrawals can be apportioned among appropriators, (c) junior appropriators can be restricted or curtailed in their withdrawals, (d) the extraction and use of groundwater can be subjected to a rotation system, and (e) well spacing requirements can be introduced for new wells. In Texas, under legislation passed in 1997, irrigators using groundwater can move return flows to natural surface streams and divert and use such flows further downstream, without fear of losing their water as a result of appearing to "abandon" it. A Government permit to do so is first required, and the amount of return flow available for reuse will be subject to carriage losses in transit as well as any amounts needed by existing appropriators of the return flow. In both California and Arizona, water users may store excess water underground when there is surplus flow available. The water is recharged underground subject to call or trade when needed. In addition, Arizona law allows any person to carry out groundwater recharge projects in return for groundwater recharge credits, under the likes of a groundwater "banking" mechanism. These credits may either be used by the recharger or sold to other water users. Arizona law further allows a person to deliver water directly to a farmer to be used by that farmer in lieu of water he would have pumped from under the ground (known as "in lieu recharge"). This effectively leaves in the ground water which the farmer would have pumped. The "in lieu" recharger receives groundwater credits which again can be used by the recharger or traded.

Under Jamaica's 1995 Water Act, interconnected surface and underground water resources can be dealt with as a single source of supply for the purposes of granting new abstraction licenses and curtailing existing licenses, within designated "emergency areas." The amendments being contemplated to Spain's 1985 Water Act reflect a conjunctive use approach in respect of the expanded brief of the River Basin Authorities to implement plans and programs for the integrated development of surface and groundwater resources; and in respect of the establishment of Boards for the Joint Development of Interconnected Surface and Groundwaters, with water users having a majority share in the relevant membership structure. In England and Wales, where current legislation attracts groundwater recharging within the scope of water abstraction licensing, thought is being given to de-regulation by replacing the licensing requirements with simpler and more expedient consent requirements.

CONCLUSION

The comparative analysis of groundwater legislation adopted in recent times in different countries suggests that groundwater is fast losing the intense private property connotation it has traditionally had and, that user rights in it no longer accrue from ownership of overlying land but from a grant of the Government or of the courts. The public domain status of groundwater underpins the usufructuary nature of individual groundwater rights and the authority of the Government to grant such rights. Vested private property rights in groundwater need to be accommodated by new legislation, with the available case law suggesting that compensation claims are most unlikely to succeed. Regulated rights in groundwater provide the regulator with the flexibility needed to adjust allocation patterns to changing circumstances, to restrain the mining of groundwater and to practice the conjunctive use of surface and underground water, without detracting from the security of tenure which is desirable for investment decisions.

Control of wastewater discharging on or under the ground, and control of land use practices are the keys to preserving the quality of groundwater from degradation – and the available stocks from irreversible total loss. Groundwater planning mechanisms and users' participation in decision-making play a key role in the success of legislation and, in particular, in reconciling the diversity of circumstances in the field with the uniformity of legislative provisions. In the last analysis, groundwater legislation need not be seen as solely prescriptive or restrictive of individual behavior – or purely regulatory in scope. Not only can it, as a complement to regulating, seek to influence the behavior of groundwater users through non-regulatory measures, notably charging. Legislation can also be enabling in scope and purpose, i.e., it can aim at regulation and other measures in incremental fashion and provide for the building blocks of such incremental approach, notably, (a) the assessment of the resource and planning its development, conservation and protection from pollution; (b) the provision of stand-by authority for the Government to experiment with designated regulatory and non-regulatory mechanisms as and where the circumstances so require; and (c) the participation of groundwater users in the making, implementation, administration and policing of regulatory and non-regulatory decisions.

BIBILOGRAPHY

BURCHI, STEFANO, PREPARING NATIONAL REGULATIONS FOR WATER RESOURCES MANAGEMENT – PRINCIPLES AND PRACTICE 109 (FAO Legislative Study No. 52, 1994).

CAPONERA, DANTE A., WATER LAWS IN MOSLEM COUNTRIES (FAO Irrigation and Drainage Paper No. 20/1, 1973).

CAPONERA, DANTE A., WATER LAWS IN MOSLEM COUNTRIES (FAO Irrigation and Drainage Paper No. 20/2, 1978).

DEVELOPMENT LAW SERVICE, FAO, ISSUES IN WATER LAW REFORM (FAO Legislative Study No. 67, 1999).

TECLAFF, LUDWIK A., WATER LAW IN HISTORICAL PERSPECTIVE (1985).

CHAPTER 4

Institutional And Legal Issues Relevant to the Implementation of Water Markets

Miguel Solanes*

INTRODUCTION

Although modern legislation has considerably broadened the type and scope of issues to be considered in the regulation of water resources, there is concern with improved water allocation through water marketing. Some authorities have, however, indicated that marketing must be regulated to prevent unwanted environmental and social effects. It has also been noticed that the performance of water markets is contingent to the situation of each particular place.

While water legislation and water management are influenced by the need to improve the economic efficiency of water allocation and use, the processes for improved allocation take place within environmental and social frameworks where market failures and externalities are common. This is best exemplified by two contemporary trends in water management: development of water markets on the one hand, and need for water planning and control of externalities on the other. Both are needed. Thus, economic flexibility may require accommodation with the environmental requirements and social concerns posed by sustainable development.

STRUCTURAL AND REGULATORY NORMS IN WATER LEGISLATION

Because water is a public flow resource, a scarce one, and also prone to negative externalities, proper management of water- and of water related activities - are crucial to the implementation of successful and sustainable processes of water development and conservation.[1]

However, the role of institutional and legal arrangements is not limited to water management and regulation of water related activities. The legal-institutional design determines the framework within which the private sector is prompted to invest in water development and conservation, therefore performing a structural function of

---

* Regional Advisor, Water Legislation, United Nations Economic Commission for Latin America and the Caribbean (ECLAC). This Chapter is an updated version of an article published in the ECLAC Magazine No 59. The Chapter has specific groundwater references not included in the article.

[1] M. L. LIVINGSTON, DESIGNING WATER INSTITUTIONS: MARKET FAILURES AND INSTITUTIONAL RESPONSES 1 (1993).

socioeconomic engineering, determining the manners in which economic agents relate to economic resources.[2]

This function of the law has tremendous relevance to conservation and development goals, since consequent on its operation economic agents are prompted to invest, if economically beneficial, in water development and conservation, of their own free will and on regular basis.[3] Security and flexibility of rights are two main structural features of legislation in general, and water law in particular.

Main Structural Elements of Water Legislation

Structural elements primarily relate to ownership of water resources, legal nature and stability of rights on water, effective and beneficial use; transferability of water rights and acknowledgement and respect of uses and customary entitlements at times of incepting formal water legislation or causing other legal changes to take place.

a) Ownership of Water Resources

Most systems of water law explicitly include water within the public domain of the state, the people or the nation. This concept has traditionally been expressed by legislation stating that water belongs to the public domain, a terminology resulting from the notion that the particularities of water resources and their importance to economy and life do not allow private ownership of water as a resource.[4]

There are, however, exceptions to the terminology. A draft water law for Perú replaced the traditional terminology of public domain for the terms "national patrimony." On the meaning of this latter terminology, within the context of the French Water Law of 1992, Gazzaniga states that the use of the term "national common patrimony" did not effectively change the legal regime of the water resources of the country. Peruvian authorities argue that the draft law proposed for Perú would in fact disaffect water from the public domain.[5]

It is apparent that the term "national patrimony" does not have the same precise legal meaning as "public domain." If the intent is to include water within the public

---

[2] *Permanent Sovereignty Over Minerals and Water Resources: Report of the Secretary-General to the Committee on Natural Resources*, U.N. ESCOR, at 10, U.N. E/C.7/1993/2 (1993).

[3] WANTRUP CIRIACY, S.V, DOLLARS AND SENSE IN CONSERVATION (Circular 402, University of California, Berkely, 1951).

[4] *See* LUDWIK A. TECLAFF, U.N. DEP'T OF INT'L ECONOMIC & SOCIAL AFFAIRS, ABSTRACTION AND USE OF WATER - A COMPARISON OF LEGAL REGIMES at 16, U.N. Doc. ST/ECA/154, U.N. Sales No. E.72.II.A.10 (1972): Código Civil Argentino, Article 2340; Código Civil y Ley de Aguas de Chile, Articles 589 y 5to; Ley de Aguas de Ecuador, Article 2; Ley de Aguas de España.

[5] Jean-Louis Gazzaniga, *Loi Sur L'Eau du 3 Janvier 1992, in* ENVIRONMENT (Fascicule 610, Editions Techniques - Juris Classeurs), August 8, 1993, at 6. *See* also García Montúfar, *Ley de Tierras y Aguas: Fomentando la Inversión Privada*, EL PERUANO, Lima, Peru, June 21, 1995, at B-6.

domain of any given country it is advisable to use the traditional terminology. Otherwise, an element of uncertainty would be introduced in new legislation.

The evolution of groundwater law regarding ownership of this particular manifestation of water resources has been somehow slower than the evolution of surface water law. For centuries groundwater was owned according to the Roman principle that the owner of surface land was also the owner of the water under the ground, or percolating in the ground. This rule, also known as the "Roman Rule" and the "English Rule" did not generally survive the threats to sustainability and the externalities associated to massive groundwater development made possible by modern technology. In many countries groundwater is presently regulated, managed and controlled as public property, or invoking the police power of governments.

In the American system, several doctrines, such as prior appropriation, reasonable use, and correlative rights have been used to improve groundwater management, with a view to ensure sustainability, curb external effects and, on a more proactive vein, optimize output. Yet, the Texas system still adheres to the English rule of absolute ownership, affording limited room for legal control and as a result highly limiting liability for damages resulting from groundwater development. The result has been a system where there are serious problems, including drawdown, mining, salination, baseflow reduction and subsidence.[6]

b) Water Rights

The issue of uncertainty raised in the previous section becomes particularly relevant when creating a system of rights on water.

While in most countries water, or at least the most important water sources, belongs to the public domain, water 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. Thus, stability of water rights is an important principle in water law, which some authorities have traced back to Roman law.[7]

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 assets when assessing properties for taxation. Additionally, the stability and certainty of water rights and appurtenant uses provide recognition to existing economies and prevent the social unrest that would result

---

[6] David Todd, *Common Resources, Private Rights and Liabilities: A Case Study on Texas Groundwater Law*, 32 NAT. RESOURCES J. 263 (1992).

[7] 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; *see* DANTE A. CAPONERA, PRINCIPLES OF WATER LAW AND ADMINISTRATION: NATIONAL AND INTERNATIONAL, at 30 and 50 (1992), quoting COSTA, LE ACQUE NEL DIRITTO ROMANO 16 (1918).

from ignoring uses existing at times of changes in water legislation.[8] The traditional Roman-English rule for groundwater does not afford security. Since everybody overlaying an aquifer can abstract water, nobody's supplies enjoy long-term security. The only secure water is the water pumped. The system therefore promotes overuse.

An accepted tenet of the requirements of successful water markets is that they do not operate without stable, clearly defined, and enforceable water rights.

A water right usually is a right to use, and ownership of a water right normally means a usufructuary power, and not ownership of the corpus of water itself. In some legislation the usufructuary power can be traded.

c) 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 23rd September 1986, the Spanish law of 1985, the new Mexican water law of 1992, the legislation of most Argentinean provinces, and the laws of the states of the American West.

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."[9]

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 misused (reasonable efficiency); (d) the use must to be reasonable as compared against 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 monopoly on a single

---

[8] U. S. Supreme Court, *Syllabus and Opinions*, No. 80 (1984); Corte Suprema de Justicia de la Nacion, *La Pampa v. Mendoza*, L-195-XVIII (1987); Francoise Conac, *Land and Water Rights Issues in Irrigated Schemes in Sub-Saharan Africa: Conflicts to be Avoided* (DVWK Bulletin No. 16, 1989); Joseph W. Dellapenna, *Dual Systems, in* 1 WATER AND WATER RIGHTS 345, 366 (Robert E. Beck et al eds., 1991).

[9] Robert E. Beck, *Prevalence and Definition, in* 2 WATER AND WATER RIGHTS 83, 106 (Robert E. Beck et al eds., 1991).

individual."[10] This antimonopoly – anti-speculation concern where claimants do not have a 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, non-riparian-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 to effective and beneficial use) are becoming widely available.

Natural resources economists argue that non-use, if not penalized with forfeiture, may result in "sleeper rights" which increase uncertainty on the quantities of available waters.[11]

The Chilean experience on the issuance of non-conditioned water rights is an apparent validation of the foreboding 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 that state-owned monopolies that benefited 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 intra-marginal 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 the conditionality of their timely development...[through new projects] by existing producers or new comers.[12]

---

[10] *Id.* at 107-108.

[11] LIVINGSTON, *supra* note 1, at 8.

[12] Eduardo Bitran & Raúl Saez, *Privatization and Regulation in Chile*, Brookings Institution Conference on the Chilean Economy, Washington, DC, April 22-23, 1993, at 50-55 (1993).

Thus, the actual operation of the Chilean system appears to confirm the rationale 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.[13] 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."[14]

Furthermore, for large institutional users the incentives to sell water rights, absent the penalty of forfeiture for non-use, are minor, if compared against 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. In mature water marketing systems, such as the American West, beneficial use and forfeiture of rights for non-use have been deemed to be to incentives to transfer water rights.[15] 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.[16]

In Chile, the single known case of non-existence of this provision, 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

---

[13] LAWRENCE ANTHONY SULLIVAN, ANTITRUST, at 25, 31, and 77 (1977).

[14] MARK ARMSTRONG ET AL., REGULATORY REFORM: ECONOMIC ANALYSIS AND BRITISH EXPERIENCE, 117 and footnote 22 (1994).

[15] BONNIE COLBY SALIBA ET AL., WATER MARKETS IN THEORY AND PRACTICE: MARKET TRANSFERS, WATER VALUES, AND PUBLIC POLICY 81 (Studies in Water Policy and Management, 1987).

[16] *See* CARL BAUER, AGAINST THE CURRENT: PRIVATIZATION, MARKETS, AND THE STATE IN WATER RIGHTS, CHILE, 1979-1993 (1995): "Private bargaining and exchange cannot coordinate overlapping resources without continues State intervention, through the courts, if not through other political organs" (at 2); "...these features [of the law] stimulate speculation.....[T]hey have been favored [by supporters of the law] saying that speculation improves market operations and price signals...[T]hey deny criticisms that speculation might distort prices through unequal bargaining power or monopoly control..." (at 57); "...[T]he 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" (at 171).

would be an infringement of its property rights, which are constitutionally protected as granted.[17]

In association with the principle of beneficial use, 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 in Mexico and Spain. However, 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.

In Chile, water allocation is not related to any specific use or price. If water is available, the Government can not, according to the water law, reject an application.[18] After allocation the only possible regulation is given by the water market. A recent report states that the results of the system include: (a) a free transfer of wealth;[19] (b) present applications for water amount to 50,000 m^3/s, four times the total exploitable volumes available in the country and without any relation with reasonable foreseen national development during the next 50 years;[20] (c) the situation distorts the operation of water trade, and other markets, since water rights can be used as a deterrent to entry into some industries; (d) the results can include underinvestment and increases in prices of products such as electricity; (e) in addition, the individualistic structure of the water rights system leaves no room for planning for the medium and long term;[21] (f) long-term externalities are difficult if not impossible to control; (g) integrated basin management is limited since rivers are divided, for administrative purposes, into sections that do not represent hydrological units; h) ground and surface water are independently managed; (i) quality and quantity are not integrated and water development is not planned according to multiple use objectives, but sectorally.[22]

d) Water transfers

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

---

[17] 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 v. Dirección General de Aguas*, Jan 7, 1997.

[18] HUMBERTO PEÑA, SEMINARIO INTERNACIONAL GESTIÓN DEL RECURSO HÍDRICO: MODIFICACIONES AL CÓDIGO DE AGUAS Y SU APORTE A LA GESTIÓN DEL AGUA 7 (1996).

[19] *Id.* at 10.

[20] *Id.*

[21] *Id.* at 12.

[22] *Id.* at 15.

systems of water marketing regulate its performance in light of social, economic, and environmental considerations.

Water rights transfers are increasingly being considered as a policy alternative to encourage the optimal use of scarce water resources, through private reallocation. They are also means to postpone the development of costly new supplies. Water markets are a distinctive characteristic of water use in the American Western States. In other areas water markets are a relatively new experience.

e) Recognition of existing uses

Legislative change creates stress for existing uses and water rights. Most legislation provides for the recognition of uses and rights already existing at the time of changes in the legal framework for water allocation and management. These provisions recognize "existing economies" and prevent opposition to legal change. The procedural aspects of the process to acknowledge and recognize existing uses should be particularly careful not to affect, through difficult formalities and short forfeiture periods, the entitlements of rural and native populations.

Main Regulatory Elements

Water legislation includes a good amount of regulatory norms. They do usually address issues of water conservation, protection of water supplies, establishment of preferences and priorities, protection of water quality, technological and efficiency requirements, inception of management areas, basin management principles, monitoring of use, requirement of information, administrative rights of entry and inspection, creation and enforcement of public rights, emergency measures, registration and recording of uses and supplies and other regulatory measures.

Groundwater poses special regulatory problems, including not only the technical content of regulation but also the appropriate regulatory level. Regarding the appropriate regulatory level (national, provincial, or local-municipal), the experience in the U.S.A. is that allowing local management of state resources results on *ad hoc* approaches to groundwater issues and incoherent policy which can only be remedied by greater state direction and control over local management efforts. Local control results in overdraft, drawdown, mining, and restrictions on water exports. Management is impaired. Since aquifers are not restricted to local boundaries, the lack of a unified administrative system undermines the ability to establish safe yields.[23]

The experience seems to be common to California and Texas, where state legislatures appear to have given authority to institutions and groups, which are not largely willing or empowered to accept responsibility for groundwater management. According to some authorities, barring exceptions, Texan local groundwater districts have

---

[23] Gregory Weber, *Twenty Years of Local Groundwater Export Legislation in California: Lessons from a Patchwork Quilt*, 34 NAT. RESOURCES J. 657 (1994); Todd, *supra* note 6.

not been very successful. Special interests, limited territorial jurisdiction vis-à-vis aquifer extension, limited powers, and ignorance of technical questions by users and stakeholders are often mentioned as causes for the relative lack of success of local arrangements and special interests representations.[24] Yet, some researchers suggest that the assessment of what arrangements are working well is a judgement contingent to the power structure of specific societies. The relevant question then is who benefits from what, since "no property system will be adopted which injures interested parties who are powerful enough, through their command over economic, social and political factors to keep it from being adopted. Nor is there any sense in which it should be adopted."[25] Although this is a bleak prognosis, for a normative, value oriented, discipline such as Law, it entails a useful suggestion: if situations should be changed, lawyers and other parties involved in processes of institutional changes must look for ways to diminish the bargaining power of groups opposing to change.[26] Therefore, context analysis becomes imperative, by opposition to purely normative counseling.

Experiences in Asia confirm the importance of choosing an appropriate jurisdictional level for the implementation of groundwater management measures. Tushaar Shah notes that, absent mechanisms for collective restraint on pumping, users fail to internalize externalities affecting groundwater and are driven into socio-ecological crisis.[27] He also refers to the intractability of some of the context problems associated to local use and control of groundwater: on the one hand local enforcement is difficult, and on the other, when successful, it may end up strengthening the monopolies enjoyed by local water sellers.[28]

The vulnerability of local level arrangements in terms of regulatory capture, or overriding predominance of privileged social groups and special interests, has been documented not only in water management literature, but also in public utilities literature. This is why specialized publications on water supply and sanitation recommend that the jurisdictional level of the regulator be high enough to prevent regulatory capture.[29]

---

[24] *Id.*; L. G. Wilson et al., *Hydrogeologic Uncertainties and Policy Implications: The Water Consumer Protection Act of Tucson, Arizona, USA*, 6 HYDROGEOLOGY JOURNAL 3 (1998).

[25] Nunn, *infra* note 50, 891.

[26] *Id.*

[27] TUSHAAR SHAH, INTEGRATING WATER RESOURCES MARKETS IN SUSTAINABLE WATER RESOURCES MANAGEMENT 4 (1993).

[28] *Id.* at 6.

[29] KARIN E. KEMPER, THE COST OF FREE WATER: WATER RESOURCES ALLOCATION AND USE IN THE CURU VALLEY, CEARÁ, NORTHEAST BRAZIL 190 (Linkoping Studies in Arts and Science, 1996); Sapin Law, France, as discussed in MARIA ELENA CORRALES, 2 MODERNIZACIÓN DE LOS SERVICIOS DE AGUA POTABLE Y SANEAMIENTO EN AMERICA LATINA 38 (1997).

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, they become not only an efficient alternative, but also a necessary solution to problems of water scarcity.

The American Experience

Water markets are an important feature of the legal system of the states of the American West. A review of their experience is important to the understanding of the subject and its complexities.

In Colorado, Nevada and Utah, water rights can be sold and bought separately from land. In other states, like Arizona, water is acquired as an appurtenance to land. Reallocation of water rights may be "with the possible exception of water quality...the most pressing matter facing the arid West."[30]

For a reallocation to be legally valid, some requirements must be fulfilled:

- water must have been beneficially used, and must continue to be beneficially used after the reallocation;
- such reallocation must not affect other users and must be in the public interest;
- in many jurisdictions, inter-basin transfers or transfer outside the area-of-origin can only take place with due consideration to local interests;
- in some jurisdictions appurtenance statutes prevent water reallocation.[31]

Marketing of water rights is a complex process, which is affected and influenced by several factors, including:

- the priority of the transacted right;
- the profile of the parties;
- geographic flexibility;
- size and economic value of the transaction;
- reliability of the marketed water right;

---

[30] Owen L. Anderson et al., *Reallocation*, in 2 WATER AND WATER RIGHTS, *supra* note 9, at 234.

[31] *Id.*

- buyer characteristics;
- volume of water transferred;
- changes in regional economies;
- system for water administration;
- availability of infrastructure to effect a change;
- environmental impacts.[32]

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 for 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." Therefore, according to some authorities, oversight and regulatory approval for water transfers and markets is required.[33]

Regulation of Water Markets in the American System[34]

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. Broadly stated, regulations impinging on the marketing process include:

- the appurtenancy 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;
- transfers to be approved by judicial, legislative or administrative authorities (the approving authority varies according to the law of each state);
- 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);

---

[32] Bonnie G. Colby et al., *Water Rights Transactions: Market Values and Price Dispersion*, 29 WATER RESOURCES RESEARCH 1565 (1993).

[33] Helen M. Ingram et al., *The Trust Doctrine and Community Values in Water*, III. World Conference on Water Law and Administration, Alicante, Valencia, Spain, at 10-11 (1989).

[34] *See* generally Owen L. Anderson et al., *supra* note 30, at 234.

- administrative recording of the transfer and filling with the authority for water management;
- issuance of permits to reallocate and use subject to existing or new conditionalities, including proof of completion of work and beneficial use;
- forfeiture of water right, (and in some states charges for misdemeanor), if prior approval is not obtained;
- limitation of transferable entitlement to historic consumptive use;
- requirement that transfer does not injure other appropriators who, even if juniors, 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;
- accommodation of uses through conditions intended to mitigate or prevent injury;
- 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 might include:

- considering the benefit to the applicant;
- effects of the economic activity resulting from the application;
- effects on fish and game resources and on public recreation;
- effects on public health;
- opportunity cost of the use;
- harms to other persons;
- intent and ability to use;
- effects on access to public and navigable waters;
- needs for water conservation;
- factors of local relevance.

Accordingly, a 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 judicial role, for some such means and fora should include water planning and public participation.

Additional considerations might include the assessment of the impacts that a transfer may have on the environment, the tax base or the local economy of the area of origin of the water allocation to be transferred.

South America: Chile and the 1995 Draft Water Law for Perú

Water marketing in South American countries is still incipient. In many cases there is still adherence to the appurtenance principle inherited from Spanish law and from a strong tradition of strict administrative controls. In some areas, such as the provinces of Western Argentina, the appurtenancy principle has sensibly contributed, in association with other factors, (such as subsidies unrelated to effective demand for produce, and preemption of some activities from the private sector), to the stagnation, and even regression, of regional economies.

However, there are some regional experiences of water marketing worth to be brought to the discussion.

There are laws, like the Chilean law of 1981, which authorize water transfers and marketing of water rights (Articles 6 and 21). Marketing of water rights is also endorsed by a draft water law prepared for Peru (Articles 26 to 29).

Neither the water law of Chile, nor the draft water law for Peru reflect the public interest considerations or the detailed elaboration of rules to prevent injury to third parties which characterized American water law. It has already been discussed that none of them require the effective and beneficial use of waters, a fact that in Chile has favored the formation of monopolies of water rights and hydroelectric generation.

In addition, some concepts, like historical consumptive use, have not been elaborated, either by the law of Chile, or by the draft proposal for Peru, since consumptive water rights allow the diversion, and eventual transfer of the full nominal entitlement of a water right and not only of the amount historically consumed, as in the American system.

There is already a Chilean case where water rights originally used for agriculture have been transferred to mining. The transfer has sensibly increased the stress on the water source. Mining is a permanent activity, while agriculture is mostly seasonal. Therefore, water abstractions have increased, without the change in use and without

ownership having been considered a relevant factor in order to prohibit, limit, or condition the water transfer.[35]

Both, in the Chilean law and in the Peruvian draft, the role of water administration and planning in assessing public interest elements, when dealing with water transfers, have been severely limited. The assumption is that market forces will deal with externalities and issues of public interest better than government organizations, whose role should be as limited as possible. The Chilean water market system has been promoted by experts, who advocated the merits of the Chilean system when compared to the American system.[36]

However, case studies and empirical assessments of the performance of the marketing of water rights in Chile, appear to indicate that the absence of public interest conditions in the water rights system and its limited regard for externalities might be negatively affecting the performance of water rights markets. Neither the number, nor the magnitude of transactions, or the ability of markets to solve conflicts within the overall framework of present Chilean water legislation, evidence a relevant role for markets. Conflicts appear to drag along, or to be adjudicated by third parties on account of legal, political or economic considerations, rather than being negotiated and contracted according to market rules. This inability of the market appears to be particularly so when dealing with multiple uses and users, large scale economic issues, basin management and inter-basin transfers.

Among the factors impairing or blocking the operation of markets is the absence of incentives to negotiate:

- public information and data are not widely available to every interested party and the administration;[37]
- water rights are free;
- water rights are not lost by non-use. Even if not presently used they are a store of future profits, at no risk or cost;
- Additional factors affecting the operation of market mechanisms are:
- absence of adequate infrastructure;

---

[35] Verbal information provided by Mr. Andrés Benitez, Subdirector de Aguas de Chile.

[36] Mateen Thobani, THE ECONOMIST, September 2, 1995; *see* also PAUL HOLDEN & MATEEN THOBANI, TRADABLE WATER RIGHTS - A PROPERTY RIGHTS APPROACH TO RESOLVING WATER SHORTAGES AND PROMOTING INVESTMENT (The World Bank, Policy Research Working Paper No. 1627, 1996).

[37] Actually, a good deal of data, as well as a good part of the information network were privatized with the hydroelectrical sector, and are no longer available for public consultation [according to verbal information submitted by Mr. Andrés Benítez, Vice-Director Dirección de Aguas de Chile]. Obviously, lack of good quality public information is a strong deterrent to agree on permanent solutions.

- lack of reliable records and registers;
- traditional approaches emphasizing the security of additional water, rather than the profitability of once in a time transaction;
- undervaluation of water rights.

Some of the large scale water conflicts of the country seem to confirm the view that contractual solutions (like marketing) do not work entirely well when many parties, large scale water units, and important water-based public services are involved.[38]

Water transactions other than those involved in large scale conflict-solving have also been limited. The lack of effective operation of market mechanisms has been attributed to constraints or transaction costs. In addition, the market and the legal system do not have penalties for inefficient, inadequate, or non-effective use of water rights: water rights are free of charges and there are no sanctions for lack of use (in the Western United States there is a requirement for effective and beneficial use of water; the requirement is the cornerstone of the system).

Accordingly, market incentives for water transactions may not have in fact encouraged efficiency in the use of water. The investments that have taken place may have been prompted by expected gains resulting from the yields of water use. It has been noted that increased investments in irrigation might be due to the creation of subsidies for irrigation development thorough Law 18. 450/1985. The law authorized subsidies for up to 75% of investments, for a period of eight years (Article 1). There have also been considerations on the equity aspects of the system. It has been found that the impact might have been negative, since small and medium size farmers did not have adequate information or enough resources to fully take advantage of the system. Low income farmers did not in fact benefit from the system: if they had rights, many times they lost them, because they did not know what to do to protect them; if they did not have water rights, they did not obtain new rights because they did not know what to do to obtain them.[39] The issue of distribution has been also considered by the World Bank, whose first annual Report on the environment states, referring to land, that excessive scale and maldistribution are more causes of environmental deterioration than misallocation.[40]

Groundwater Markets

Groundwater markets are utilized in different parts of the world. However, regional perceptions of their role vary. While in the United States they are seen as tools to improve efficiency in water allocation and use, in South Asia they are regarded as tools to

---

[38] ROGER FINDLEY ET AL., ENVIRONMENTAL LAW 88-89 (1992).

[39] BAUER, *supra* note 16, at 3.

[40] THE WORLD BANK, THE WORLD BANK AND THE ENVIRONMENT - FIRST ANNUAL REPORT 42 (1990).

improve access to the resource pool.[41] Thus, at least theoretically, equity would be an important consideration in South Asia. As a result of the above differences, while Western systems focus on appropriate water rights to drive water markets, South Asia relies on electricity prices and subsidies.[42]

In a curious development what is interference with free market forces in the West is a main policy tool in the East. Yet, groundwater markets in South Asia have positive efficiency and equity impacts, including, *inter alia*: improved incomes for non-well owners, appreciation of market value of lands benefiting from market water - if not from their own wells; more extensive use of existing wells, allowing economies of scale and spreading of overheads over large areas; improved labor and employment conditions and expansion of the secondary benefits of irrigation.[43]

Both, Asian and Western researchers and authorities agree that groundwater marketing is riddled with externalities and other market failures such as monopolies. In South Asia, as in Texas, groundwater is common property (in economic terms), privatized by extraction. Therefore, every landowner has an incentive to pump as much as possible, since what it is not pumped, remains only to be appropriated by someone else. Thus in some areas, Asian countries and Texas may share the same problems.

In a number of places traditional and aboriginal water users may see their uses impaired and even eliminated by modern groundwater development, without compensation. The Indian users of the Altiplano in Peru, Bolivia, Northern Argentina, and Northern Chile, see their traditional water sources dried-up by pumping by large scale farms, mines and cities. Similar problems affect traditional spring uses in Oman and Yemen. Massive and subsidized development of groundwater irrigation in Mendoza, Argentina, resulted in the drying-up of springs and brooks fed by groundwater, with ensuing environmental externalities affecting the public, and economic injury to the interests of individual users. Dug wells dry up as a result of the tubewell revolution in Asia. Unlimited pumping for marketing will obviously aggravate these situations.

Many context factors promote undesirable effects. Some of them are macrofactors, such as general subsidies and lack of effective democratic institutions. Others relate to the institutional system for water use: lack of formal rights benefiting traditional users; generalized government disregard for, and ignorance of, traditional and customary uses; lack of knowledge and information about groundwater occurrence and characteristics; deficient administration, inability to enforce groundwater legislation and water subsidies.

---

[41] SHAH, *supra* note 27, at 2.

[42] *Id.*

[43] *Id.* at 10.

Context factors such as availability of rural electrification, feudal social structures, and taboos on water selling also affect the operation of groundwater markets.[44] Context factors do also inform the role and functions of water markets. Therefore, in South Asia a water sale may not be a purely economic transaction, but also an opportunity for leverage to secure more land or labor at times of peak demand.[45] Thus, in some traditional societies, water markets do not operate in isolation, but interlock with labor and credit markets, creating water lords with formidable concentration and ability to skim monopolistic rents by sellers. Therefore, prices have important equity dimensions.[46]

In the South Asian context it has therefore been suggested that improvements in the efficiency and equity aspects of groundwater market performance require curtailments in the monopoly power of sellers. While the means available to this end appear to be limited, the use of energy price and supply may be a main element of monopoly control policies. Thus, market behavior is a function of, and amenable to regulation by, the management of economic inputs. Therefore, considering that groundwater rights are poorly defined, that groundwater ownership is a functionally vague concept, and that law enforcement is difficult, policies to improve market functioning will be more successful relying on the engineering of the economic inputs associated to groundwater use and development than solely on legal measures. Legal measures may complement the implementation of market improvement policies, but they can not by themselves successfully cope with the effects of pervasive economic stimuli.

Contrary to common wisdom in the West, water markets in South Asia have operated without clearly defined systems of water rights. Moreover, the water sellers may have been producing water to sell, not selling the water they were using, an important requirement in American water marketing. This requirement was incepted in American law to prevent monopolies. Its absence - and the possible impossibility to enforce it if existing - in the South Asian case may contribute to explain the regional problems of monopolies.

There are peculiarities of groundwater marketing that require the regulation of some factors not normally present in surface water markets, such as drawdown externalities, well interferences, declining water tables, increasing lifts, loss of pressure, and saline intrusion. Some authorities also mention inter-temporal externalities and secondary economic effects.[47]

One important consideration in surface water markets, the restriction of transfers to volumes of water effectively used and consumed by the seller, is particularly important for groundwater management. In Copiapó, Chile, water rights previously used for

---

[44] *Id.* at 13: discussion of Orisa, Bihar and West Bengal in India.

[45] *Id.* at 15.

[46] *Id.* at 17.

[47] Griffin Ronald et al., *Water Marketing in Texas: Opportunities for Reform*, 32 NAT. RESOURCES J. 279 (1992).

agriculture were sold for mining use outside the original area of groundwater recharge. The new use does not only use more water than the original agricultural development but, by changing the place of use, raises concerns regarding the future balance of the aquifer, since past recharge flows have been altered.

In Asia, the need for strict regulation of overexploited areas has been suggested, since competitive groundwater markets relying on a common resource aggravate processes of aquifer depletion.[48] This agrees with the general proposition that, because of the public good characteristics of water and its many interdependencies, perfectly competitive markets are not feasible alternatives for water allocation processes.[49] In addition, lacking an effective and enforced system of groundwater rights, rights to groundwater in some South Asian regions operate under the rule of capture, meaning that water has to be abstracted before being sold, and thereafter it has to be conveyed, increasing costs vis-à-vis systems where water is not transferred in corpus, but as a right to use, and then abstracted where needed.

Thus, it is possible to identify two different modalities of groundwater marketing: selling or rather leasing the operations of a well and conveyance facilities to capture and transfer a portion of a common pool good; and selling a right to use, which the buyer uses where needed.

While water markets improve water allocation, their sustainable, efficient and equitable performance is contingent to the structural design of water rights.

Such design needs to consider at least three main features affecting groundwater use and marketing under the rule of capture - also absolute ownership - doctrine: the common pool externality, the public good nature of pumping lifts and the possibility to transfer water claims.[50]

A property right system devised to limit third-party effects can expedite the market allocation of groundwater. It requires the establishment of formal limits on the effects a third party must endure from pumping by others and on the impact that the pumper may have on the static water level. In the absence of formal limits, the commodity is not as identifiable as it can be.[51] Such limits are a function of the sustainability of the aquifer and of the aggregate impact of the different users relying on it. Additionally, design of groundwater rights and marketing systems should take into account the interconnections between surface and groundwater, to prevent interferences with surface water under the disguise of groundwater use.

---

[48] SHAH, *supra* note 27, at 8.

[49] BONNIE COLBY SALIBA ET AL., WATER MARKETS IN THEORY AND PRACTICE: MARKET TRANSFERS, WATER VALUES AND PUBLIC POLICY 31 (Studies in Water Policy and Management No. 12, 1987).

[50] Susan C. Nunn, *The Political Economy of Institutional Change: A Distribution Criterion for Acceptance of Groundwater Rules*, 25 NAT. RESOURCES J. 871 (1985).

[51] Jacque L Emel, *Groundwater Rights: Definition and Transfer*, 27 NAT. RESOURCES J. 654 (1987).

The sustainable implementation of a groundwater market requires an adequate system of water administration, aquifer knowledge and appropriate structural and regulatory design of water rights.

CONCLUSION

Water markets are a valid alternative for increasing the efficiency of water use and reallocation. Systems where water markets do not exist show structural rigidities that negatively affect the efficiency of water allocation, and also the efficient allocation of resources other than water. The areas with a strong tradition and experience in water marketing have established conditionalities aimed at preventing monopolies and protecting public and private interest. In relative terms, these areas do have strong systems of water administration where public authorities do actively intervene in water use and in the assessment of water transactions, through either administrative, judicial or legislative approvals. The experience of areas where the public interest element is missing (there is no requirement of effective and beneficial use, and regulation and planning are disregarded and discouraged), is that the role of markets has not been as relevant as assumed by the theoretical justification of the model. These areas are already showing problems of monopolization of water rights and related public utilities, and conflicts that markets have not been able to solve and which water administration are relatively impaired to address.

Water legislation should include water marketing principles, within a balanced structure where public interest elements, including the rule of effective and beneficial use, are accommodated to property protected water rights. Water markets are heavily dependent on appropriate infrastructure, to assess and evaluate available resources and to convey water from one place to another; and on appropriate administration, granting and recording of water rights, to give security to their validity, content and existence. Thus, it appears that the inception of sustainable water markets is heavily contingent upon proper water administration, hence upon a mix of private and public elements and efforts. Not the least of this constellation of factors and elements is the payment of adequate fees for water use, both to encourage efficient use and to defray the expenses of adequate administration.

While the above considerations apply to water markets generally, groundwater marketing poses special challenges. Groundwater marketing without appropriate knowledge and management of aquifers may be unsustainable, since landowners and traders exploiting aquifers for sale have every incentive to appropriate a common resource, through individual abstractions not geared to the safe yield of the source. When coupled with subsidies to pumping, the system may result in even higher rates of depletion. In some Asian countries uncontrolled groundwater abstraction and trade have been found to strengthen the monopolist power of relatively wealthier landowners/traders. In other countries they negatively affect traditional and customary water uses. In addition, market water power is used for leverage in labor and credit markets, consolidating "holdings" of economic and social influence. Uncontrolled water abstraction and trade are associated to the lack of appropriately defined and designed water rights. Traders not

having rights to a quantified stock of groundwater are not in fact marketing their share in the aquifers, but hiring pumping and conveyance facilities to access a common resource. This is so because there are no objective limits to their rights to abstract. In a normal market a transferred right diminishes the stock of units that the trader has available for future trade. In uncontrolled water markets limits to abstractions and transfers are not legal, but factual: the carrying capacity of the aquifers. Thus, reaching such limits may result in economic, ecological, and social crises.

The need for adequate regulation of groundwater markets is self-evident. The two fundamental elements in such regulation are adequate aquifer information and designing and limitation of water rights and their trade according to the quantitative and qualitative limits of the aquifers. Yet, enforcement of regulations is conditioned by prevalent socioeconomic conditions and culture. In addition, such enforcement may be unable to cope with economic incentives such as subsidies. While enforcement is generally individual and ex-post, subsidies work across the board, permanently. Thus, a policy of sustainable groundwater markets may need to start with the assessment, and eventual removal or reformulation, of subsidies. Stakeholders participation and reciprocal monitoring may assist in the process of developing sustainable water markets. Yet, in non-pluralistic, special-interests-privileged-access societies, such measures may face severe limitations, since social power is unevenly distributed. Thus, measures intended to promote the sustainable inception and development of water markets need to be based on an interdisciplinary approach coordinating legal, economic, and social analysis and tools.

BIBLIOGRAPHY

ARMSTRONG, MARK ET AL., REGULATORY REFORM: ECONOMIC ANALYSIS AND BRITISH EXPERIENCE (1994).

BAUER, CARL, AGAINST THE CURRENT: PRIVATIZATION, MARKETS, AND THE STATE IN WATER RIGHTS, CHILE, 1979-1993 (1995).

BECK, ROBERT E. ET AL. EDS., WATER AND WATER RIGHTS, Volumes 1 and 2 (1991).

Bitran, Eduardo & Saez, Raúl, *Privatization and Regulation in Chile*, Brookings Institution Conference on the Chilean Economy, Washington DC, April 22-23 1993 (1993).

CAPONERA, DANTE A., PRINCIPLES OF WATER LAW AND ADMINISTRATION: NATIONAL AND INTERNATIONAL (1992).

CORRALES, MARIA ELENA, 2 MODERNIZACIÓN DE LOS SERVICIOS DE AGUA POTABLE Y SANEAMIENTO EN AMERICA LATINA (1997).

Emel, Jacque L, *Groundwater Rights: Definition and Transfer*, 27 NAT. RESOURCES J. 654 (1987).

FINDLEY, ROGER ET AL., ENVIRONMENTAL LAW 88 (1992).

Gazzaniga, Jean-Louis,*Loi Sur L'Eau du 3 Janvier 1992* (Environment, Fascicule 610, Editions Techniques - Juris Classeurs, 1993).

Griffin Ronald et al., *Water Marketing in Texas: Opportunities for Reform*, 32 NAT. RESOURCES J. 279 (1992).

HOLDEN, PAUL & THOBANI, MATEEN, TRADABLE WATER RIGHTS - A PROPERTY RIGHTS APPROACH TO RESOLVING WATER SHORTAGES AND PROMOTING INVESTMENT (The World Bank, Policy Research Working Paper No. 1627, 1996).

KEMPER, KARIN E., THE COST OF FREE WATER: WATER RESOURCES ALLOCATION AND USE IN THE CURU VALLEY, CEARÁ, NORTHEAST BRAZIL (Linkoping Studies in Arts and Science, 1996).

LIVINGSTON, M. L., DESIGNING WATER INSTITUTIONS: MARKET FAILURES AND INSTITUTIONAL RESPONSES (1993).

Montúfar, García, *Ley de Tierras y Aguas: Fomentando la Inversión Privada*, EL PERUANO (Lima, Peru), June 21, 1995, at B-6.

Nunn, Susan C., *The Political Economy of Institutional Change: A Distribution Criterion for Acceptance of Groundwater Rules*, 25 NAT. RESOURCES J. 871 (1985).

PEÑA, HUMBERTO, SEMINARIO INTERNACIONAL GESTIÓN DEL RECURSO HÍDRICO: MODIFICACIONES AL CÓDIGO DE AGUAS Y SU APORTE A LA GESTIÓN DEL AGUA (1996).

SALIBA, BONNIE COLBY ET AL., WATER MARKETS IN THEORY AND PRACTICE: MARKET TRANSFERS, WATER VALUES, AND PUBLIC POLICY (Studies in Water Policy and Management, 1987).

SHAH, TUSHAAR, INTEGRATING WATER RESOURCES MARKETS IN SUSTAINABLE WATER RESOURCES MANAGEMENT.

SULLIVAN, LAWRENCE ANTHONY, ANTITRUST (1977).

Teclaff, Ludwik A., U.N. Dep't of Int'l Economic & Social Affairs, Abstraction and Use of Water - a Comparison of Legal Regimes, U.N. Doc. ST/ECA/154, U.N. Sales No. E.72.II.A.10 (1972).

THE WORLD BANK, THE WORLD BANK AND THE ENVIRONMENT - FIRST ANNUAL REPORT (1990).

Todd, David, *Common Resources, Private Rights and Liabilities: A Case Study on Texas Groundwater Law*, 32 NAT. RESOURCES J. 263 (1992).

Weber, Gregory, *Twenty Years of Local Groundwater Export Legislation in California: Lessons from a Patchwork Quilt*, 34 NAT. RESOURCES J. 657 (1994).

Wilson, L. G. et al., *Hydrogeologic Uncertainties and Policy Implications: The Water Consumer Protection Act of Tucson, Arizona, USA*, 6 HYDROGEOLOGY JOURNAL 3 (1998).

PART III

WORLD BANK EXPERIENCE WITH GROUNDWATER

CHAPTER 5

Mitigating Natural Groundwater Contamination in Bangladesh: Early Policy Lessons From a Development Project*

Nadim Khouri and Sarwat Chowdhury**

INTRODUCTION

Water quality dimensions are often absent in the on-going efforts to clarify, codify, and implement the policy, legal and institutional dimensions to promote groundwater use for economic and social development, particularly in the developing world. Moreover, past water and sanitation projects financed by the World Bank have rarely included a systematic consideration of groundwater quality issues. In the present Chapter, we use an on-going development project to illustrate some of the implications of groundwater quality in sustainable development, and raise some critical questions that, in our opinion, need to be addressed at the policy level to ensure the fullest contribution of groundwater to over-all human well-being and development. The purpose of this Chapter is to briefly present the issue of groundwater contamination by naturally occurring arsenic in Bangladesh. It then discusses the country's internationally-supported Bangladesh Arsenic Mitigation - Water Supply Project (BAMWSP) highlighting the strategic and investment elements of the project. Finally, based on the project's strategic directions and early lessons, we propose some priority issues to clarify the policy, legal and institutional framework of water quality. Our belief is that some of these issues require urgent attention - such as the need to immediately include and implement the systematic analysis of groundwater quality in the environmental analysis of development efforts with a groundwater component or impact.

---

* The Project design core team included Messrs. Guy Alearts, Babar Kabir and Nadim Khouri. Parts of this Chapter describing the Project and its context are largely based on two World Bank publications: The World Bank, *Bangladesh Arsenic Mitigation - Water Supply Project*, Project Appraisal Document, Report No: 18252-BD (1998); and The World Bank, *The Bangladesh Arsenic Mitigation - Water Supply Project: Addressing a Massive Public Health Crisis*, Project Brief, Rural Development/Water Supply Program (co-authored by Rebeca Robboy and the Project design core team.)

** Nadim Khouri is a Senior Natural Resources Specialist, Latin America and Caribbean Region, The World Bank; formerly with the South Asia Rural Development Sector Unit, The World Bank; Sarwat Chowdhury is a Consultant, South Asia Rural Development Sector Unit, The World Bank.

BANGLADESH'S ARSENIC CRISIS: LARGEST MASS POISONING IN HISTORY?

Beginning in the early 90s, there has been an increasing and alarming evidence of large scale contamination of Bangladesh's groundwater with naturally occurring arsenic. At present, hundreds of people are believed to be dead from long-term ingestion of arsenic, and dangerous levels of arsenic have been detected in wells over more than half of Bangladesh's districts. It is conservatively estimated that about 20 million of the country's 120 million population are presently ingesting dangerous amounts of arsenic through groundwater, the most common source of drinking water in Bangladesh. However, symptoms are hard to detect, good quality data is only now being produced, and most of the wells are yet to be analyzed. The urgent need for understanding the magnitude and processes of the arsenic contamination greatly influenced the strategy of intervention of the Government of Bangladesh and its. However, the need for early action on an emergency basis (in view of the numbers of people presently affected or potentially at risk) imposed the development of plausible hypotheses on which to build an over-all and multi-sectoral strategy of intervention. Before presenting this strategy, in the following sections, we attempt to identify some aspects of what we know about arsenic contamination in general, and the problem in Bangladesh in particular.

Arsenic is a naturally occurring element, usually found in nature in combination with other elements, mainly sulfur, carbon, hydrogen, oxygen or chlorine. Natural arsenic compounds include many different oxidation levels of arsenic, both in organic and inorganic forms. World-wide, arsenic has been associated with four primary geochemical environments: basin-fill deposits of alluvial/lacustrine origin, volcanic deposits, geothermal systems, and uranium/gold-mining areas. Arsenic as a site-specific issue has occurred in many areas including Argentina, Canada, Chile, China (Inner Mongolia), India (West Bengal and other areas), Taiwan, and USA. Evidence shows that elemental arsenic is insoluble, while the oxidized form is soluble and capable of moving into groundwater. Other geochemical factors that impact on arsenic mobility include age of deposits, presence of other elements (e.g. iron), and grain size and distribution. As for many toxic compounds, the drinking water standard for arsenic is not supported by undisputed scientific evidence. In 1999, the World Health Organization (WHO) drinking water standard for arsenic was 10 microgram per liter (or 10 parts per billion) and the United States Environmental Protection Agency (EPA) standard was five times that concentration. However, the EPA is currently revising its standard to a level expected to reach below the WHO standard. In 1999, Bangladesh's standard is the same as the EPA's, at 50 parts per billion of arsenic in drinking water.

In terms of health impacts, a healthy person usually ingests a small amount of arsenic every day through water and (principally) food (on average about 25 to 50 micrograms per day, most of it is then excreted). However, when ingested in excess, the element gradually accumulates in the human body. Depending on the levels of exposure, the presence of non-contaminated water, and the overall health/nutrition status of patients, several years of arsenic exposure can cause any of a series of health ailments that could ultimately lead to death. Possible health effects include: skin lesions (dark or white

spots), keratoses on the hands and feet, cancers of the skin, lung, kidney, liver and bladder, and other diseases that can affect, for example, the digestive, reproductive and cardiovascular systems. Finally, there are indications that child development is affected by arsenic. Up to a certain point in the development of arsenic-induced diseases, it is still possible to "decontaminate" the body by drinking arsenic free water, thus gradually purging the body of the excess arsenic. There is no medicine to treat arsenic toxicity directly, although some research is going on in this area.

In Bangladesh, the diagnosis of arsenic-induced health impacts was the first sign that something was wrong with the water supply system of some areas, both rural and urban. The use of groundwater for both irrigation and water supply had boomed in the 70s, the latter as part of a success-story of the UN International Water Decade for Water Supply and Sanitation. With external collaboration and intensive government-NGO partnerships, various efforts initiated in the Decade succeeded in shifting water supply, especially in rural areas, from surface water that was generally highly contaminated with fecal microbes to microbiologically purer groundwater. The shift to well-water in Bangladesh (presently supplying 97% of rural people's drinking water supplies) has been credited with dramatically decreasing the incidence of diarrheal diseases and cutting in half the rate of child mortality related to water-borne diseases (about 250,000 per year at the start of the Decade). Now that the unanticipated problem of arsenic contamination has surfaced, it is important to preserve those gains, and to build on the lessons learned during the Decade while preparing to confront for the first time a problem of chemical contamination of groundwater of such magnitude.

THE BANGLADESH ARSENIC WATER SUPPLY PROJECT (BAWSP): URGENT ACTION IN A SUSTAINABLE FRAMEWORK

In 1997, building on early interventions from the Government and NGOs, the World Bank, in collaboration with other external support agencies, began to assist Bangladesh in the development of an integrated approach to tackle the arsenic problem (without undoing the successes of the Water Decade). A partnership was formed grouping around Bangladesh's NGOs and Ministries of Health and Local Government; an increasingly active group of multinational agencies (UNDP, WHO, UNICEF and the World Bank); and bilateral agencies from Switzerland, the United Kingdom, The Netherlands, Denmark, Japan, and others. It was quickly decided to fund urgent studies (by UNDP and the United Kingdom principally) that would shed some light on the magnitude and science of the problem. At the same time, a decision was taken for emergency interventions (even with an incomplete set of information), so that on-the-ground alleviation could be initiated as early as possible. By 1998, the BAWSP (US$44.4 million) was designed, and signed by Bangladesh and the World Bank (US $32.4 million of IDA interest-free credits – i.e. 24,200,000 SDR, expressed in Special Drawing Rights equivalent), and the Swiss Agency for Development and Cooperation as co-financiers (US$3.0 million in grants). Additionally, a flexible framework for international collaboration promoted the participation of many external support agencies as "parallel" financiers.

The objective of the Project is to reduce mortality and morbidity, in rural and urban populations caused by arsenic contamination of Bangladesh's groundwater within sustainable strategies of water supply, health, and water management. It is seen as a first-phase, four-year effort, in what will probably be a 12- to 15-year program of support to Bangladesh. The Attachment summarizes all the components of the Project. We shall highlight here some of the main strategic choices that were made in designing the Project. First and foremost, the Project continues the two-prong approach of dealing with emergency issues while building more sustainable systems of implementation, financing, and knowledge gathering and sharing. Some of the project highlights are as follows:

Emergency actions include: (a) testing for arsenic of all wells in Bangladesh (an exercise unprecedented in magnitude in the world), beginning with the at-risk areas, founded on the increasing database currently being accumulated; (b) rapid health surveys and referral of patients to health services; and (c) provision of essential information and limited funding for alternative clean water where the water is contaminated.

Sustainable interventions are initiated in parallel with the emergency actions. They include participatory design and implementation of sustainable water supply interventions in arsenic affected areas. This component will also apply lessons learned from the Water Decade, especially in the implementation of demand-driven, community-based interventions in the rural areas. This requires intensive Project support to community mobilization, participatory planning and design of interventions, preparation of sub-projects for funding, and joint financing and implementation with the help of NGOs and government agencies. There are, at present, few (if any) low-technology and affordable solutions for the treatment of arsenic in non-piped water systems. The Project will greatly concentrate on applying any new knowledge in solving the problems of rural communities in the most integrated and effective way. Current interventions in rural areas will include alternative water sources such as rainwater harvesting, more efficient use of non-contaminated wells in the area, treated surface water (if safety can be assured), selective well drilling, and simple arsenic removal techniques as they are found effective.

In urban areas, more often than in rural areas, there is a factor of economies of scale that make some of the existing technologies directly applicable to the Bangladeshi context. In these areas, the Project will be selective and concentrate on the preparation of feasibility studies for municipalities in arsenic affected areas and will seek parallel funding from additional external sources to implement the urban sub-projects.

The integrated approach of the Project includes the provision of sanitation and other environmental interventions wherever they will improve and protect the impact of water supply interventions, especially in rural areas. The Project will also promote and reinforce the involvement of local government entities and local staff of the health and water agencies and their interaction with NGOs and local communities.

Knowledge management is being promoted by the Project through the establishment of a National Arsenic Mitigation Information Center (NAMIC) based in Dhaka, which has begun collecting, interpreting and disseminating relevant information

on various facets (including environment, technology, sociology and economy) of the arsenic problem. This is a key element in transforming Project lessons in useful policy, legal and institutional recommendations for longer term development objectives.

Research is promoted and prioritized under the Project by a local Technology Assessment Group (TAG) that reviews technology options, provides funds to local researchers, and covers all aspects of arsenic mitigation, from strictly technological to socioeconomic factors.

Capacity building and training are important elements of such a learning-intensive effort. The Project provides capacity building to communities, NGOs, central and local government staff in the many sectors involved in the arsenic problem. During the first months of Project implementation, training will be focused on community-based strategies for planning and implementation of development, as this represents the most challenging departure from the "business as usual" scenario in the Bangladeshi water sector.

In summary, this first-phase Project will deal with emergency issues and establish a set of "model" interventions that should show the way for a longer-term program of implementing participatory and sustainable water supply strategies in rural and urban areas, considering arsenic - and other quality parameters - as critical design parameters. Reaching even the short-term objectives of the current Project is fraught with risks that are discussed comprehensively in the Project Appraisal Document and summarized in the Logical Framework (Attachment) of this Chapter. Some of these risks, more directly related to policy and legal dimensions of the problem, will be presented in the third and last section of this Chapter.

EARLY LESSONS FROM BANGLADESH ON POLICY AND LEGAL ASPECTS OF GROUNDWATER QUALITY ISSUES: IS IT TIME TO BITE THE BULLET?

It is generally accepted that a key step in designing policy (and its legal framework for implementation) is to define the problem and show that there is indeed an element of public sector involvement (i.e. that the "market" will not be able to handle the problem entirely on its own.)[1] The problem of arsenic contamination in Bangladesh is only the latest (and apparently worst) example of natural chemical contamination of groundwater in the world. For example, for many years, fluoride toxicity in groundwater has been known to affect people around the world. However, such examples should not cause us to reverse the policy of promoting groundwater use for drinking purposes - a policy that has effectively saved millions of lives. Nevertheless, since these policies usually receive the support of the government, it is necessary that groundwater quality be part of the policy alternative analysis. Moreover, the means to mitigate impacts of this water quality issue should be part of the development implementation plan.

---

[1] *See*, e.g. , EDITH STOKEY & RICHARD ZECKHAUSER, A PRIMER FOR POLICY ANALYSIS (1978).

Lessons around the world point to the need to consider, wherever possible, water resources as a private good; and this would of course limit the need or requirement for the government to "guarantee" clean groundwater resources. This particular topic (water rights) would require more space than allowed in this Chapter. It is however important to specify that, whatever the level of government interventions in groundwater management, water quality concerns should not lead to more government involvement especially where the private sector can be more effective. In Bangladesh, for example, only a minority of wells are being sunk by the Government. The private sector and NGOs are extremely active, and their role will be taken fully into consideration in deciding on the distribution of responsibilities, and in internalizing the need to monitor groundwater quality.

While we continue to learn from development activities such as the BAWSP, the following specific steps are suggested, based on the above discussion, for implementation by developing countries and their partners in the development community:

- All aspects of groundwater quality should be specifically considered in the environmental impact assessment of development projects that impinge upon groundwater.

- Mechanisms for project planning and approval in government agencies and their partners in the external aid community should reflect the above interest in water quality.

- A primary responsibility of the government would be to collect and share information on water quality wherever government funding is involved.

- The above steps will require a legal and regulatory framework for effective implementation. Additionally, policy implementation will require legal definitions that can only be decided on country - or area-specific levels - e.g. what is "clean" water, how to enforce standards, how to choose between alternative policy directives with respect to groundwater use, including the definition/redefinition of water rights.

- Finally, the interaction of groundwater use for drinking water supply with other water uses (such as agriculture and industry), has a significant water quality dimension that needs to be incorporated in the overall legal framework of groundwater use due to externality factors and other market failures that necessitate selective policy and government involvement, including through legal means.

CONCLUSION

In this Chapter, we have tried to go beyond the simple presentation of the on-going Project to suggest that groundwater quality is an increasingly important issue for some specific vital reasons. First, most developing countries have drinking water policies, especially in rural areas, that favor groundwater over surface water. Second, there is a

world-wide evidence of toxic elements in groundwater, even if less harmful than water-borne diseases. Some of the legal and policy implications of this increased interest in groundwater quality were listed, starting with the need to immediately integrate groundwater quality investigations in all environmental impact assessments of development projects that have an effect on groundwater. It is also hoped that continued collaboration and exchange of information will help accelerate the use of lessons learned around the globe to formulate better tools for the safe and sustainable management of groundwater. The BAWSP can play its share in this international partnership.

BIBLIOGRAPHY

Anderson, Jonathan, *Water: A Scarce Commodity*, The WASHINGTON POST, April 17, 1999, at A11.

Bearak, Barry, *Arsenic in Drinking Water*, FRONTLINE, January 1, 1999, at 70.

STOKEY, EDITH & ZECKHAUSER, RICHARD, A PRIMER FOR POLICY ANALYSIS (1978).

The World Bank, *The Bangladesh Arsenic Mitigation - Water Supply Project: Addressing a Massive Public Health Crisis*, Project Brief, Rural Development/Water Supply Program Project Brief (co-authored by Rebecca Robboy and the Project Design Core team) (1999).

The World Bank, *People's Republic of Bangladesh, Arsenic Mitigation - Water Supply Project*, Project Appraisal Document, Report No: 18252-BD, Rural Development Sector Unit, South Asia Region (1998).

The World Bank, *Arsenic Mitigation – Water Supply Project*, Development Credit Agreement between People's Republic of Bangladesh and International Development Association, dated September 21, 1998, Credit Number 3124-BD (1998).

ATTACHMENT

Bangladesh Arsenic Mitigation -Water Supply Project: Project Design Summary

Narrative Summary	Performance Indicators	Monitoring & Supervision	Assumptions (risks)
Sector -Related Country Assistance Strategy Goals: Improve access of the poor to basic services; Improve rural infrastructure; Develop of a land/water management strategy.	Increased capacity at local level (rural villages, and towns) to plan, operate and maintain water supply and increased capacity with national service agencies to support this; Lessons learnt from the project are integrated in water resources management plans.	Statistics on water supply coverage and institutional capacity of LGD, UNICEF and RWSG-SA; Statistics on public health of MoHFW; Water management plans; CAS discussions and review.	**(From Goal to Bank Mission)** Adequate availability of good water resources; Project does not divert resources from other priority water supply programs; Institutional linkages expand between project and other water management agencies.
Development Objective: Reduce mortality and morbidity in rural and urban population caused by arsenic contamination of Bangladesh's groundwater within sustainable water supply, health and water management strategies.	1. Quantity of arsenic ingested by most of the population at risk is significantly reduced; 2. Coverage of sustainable safe water supply increased; 3. Increased percentage of treated arsenicosis patients in the project areas.	Reports and statistics of LGD, MoHFW, third-party monitoring and donor coordination, PMU and others.	**(From Development Objective to Project)** Stakeholders learn lessons from successes and mistakes of current project to continue with the long-term investment program.
Outputs: 1. Rural and urban infrastructure for water supply and sanitation and for water treatment in arsenic- affected areas. Selective emergency health and water supply interventions. Design of investment plans to expand sustainable water supply and sanitation;	1.1 Increased awareness in all arsenic-affected areas (occurrence, effect and testing); 1.2. Arsenic-free, safe, drinking water in 4,000 villages covered by the project; 1.3. Sixty-four municipalities surveyed and arsenic mitigation strategies developed for implementation; 1.4. Decrease of the time required to supply local populations with short-term supplies of safe water	1 Records of Ministry of Local Government, Rural Development and Cooperatives 2 Records of NGOs 3. Records of PMU (NAMIC)	**(From Outputs to Development Objective** 1 Health of patients affected by arsenicosis does improve with clean water 2 Use of surface water doesn't introduce other water-related diseases 3 GoB and donors remain committed 4 Community can be organized to bear O&M costs and - % of capital costs.

Narrative Summary	Performance Indicators	Monitoring & Supervision	Assumptions (risks)
	while long-term options are evaluated.		5 Emergency interventions do not undermine long-term, sustainable water-supply and sanitation
2. Sustainable water supply and treatment strategies and technologies. Description of the origin of arsenic and processes of groundwater contamination in Bangladesh and options for policy implications.	2.1. Improved knowledge of extent and origin of arsenic contamination and potential water policy implications available for participatory decision making; 2.2. Improved mechanism for data analysis and exchange; 2.3. Increase in number of options of technologies and delivery systems for water supply and sanitation in arsenic-affected areas.		6 The Project is correct in the assumed linkages in the natural/socioeconomic system of arsenic contamination.
3. Strengthened, decentralized technical and socioeconomic capacity to prepare and execute participatory and rural/urban water supply projects. Collaborative institutional framework to: (i) prioritize on-site arsenic mitigation interventions; (ii) test technologies and delivery mechanisms; and (iii) disseminate information.	3.1. Increased capacity of communities, local and central government, NGOs and the private sector in participatory planning and design, and in O&M of water supply systems; 3.2. Increased capacity of DPHE to support demand-driven and decentralized water and sanitation projects, through (i) improved skills mix, (ii) enhanced internal procurements, (iii) appropriate mandate in sector policy. 3.3. Improved cost recovery in rural and urban schemes; 3.4. Good quality annual plans produced and processed timely; 3.5. A substantial number of CBOs organized, empowered and operational; 3.6. Population in all arsenic-affected areas is		

Narrative Summary	Performance Indicators	Monitoring & Supervision	Assumptions (risks)
	aware of its occurrence, effect, and how to obtain test and mitigation advice.		
Project Components/ Subcomponents):	**Inputs: (Budget for each component)**		**(From Components to Outputs-Risks)**
1. On-Site Mitigation: Urgent health interventions; Emergency water supply; Sustainable rural water supply/sanitation; Sustainable urban water supply and sanitation; Community education and participation.	US$ 18.7 million	PMU progress reports; NGO reports; Local government reports; IDA supervision reports; Audit reports; Donor coordination reports;	Organizational capacity and internal coherence of local communities and government are effective. The empowerment of local government, CBOs and NGOs are facilitated. Number of entities involved is manageable. Partnerships and fair competition are facilitated at the local level.
2. Improved Understanding of the Arsenic Problem: Data-base on arsenic contamination, water quality, socioeconomic conditions in arsenic-affected areas; studies and research in arsenic-affected areas on: participatory planning and implementation of appropriate technology for water supply and sanitation; cost-recovery in rural and urban schemes; appropriate technology for testing and arsenic water treatment; hydrogeology and geochemistry of arsenic in groundwater; land-use/arsenic interactions.	US$4.4 million	PMU reports; research institution reports; IDA supervision reports; audit reports; donor coordination reports;	Effective collaboration of scientific institutions. Capable entities for studies and research are successfully identified. Effective network of information exchange in Bangladesh and globally.
3. Strengthening of Implementation Capacity: Capacity building in project management and subproject appraisal. Capacity building on arsenic mitigation and participatory water supply and sanitation at the levels of communities and villages, local and central	US$ 21.3 million	PMU reports; IDA supervision reports; Audit reports; Sector Policy documents; NGO documents; Donor coordination reports.	Project staffing is based on competition and merit. Key project staff who are effective are kept for at least three years. Effective coordination between entities under different Ministries.

Narrative Summary	Performance Indicators	Monitoring & Supervision	Assumptions (risks)
government, DPHE, private and government laboratories, NGOs, health workers, physicians and medical students. Monitoring and support to the implementation of Bangladesh's National Water Supply and Sanitation Sector Review.			

CHAPTER 6

Groundwater Resources Management in Jordan: Policy and Regulatory Issues

Andrew Macoun and Hazim El Naser*

INTRODUCTION

Jordan faces severe limitations of water resources availability that have become more acute with time, as population and water consumption have grown. Most water is drawn from groundwater aquifers, both renewable and nonrenewable. The water crisis that affected the national capital of Amman during the summer of 1998, when algal growth in the surface water supply forced the closure of a water treatment plant supplying Amman with 40% of its daily requirements, is just the latest manifestation of problems related to the serious water shortage facing the Kingdom. Renewable water resources have fallen below 170 m^3/person/year and the incremental cost of new urban bulk water supply to Amman has risen to exceed US$ 1/m^3 - higher even than the cost of seawater desalination because of the city's elevation and distance from available resources. Present national water use is about 1000 million cubic meters per year (MCM/yr.) - 65% for irrigated agriculture, 30% by domestic consumers and 5% industrial uses. Rainfall during the winter of 1998/99 was about 40% of normal, and dams that should be overflowing are less than half full. A drought contingency plan has been drawn up in anticipation of a particularly difficult summer, and Syria has agreed to release 8 MCM to alleviate the shortages experienced by its neighbor.

It is in the above context that the World Bank is supporting a major groundwater development project to abstract a relatively deep transboundary fossil aquifer in the south of Jordan and convey water over three hundred kilometers, and a static lift of more than half a kilometer to augment the water supply to the national capital of Amman. The interesting aspects of the Project are not engineering however. They relate to groundwater issues: the use of a non-renewable aquifer; the unsustainable mining of renewable aquifers elsewhere in Jordan; the transboundary issues related to the Qa Disi Aquifer; and the overall water resources management policies of the Government.

This case study will focus on: (a) the sources of groundwater in Jordan and measures that are being implemented to regulate the mining of renewable aquifers; and (b) the transboundary issue related to the proposed development of a large aquifer shared with the Kingdom of Saudi Arabia, including the economic and social aspects of natural capital depletion. These measures will be described within the framework of the recently

---

* Andrew Macoun is a Senior Sanitary Engineer, Rural Development, Water and Environment Group, Middle East and North Africa Region, The World Bank; Dr. Hazim El Naser is Secretary-General, Water Resources, Ministry of Water and Irrigation, Jordan.

issued Jordan Water Strategy (1997) and the Groundwater Management Policy (1998), the relevant legal and regulatory provisions, and the World Bank's Operational Policy and Bank Procedure OP 7.50 on Projects on International Waterways.

SOURCES AND USES OF WATER IN JORDAN

The schematic diagram below (Figure 1) shows the present sources and quantities of water in Jordan and the purposes for which they are utilized. The most notable features are: the substantial overdraft of the northern aquifers; the limited development of the southern non-renewable aquifer; the utilization of reclaimed wastewater; and the major irrigation water use in the Jordan Valley.

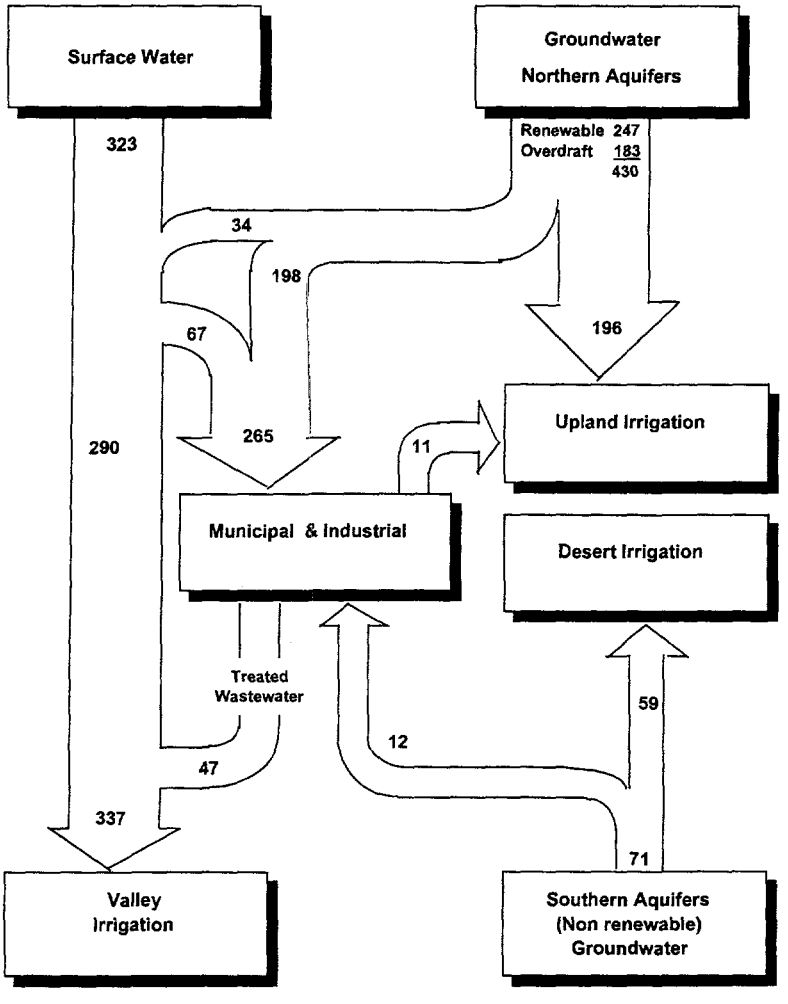


Figure 1: Indicative Sources and Uses of Water in Jordan (1995) (MCM) (Source: The World Bank, Report No. 17095-JO).

The projected picture 20 years from now (Figure 2) is expected to change significantly. How will this be done? Use of the northern aquifers will have to be reduced to sustainable limits if they are not to be completely depleted and possibly suffer irreversible damage, either by regulation or by users agreeing to a cooperative planned reduction in withdrawals; the southern fossil aquifers - both fresh and brackish - will be exploited to their economic limit to offset reductions in renewable groundwater use; wastewater reclamation and reuse will have grown and diversified substantially; and irrigated agriculture will have reached its limits. Not shown in the diagram are major improvements in water use efficiency for both irrigation and urban uses. Even with these measures achieved, a deficit amounting to 40% of projected use is foreseen with no identifiable solution.

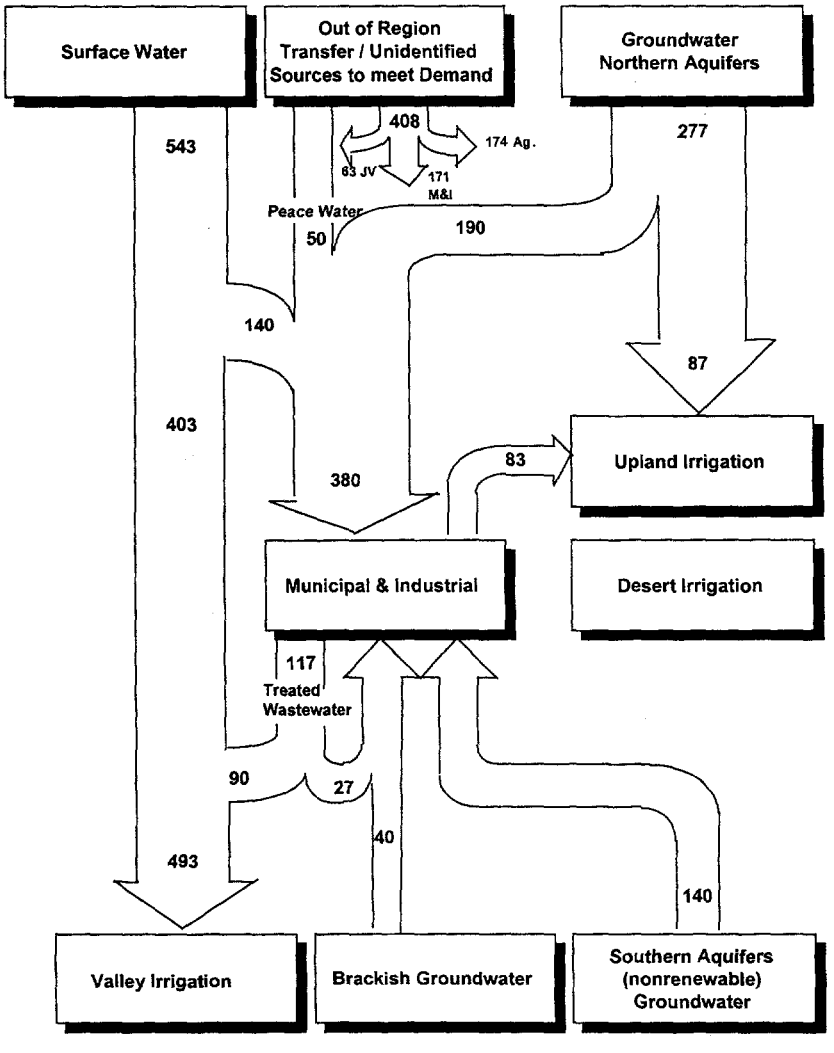


Figure 2: Future Indicative Sources and Uses of Water in Jordan (2020) (MCM) (Source: The World Bank, Report No. 17095-JO)

This projected gap is shown below (Figure 3), as well as the temporal changes in the various component water uses. Noteworthy are the projected severe reduction in upland irrigation by small private farmers, the expansion of public irrigation in the Jordan Valley up to 2005, and the growth of urban water use, despite major projected improvements in efficiency expected to result from the private sector management of water services in Greater Amman (about half the national population) and possible elsewhere.

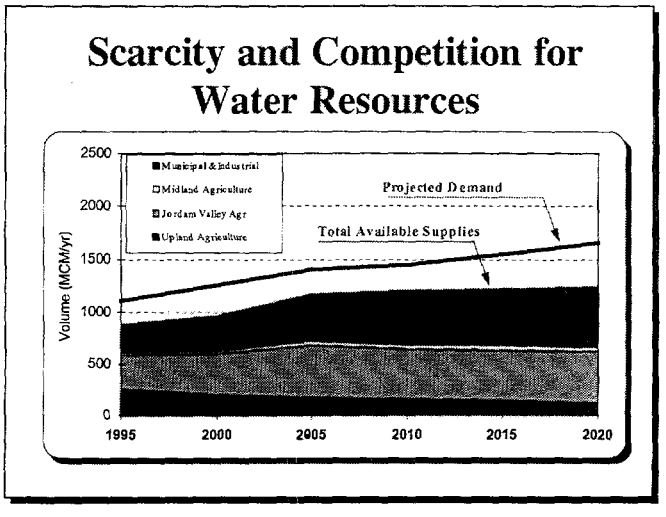


Figure 3: Scarcity and Competition for Water Resources
(Source: The World Bank, Report No. 17095-JO)

Regulation of Groundwater Use

The mining of aquifers in Jordan is substantial and not necessarily bad practice to utilize stored groundwater, but it is undeniably unsustainable - Figure 4 indicates the extent of Jordanian and regional groundwater mining. The main question is: How is a 60% reduction in groundwater use to be achieved by farmers in highland areas?

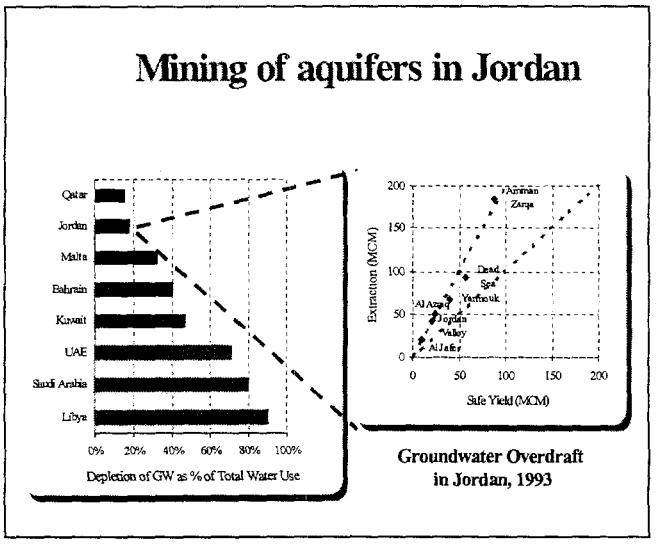


Figure 4: Mining of Aquifers in Jordan (Source: The World Bank, Water Context in MENA)

The law in Jordan defines all water as the property of the state although rights to the use of water are recognized. The Water Authority of Jordan (WAJ) is empowered to regulate water use and their record on groundwater is depicted in the Figures 5 and 6 below. Noteworthy points are: the reduction in abstraction from each aquifer but one from 1993-1997; and that all aquifers, but one, exceed 150% of the sustainable yield. How has this improvement been achieved and what are the prospects for further improvement?

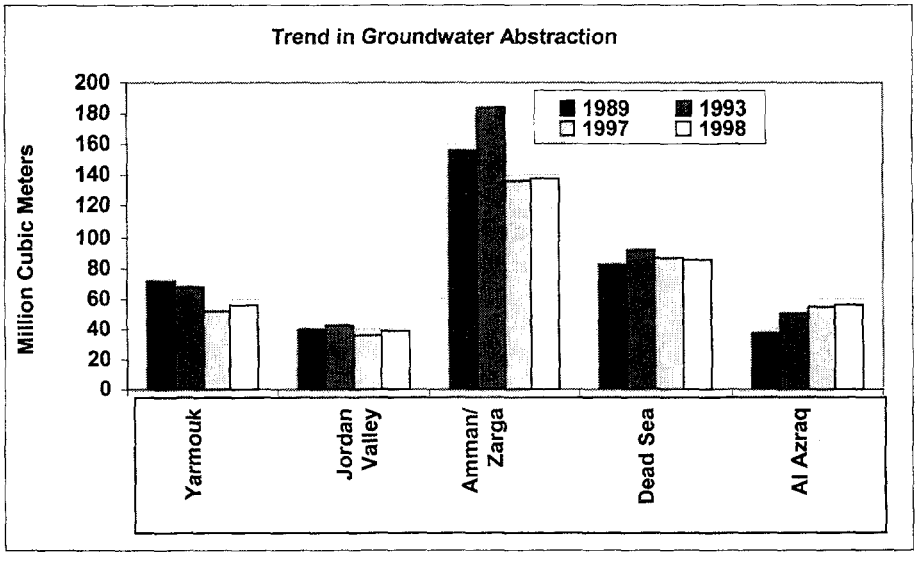


Figure 5: Trend in Groundwater Abstraction (Source: Ministry of Water & Irrigation, Jordan, Report on Groundwater Basin Monitoring and Protection Project)

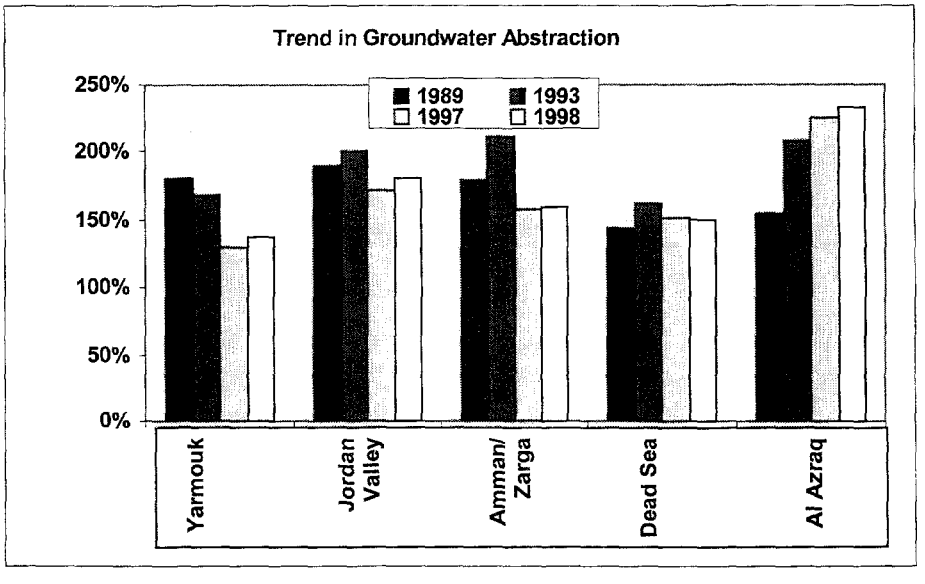


Figure 6: Trend in Groundwater Abstraction (Source: Ministry of Water & Irrigation, Jordan, Report on Groundwater Basin Monitoring and Protection Project)

The issuing of licenses for new, or renewal, wells has almost ceased. Industries and educational institutions are the only exceptions to a ban on new well drilling that is enforced through strict control over drilling rigs (Figure 7).

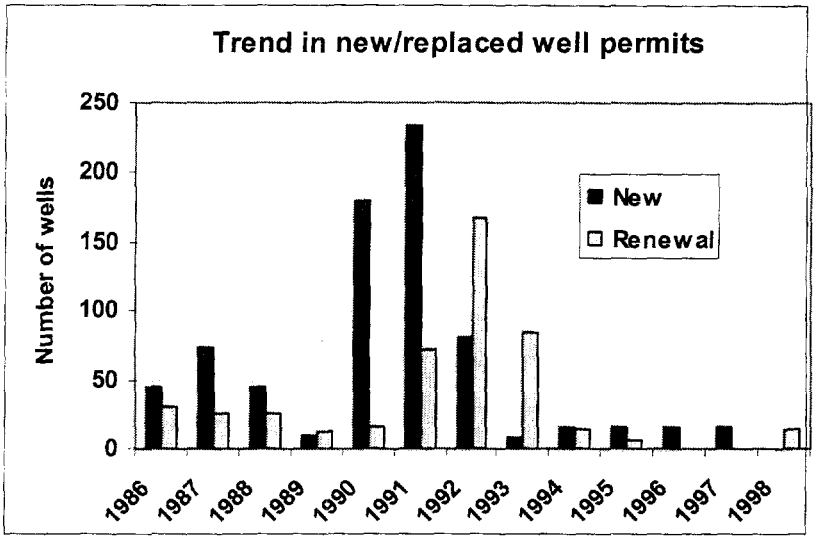


Figure 7: Trend in New/Replaced Well Permits (Source: Ministry of Water & Irrigation, Jordan, Report on Groundwater Basin Monitoring and Protection Project)

Flow meters are being installed on all existing wells (Figure 8) and a quota specified in the well abstraction permit that limits the quantity of water that may be abstracted without payment of a penalty for overuse, has been recently established at JD (Jordanian Dinar) 0.250/m^3 - approximately \$0.35/m^3. Industrial well owners pay this amount on all water abstracted, that is, with no free allowance.

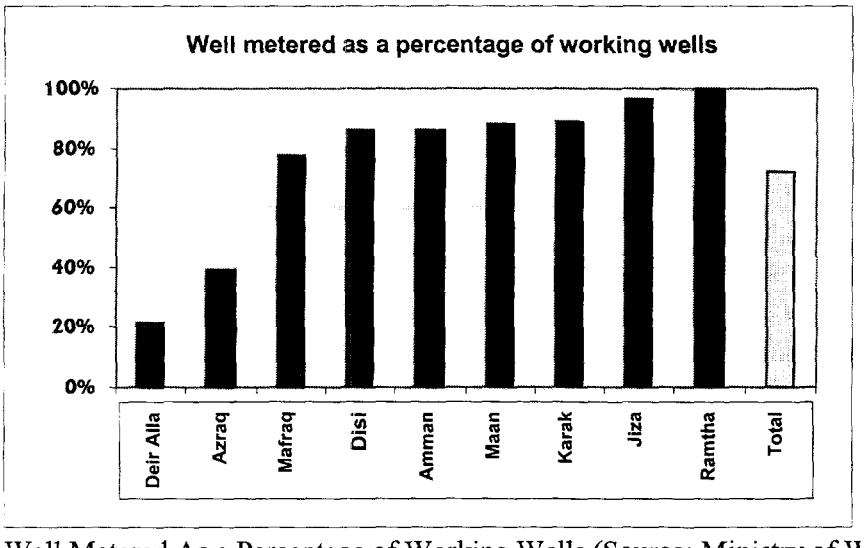


Figure 8: Well Metered As a Percentage of Working Wells (Source: Ministry of Water & Irrigation, Jordan, Report on Groundwater Basin Monitoring and Protection Project)

With the assistance of the World Bank and German *Kreditanstalt fur Wiederaufbau* (KfW), a Basin Protection Unit has been established in each groundwater basin, staffed by a hydrogeologist, a retired army general and necessary equipment and support staff. Success has been mixed. A complete inventory of all legal and illegal wells has been compiled and the support enlisted of a Ministerial Committee comprising the membership of the Minister of Interior, Badia and Border Police, the Ministers of Justice, Agriculture, Finance, Water & Irrigation and others. It is apparent that although such heavy political support can be effective in giving a campaign initial momentum, it cannot be sustained and success may depend more on convincing well owners to cooperate than in trying to enforce the rule of law at the margins of its reach. A new project with USAID support has been formulated to further explore and implement a solution to groundwater management. Failure will result in depleted and degraded aquifers, serious economic and social adjustment in the agricultural sector, and substantially higher costs of urban water supply as more expensive sources have to be utilized to fill the gap left by inexpensive renewable groundwater.

THE TRANSBOUNDARY QA DISI AQUIFER

The Government has requested assistance from the World Bank to develop the Qa Disi Aquifer and to convey water at up to 100 MCM/yr. to meet the growing demand in Amman. A build, operate, transfer (BOT) contract is proposed for which the Bank is expected to offer to bidders a partial risk guarantee that would protect commercial lenders against Government default, leading to better lending terms.

The Qa Disi Aquifer underlies southern Jordan and northern Saudi Arabia. It is in a sandstone structure and dips northward to the Dead Sea but water movement is extremely slow and it is considered to not form a "unitary whole" with surface waters. It therefore falls outside the Bank's OP 7.50 (which applies only to surface water) and the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses. Nevertheless, the principles that underlie evolving water law have been applied as they would have been to a surface water or to other groundwaters: notification to riparians of the intention to develop the resource; fair and equitable sharing of the resource; and do no harm as a result of utilizing the resource.

In pursuit of those principles, the Government has taken the following steps:

- Notified the authorities of Saudi Arabia of their intention to exploit the Qa Disi aquifer underlying Jordan;
- Carried out a Risk Assessment Study, financed by the Bank, to determine the impact on the aquifer of possible future abstractions south of the Saudi border;
- Carried out an environmental impact assessment; and

- Is implementing a project that includes water network restructuring and a management contract with a private sector utility operator to take over management of the Greater Amman water supply (and sewerage) services in order to reduce physical and administrative losses to acceptable levels and improve the financial viability of the Disi/Amman Water Conveyor Project.

The Saudi Government was notified in February 1999 and has not formally responded, although the Jordanian Minister was verbally advised that the Saudis had no objection.

The Risk Assessment indicated that expected abstractions in Saudi Arabia would not significantly affect water levels in the Jordanian wellfields, but that any new and unexpected developments close to the border represented a potential project risk. Other risk factors were minimal. The greatest threat to the longevity of the aquifer in fact comes from the decision some 15 years ago to award concessions to a number of Jordanian companies to abstract water for agricultural purposes. These concessionaires currently abstract approximately 60 MCM/yr. and are lowering the water table by up to 800 mm/yr. Their future impact has not yet been fully assessed, but public opinion is growing in the present climate of drought to limit these abstractions.[1]

An Environmental Impact Assessment was carried out as part of the Feasibility Studies but focussed mainly on mitigating impacts of constructing the proposed project. Although the resource is a non-renewable one, it might be considered in the same context as development of mineral deposits and oil/gas utilization. In fact, unlike those resources, water itself is quite an abundant natural resource in a less pure state (seawater) and future generations will have other options such as seawater desalination, the cost of which continues to decline. Other environmental/social impacts have yet to be fully assessed, but are considered manageable or slight - the aquifer is deep and has no impact at the surface, the strata is sandstone and land settlement is not anticipated, resettlement is not required and biodiversity is not an issue.

The economic analysis of the Project is yet to be completed but depletion of the natural capital will not be treated as a free good. A "user cost" or "depletion premium" will be calculated to measure the opportunity cost of foregone resources in the future. For example, this premium might be calculated as the present discounted value of the incremental cost that future consumers would have to pay to switch to the next most cost-effective resource. It is not at all improbable, with advances in desalination technology that are already becoming evident, that this alternative might in future be cheaper than abstraction of deep groundwater. Other major donors to Jordan in the water sector have declined participation in the Disi Project on conservation grounds.

---

[1] According to the concessions, abstractions could be increased to an aggregate 95 MCM/yr. and continued indefinitely in the case of the largest of the concessions.

The Water Authority of Jordan has a history of excessive losses and declining physical and financial performance. In view of the desire to develop the Disi Project, the World Bank has supported WAJ to implement an Amman Water and Sanitation Management Project that includes:

- a performance-based management contract with an internationally experienced utility company to improve the efficiency and adequacy of water services in Amman; and

- restructuring and rehabilitation of the water supply network to provide bulk distribution mains, pressure zoning, storage reservoirs, and gravity distribution.

The four-year Management Contract was awarded in April 1999 and co-financing has been secured to enable the whole system to be restructured. Demand management measures have also been introduced - most notably a new tariff system and a substantial increase in water (40%) and wastewater (50%) tariffs. Like most countries, Jordan had adopted a progressive block tariff structure, intended to ensure that water was available to the poor, but that the larger users of water pay a higher price. They found that the bulk of the subsidy in fact was going to larger consumers and revised the water and wastewater tariffs to an increasing rate structure that denied any concessionally priced water to large consumers. However this is only part of the overall picture of water use in Jordan.

CONCLUSION

The first part of this Chapter described how groundwater is used in Jordan. Significant issues remain, including the expansion of irrigated agriculture, the low value added to water used for irrigation compared to industrial use, irrigation tariffs that fail to recover any of the capital investment in irrigation schemes, and the inefficiency of publicly managed irrigation systems at a time when urban consumers are facing substantially higher tariffs to develop new resources such as at Disi.

With the active support of donor partners, the Government of Jordan is making impressive strides in dealing with the reality of very limited water resources. There are few examples to follow in the developing world.[2] Experience in recent years has posed a number of questions to which answers are still being sought:

- In the face of resistance of well owners to efforts by Government to meter and regulate water use, would a strategy based on a more cooperative approach have any greater prospect of success?

---

[2] Howard Schneider, *A Middle East Drought Threatens to Unleash a Flood of Problems*, THE WASHINGTON POST, June 28, 1999.

- Rights to groundwater are linked to ownership of land. Should abstraction quotas be set on the basis of water needs for cropping patterns, or should they be related directly to the area of land and the yield of the aquifer underlying that land?

- Are the provisions of the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses, which is not yet ratified, adequate for managing shared water resources?

- Is the lack of an established methodology for handling the development of non-renewable resources in project environmental and economic analysis, and the fear of a "green backlash" deterring donor support for priority developments such as the Disi Project?

- In a situation where water throughout the arid Middle East is allocated by administrative decree rather than pricing and market forces, how should policy best move increasingly limited water resources away from traditional and heavily subsidized low value agriculture towards more economically productive uses?

BIBLIOGRAPHY

Darghouth, Salah, *The Water Context in MENA/MED* (Paper presented at the First Regional Seminar, MENA/MED Water Initiative, Cairo, June 1998) (unpublished).

Hudes, Karen A., *Riparian Issues: Jordan: Development of the Qa Disi Aquifer in Southern Jordan, Application of OP 7.50 to Groundwater,* (visited Sept. 13, 1999) <http://wbln0023.worldbank.org/legal/legpopkms.nsf/ByRepNo/QR039813?Open Document>.

Hudes, Karen A., *Shared Water Resources in the Jordan River Basin*, 1 ACROSS BORDERS GONZ. INT'L L.J. 6, (visited Sept. 13, 1999) <http://www.law.gonzaga. edu/borders/water.htm>.

MINISTRY OF WATER & IRRIGATION, THE HASHEMITE KINGDOM OF JORDAN, JORDAN WATER STRATEGY (Policy Paper, 1997).

MINISTRY OF WATER & IRRIGATION, THE HASHEMITE KINGDOM OF JORDAN, GROUNDWATER MANAGEMENT POLICY (Policy Paper No. 3, February 1998).

MINISTRY OF WATER & IRRIGATION, THE HASHEMITE KINGDOM OF JORDAN, OVERVIEW REPORT: GROUNDWATER BASINS MONITORING AND PROTECTION PROJECT (1993-1997) (1998) (unpublished).

Schneider, Howard, *A Middle East Drought Threatens to Unleash a Flood of Problems*, THE WASHINGTON POST, June 28, 1999.

The World BANK (RURAL DEVELOPMENT, WATER AND ENVIRONMENT DEPARTMENT, MIDDLE EAST AND NORTH AFRICA REGION), THE HASHEMITE KINGDOM OF JORDAN WATER SECTOR REVIEW, VOLUME I: MAIN REPORT AND ANNEXES A-B (Report No. 17095-JO, October 15, 1997).

CHAPTER 7

Groundwater Management in Mexico: Legal and Institutional Issues

Karin Kemper*

INTRODUCTION

The World Bank, together with Mexico's National Water Commission (*Comisión Nacional del Agua*, CNA), conducted a study about groundwater management in Mexico. The objective of the study is to identify policy options for aquifer stabilization. This Chapter briefly describes the groundwater situation in the country and some of the preliminary findings of the study with regard to legal and institutional issues.

Mexico covers an area of about 2 million km^3 and has a population of about 98 million inhabitants. Geographic distribution and economic activities are inversely related to water availability. Two thirds of the national territory contain less than one third of the available water resources. In these arid and semi-arid regions, where the major part of Mexico's large cities, industrial infrastructure and irrigated agriculture are located, groundwater frequently constitutes the most important or only supply source.

Groundwater development in Mexico accelerated in the late 40s and early 50s as a consequence of general development in the country. Nowadays, approximately one third of the water used in agriculture originates from groundwater sources, supplying 2 million of the country's 6 million irrigated hectares. Thus, irrigation alone consumes about 70% of the total of the abstracted groundwater in the country.

In the urban centers, about 49 million inhabitants, i.e. more than half of the total population, rely on groundwater. In rural areas, 20 to 30 million inhabitants are supplied by groundwater. Regarding industrial water use, the major growth poles are to be found in the north and center of the country, again principally relying on groundwater. Considering these numbers, the strategic importance of groundwater for the socioeconomic development of the country - and therefore the necessity for its sustainable management - is evident.

Unfortunately, a preoccupying situation has developed. 100 of the 647 aquifers identified by CNA are considered to be over-exploited. These aquifers represent 51% of total national abstraction. If current consumption patterns prevail, it will not be possible to ensure sustainable development based on groundwater as an input.

---

* Economist, Environmentally and Socially Sustainable Development Unit, Latin-America and Caribbean Region, The World Bank.

The effects of groundwater overexploitation are expressed in negative socioeconomic impacts, such as increases in pumping costs (thus rendering irrigation more expensive with detrimental effects especially for small and poorer farmers); environmental costs in terms of salinization and toxic contamination, as well as health costs related to contamination and water scarcity. In addition, uncontrolled overexploitation implies the need for high-cost investments to develop alternative water sources which may consist in transferring water from different hydrological regions. The opportunity cost of the capital invested in such endeavors needs to be taken into account given that the need for such investments could be reduced if demand management options leading to more efficient water use were effectively implemented.

With respect to the deterioration of the groundwater situation in the country and the associated undesirable effects, CNA and the World Bank conducted a joint study of 20 of the 100 overexploited aquifers. The sample aquifers are distributed in twelve states and are representative of the varying problems. In addition, five of these aquifers, notably Hermosillo, Aguascalientes, Celaya, Querétaro and Santo Domingo, are studied in more detail. The study aims at developing viable policies for aquifer stabilization, which eventually can be applied at the national level. In addition, a pilot project is being developed for up to five of the most affected aquifers and will serve as a basis for development of a methodology that seeks to put the previously identified options into practice. The pilot project is under preparation and due to start at the end of 1999.

STUDY CONTENTS

The Study consists of six background papers, covering the following topics:

- hydrogeological conditions and trends;
- hydro-economic simulations of different groundwater management regimes;
- the impact of energy costs on irrigation;
- urban and industrial groundwater use;
- a laissez-faire scenario;
- legal and institutional issues of groundwater management.

Based on these six background papers, a strategy paper outlining possible policy options has been prepared.

SOME PRELIMINARY RESULTS

The study results strongly point to the fact that underlying legal and institutional issues are of utmost importance to improving groundwater management in Mexico. While technical interventions will play an important support role, they alone will not provide a solution. The following paragraphs outline some of the major issues.

Users' Involvement and Decentralization

In Mexico, the only water authority at federal level is CNA, an administrative authority under the Ministry of the Environment, Natural Resources and Fisheries. In line with the National Development Plan (1995-2000), CNA is in a decentralization process. Thirteen regional bureaus have been created according to hydrological regions. Furthermore, the creation of State Water Commissions is being promoted in order to transfer operational functions to the states, which until now have been carried out by CNA.

CNA's decentralization has been greeted with enthusiasm by some states, notably Guanajuato, where the government is developing an ambitious institutional project, including a State Water Law in order to enable the State Water Commission to have ample power for state level water resources management. In other states, decentralization is received in a less active manner.

Other programs which are also directly or indirectly related to groundwater resources are decentralized by means of legal agreements (*convenios*), but since political and aquifer boundaries do not coincide, many actions by state and municipal governments may even have negative impacts on aquifer management. Thus, it is necessary that policies be integrated to improve groundwater management.

Part of the decentralization effort in water resources management is related to the creation of river basin councils, commissions and committees. These are organs of coordination and collaboration (*concertación*) between government representatives, the public sector and users in the principal river basins of the country. The aim is to formulate and support the execution of programs to improve water management. The Basin Committees do not have legal status and are conceived as supporting units rather than authorities. Therefore, their agreements alone are not binding, but depend on political will and budgetary commitments by the governments involved.

It is part of the Hydrological Plan to promote users' organizations in regions with problems of overexploitation.[1] The organization of users at aquifer level is being promoted by CNA through the creation of Technical Groundwater Committees (*Comites Técnicos de Aguas Subterráneas*, COTAS). These have the objective of assisting users in participating in the formulation and execution of programs and action for aquifer rehabilitation and preservation, as well as better groundwater management with regard to quality and quantity.

---

[1] *See* in general CECILIA M. GORRIZ ET AL., IRRIGATION MANAGEMENT TRANSFER IN MEXICO - PROCESS AND PROGRESS (World Bank Technical Paper No. 292, 1995), and SALMAN M. A. SALMAN, THE LEGAL FRAMEWORK FOR WATER USERS' ASSOCIATIONS – A COMPARATIVE STUDY (World Bank Technical Paper No. 360, 1997).

COTAS are not expressly defined in Mexico's National Water Act, 1992,[2] but the law stipulates that users can organize themselves according to their wishes in order to develop and use water resources.[3] For this, they can constitute one of the juridical persons recognized by current legislation. In spite of this possibility, the COTAS are currently being set up within the same framework as the river basin councils, i.e. as simple organs of coordination and *concertación*, without authoritative power, or administrative or financial autonomy.

Evidently, the incentives water users will have to organize and take responsibility for management of their local groundwater resources will be very weak if no real powers are being conveyed to the COTAS and if dependence on federal funds, authority and decision-making persists. An important opportunity might be lost to make users realize that they are part of the solution and need to take both responsibility and decisions to preserve their resource base.

Water Rights and Water Markets

Until now, users have had little incentives to conserve groundwater and to join forces for preserving their resource base. One way to achieve sustainable management of natural resources with a common good character is to give users well-defined and secure use of property rights. Mexico has started this process by allocating water rights to all users, for both surface and groundwater. The rationale is that right holders will have a longer-term perspective and thus use their resource more efficiently in order to preserve (future) revenue streams. It is also expected that if these rights are tradable, as they officially are in Mexico, then the resource will be put to its highest valued use since a market will develop in areas of scarcity.

In the case of groundwater, however, water rights have been over-allocated in the initial process, i.e. if all right holders exercise their legal rights, more water will be withdrawn annually than the natural recharge of the aquifer can replenish. As such, the sinking of groundwater levels would continue. In addition, if water trading takes place, it will be on the basis of too much use so that there will be no effect on aquifer stabilization. Thus, the market approach alone would not accomplish restoration of aquifer levels. In those aquifers which are not yet over-exploited, water trading could, of course, lead to the desired effects and future degradation can be avoided.

In addition, according to Mexican law, the water use rights that are obtained through a concession title do not transmit rights in an economic sense. Therefore, they are not considered a part of the rightholder's assets. For example, it is currently not yet possible to use a water right as a mortgage.

---

[2] For an English translation of the Act *see*, CECILIA M. GORRIZ ET AL, *supra* note 1, at 43.

[3] Hector Garduno Velasco, *Modernization of Water Legislation: The Mexican Experience, in* DEVELOPMENT LAW SERVICE, FAO, ISSUES IN WATER LAW REFORM (FAO Legislative Studies No. 83, 1999), at 83.

At the same time, water markets are authorized in the National Water Act in the following terms:

- Between water users, if only the right holder changes. It is sufficient to inform CNA.

- With prior authorization by CNA, if the trade would imply changes in the hydrological conditions of the respective river basin or aquifer or if third parties are affected.

- In the case of groundwater resources located in *zonas de veda*[4] or in regulated aquifers, the transfer needs to include the land, except if otherwise authorized by CNA. Since the *zonas de veda* are basically inoperational, most groundwater rights can in fact be transferred without the land.

- In the case of irrigation districts, the full or partial water right transfers are regulated within the district itself.

Transfers are only permitted between users of the same basin or aquifer. This restriction constitutes a limitation in cases where, for example, an irrigation district possesses all of the water rights over an aquifer (the case in Hermosillo), while urban population close by needs to look for expensive alternatives because it cannot purchase these water rights. The National Water Act itself does not prohibit out-of basin or aquifer transfers. This restriction was introduced in the law regulations issued under the Act.

The above shows that water markets have a sound legal basis, but that a number of issues still need to be resolved to enhance their functioning in practice. This relates as much to a clarification of the amount of water rights already allocated as to administrative facilitation of water trades between different types of users.[5]

Water Tariffs

A further way of providing incentives for more efficient use is to introduce water charges. In Mexico groundwater users pay *derechos de agua* which are semi-annually defined in the *Ley Federal de Derechos* (Federal Rights Law). Since groundwater is property of the Federation, only Congress can determine these taxes. Currently, industries pay the most, while water utilities pay only a fraction – if they pay at all. The agricultural sector, which as mentioned previously, stands for 70% of groundwater use in the country, is exempt from payment.

---

[4] *Zonas de veda* are lands above aquifers where withdrawal is prohibited or severely restricted. In practice, however, no *zonas de veda* have been enforced.

[5] *See* generally MANUEL MARINO & KARIN E. KEMPER EDS., INSTITUTIONAL FRAMEWORKS IN SUCCESSFUL WATER MARKETS – BRAZIL, SPAIN, AND COLORADO, USA (World Bank Technical Paper No. 427, 1999).

Thus, it can be concluded that water tariffs as a demand management tool do play a role with regard to industrial consumption while they have no effect on agriculture and probably little on the water companies. At the same time, industry consumes relatively little water and the tariffs are related only to water quantity and not to quality, which would be a further issue to tackle.

Energy Costs and Agricultural Policies

Agricultural groundwater use is conditioned by energy tariffs. Preliminary study results show that, although energy costs for rural activities are subsidized, the effect of sinking groundwater levels, for example in the Costa de Hermosillo, is strong enough that small scale farmers with less valuable production are being forced to leave the market. This indicates that subsidized energy tariffs may have a doubly detrimental effect on small farmers. First, they encourage overexploitation of the aquifer by all agricultural users since they are applied indiscriminately. Second, once the aquifer is over-exploited, the smaller farmers lose, while the larger farmers continue to pump and produce at subsidized rates.

To avoid the detrimental effects of subsidized energy tariffs on groundwater overexploitation, it might be worthwhile contemplating a different way of supporting small farmers, possibly by lump sum payments. Larger farmers producing high-value crops such as vegetables and fruits would more easily be able to compensate for higher energy costs by investing in water-saving irrigation technologies and becoming more efficient water users.

CONCLUSION

Given the importance of groundwater for Mexico's economy and future development, improved management of the resource is clearly paramount. A strong legal basis already exists, but as in many cases, the actual implementation of the legal possibilities is still in a formative stage and conditioned by a number of interests of the different parties involved.

With regard to users' involvement, current legislation would permit considerable autonomy for the COTAS and if successfully applied, these entities could come to play a pivotal role in managing their local resource. To ensure the COTAS' interest in taking on responsibility, their legal status should be clear and a financial mechanism would have to be put in place that would enable them to be financially independent in the long run. The financial system would clearly benefit from an overhaul in such a way that resources generated at local level would stay there, thus giving users incentives to pay tariffs.

Furthermore, water markets might need some more incentives, e.g. through flexibilization of out-of basin or aquifer transfers. There are also indications that new instruments such as partial sales and lease agreements would provide more flexibility, and thus more market activities.

Finally, the linkage between agricultural, urban, industrial and energy policies is evident in groundwater management. With groundwater resources severely threatened, it is becoming necessary to contemplate packages where different sectoral policies work together to provide the incentives for stakeholders to adequately manage the resource. Agricultural policy, for example, cannot be delinked from water policy if agriculture is the principal user.

BIBLIOGRAPHY

GORRIZ, CECILIA M. ET AL., IRRIGATION MANAGEMENT TRANSFER IN MEXICO - PROCESS AND PROGRESS (World Bank Technical Paper No. 292, 1995).

MARINO, MANUEL & KEMPER, KARIN E. EDS., INSTITUTIONAL FRAMEWORKS IN SUCCESSFUL WATER MARKETS – BRAZIL, SPAIN, AND COLORADO, USA (World Bank Technical Paper No. 427, 1999).

SALMAN, SALMAN M. A., THE LEGAL FRAMEWORK FOR WATER USERS' ASSOCIATIONS – A COMPARATIVE STUDY (World Bank Technical Paper No. 360, 1997).

The World Bank, Mexico: Policy Options for Aquifer Stabilization (two volumes), (forthcoming).

Velasco, Hector Garduno, *Modernization of Water Legislation: The Mexican Experience, in* DEVELOPMENT LAW SERVICE, FAO, ISSUES IN WATER LAW REFORM (FAO Legislative Studies No. 83, 1999).

CHAPTER 8

Experience with Groundwater Irrigation in Nepal

Ohn Myint*

INTRODUCTION

Nepal has a total land area of 14.7 million ha. About 2.6 million ha or 18% of the country's area is under cultivation. Out of the total arable land, about 1.8 million ha are irrigable, of which 1.4 million ha (76%) are in the country's plains - Terai, and the remaining 0.4 million ha are in river valleys, tars and leveled terraces in the hills and mountains. The share of irrigated crop land in the country is quite low, approximately 35 % or about 1.05 million ha. Of that amount, about 0.15 million ha are under groundwater irrigation, which has the capability of being irrigated around the year. The Terai, which contains three quarter of the irrigable land, is only one-third irrigated and no more than 25% of that receive year-round irrigation. About 75 % of the existing surface irrigation were developed and managed by beneficiary farmers group.

The population of Nepal in 1997 was 21.5 million, and, with a growth rate of 2.1% per annum, is expected to reach 30-35 million in the next 25 years until it stabilizes. About 47% of the total population are in the plain Terai, 45% in the Hills and 8% in the Mountains. According to the 1991 census, total household was 3.3 million and the national family size was 5.6. Over 91% of the people live in 3,995 village development councils (VDCs), the lowest administrative body of the country, with each VDC population varying between 3600 to 4000. Average family holding in the Terai is 1.3 ha and 0.7 ha in the Hills and the Mountains.

GDP growth has fallen from 5.5% in FY91-94 to 4.4% in FY95-96, and estimated to further decline to 4.0% in FY97, and about 2% in FY98. The agriculture growth rate of 2.3% has hardly kept pace with the population growth. As a result, per capita production in Nepal is declining. On the other hand the non-agricultural sector has grown at almost 7% per year for the last ten years, with industrial activity expanding to 19% of the GDP. Agriculture remains the largest user of water, with irrigation accounting for 75% of consumptive use.

GROUNDWATER SECTOR

The annual water resources potential of Nepal is about 200 billion m^3, which works out to a per capita availability of 11000 m^3 for today's population. This compares

---

* Senior Irrigation Engineer, Rural Development Sector Unit, South Asia Region, The World Bank.

well with the global average supply of renewable fresh water of about 7,400 m^3 per capita. But most of the rivers being monsoon rain-fed with highly seasonal variation in flows with high silt content. Therefore, water availability is temporal and spatial. It varies between 8,300 m^3 per capita during the monsoon season (about four months) to 2,700 m^3 per capita in the dry season. The dry season quota is alarming when compared to the threshold level of water stress of 1,700 m^3 per capita. Moreover, thirty years from now, the availability of water will decline to 4,500 m^3 during high flows and 1,400 m^3, much below the water stress level, during the rest of the year. On a spatial basis, many areas of the country are found under severe water stress conditions.

Resolution of these unequal seasonal flows by reservoirs has been dampened due to riparian issues with the downstream neighbors and the high capital requirements of river-storage schemes. Along with India and Bangladesh, Nepal is also a member of the Ganges River Basin. The alternative, the shift towards the use of groundwater, allows a more predictable supply, closer to the farmers' fields, but the trade-off are higher operation costs, high fragmentation of land holdings, and lack of rural road networks, rural electrification and or diesel servicing facilities. A systematic approach to these issues in the irrigation system design could patch up half of the water stress quantity using groundwater in the Terai. The Terai is rich in groundwater in the form of a natural aquifer, which could be exploited at a low investment. The annual recharge is estimated to range from 124 to 685 mm. Various studies have estimated availability of groundwater between 12.0 to 5.8 billion m^3. Based on the measures of seasonal fluctuations of water tables in the shallow tube wells, the reserve has been assessed at 8.8 billion m^3. This amount, when considered in conjunction with the suitability of land and hydrogeologic condition, can be used for developing about 400,000 ha of land suitable for irrigation by shallow/deep tube wells. Since the early 1980s, groundwater development, mainly through shallow tube wells owned by individual farmers, has become an important source of irrigation in the Terai. However, prospects for future growth in individual farmer demand for tube well development are limited due in part to small and fragmented land holdings.[1] With strong Nepali traditional habit of collective irrigation development, expanding private groundwater system development through group owned and managed approach has good possibilities for both shallow and deep tube well.

BANK EXPERIENCE IN GROUNDWATER IRRIGATION PROJECTS

The World Bank has become involved in irrigation development in Nepal since 1973. To date the Bank has supported eleven major irrigation projects, of which eight have been completed. Together, they provide improved surface water irrigation facility in over 90,000 ha, and groundwater irrigation for about 9,000 ha. Among the Bank-funded

---

[1] A recent socioeconomic survey in Terai showed that the average size of a parcel varies from 2.6 for marginal farmers, 5.5 ha for small farmers, 5.8 ha for medium farmers, and 6.2 ha for large farmers. Therefore the size of parcel per ha varies from 5.8 for marginal farmers to 0.7 for large farmers and it is increasing over time.

irrigation projects, the Bhairawa Lumbini Groundwater Irrigation Project in Rupandehi is one of the successful projects in the Terai after modifications of the system development and design using farmers' involvement. It has established an effective model and capacity for groundwater development using improved deep tube well technology and users' participation. Project implementation is being carried out in three stages. Stage I project started in 1978 and was completed in 1984. Stage II started in 1983 and was completed in 1991. And Stage III has started in 1992 and completion is expected in June 1999.

The original Stage I project comprises 64 tube well systems, and the Stage II project comprises of 38 deep tube well systems. Each tube well system irrigates about 120 ha with an average tube well depth of more than 120 meters and a yield of about 300 to 400 m^3/hr. Completion of Stages I and II before 1990 was based on the supply driven principle wherein the Government identified, designed, implemented and operated the tube well systems. The tube well users were required to pay annual water charges of Rs.200 per ha. This was then increased to Rs.400 per ha per year. Even though Stage I was a success, the level of cost recovery was poor, resulting in the level of Operation Maintenance (O&M) groundwater irrigation being expensive, with high government subsidy.

The average cost recovery was only about 10% of targeted amount and O&M funding continues to be inadequate. This problem is endemic in both surface and groundwater irrigation, and the systems' serviceability evolves in a vicious cycle of "construction-destruction-and-rehabilitation." Unless the level of O&M is prioritized according to the availability of funds and the nature of the irrigation systems, the performance of public irrigation systems will not improve and investment, which has been already made, will be lost. To address these constraints in irrigation development, the Government in 1988 promulgated a new Irrigation Policy, which was based on the principles of participatory irrigation development and management by beneficiary farmers. This Policy was later amended in 1992 and 1997.

In the case of original public groundwater systems like Stage I and II , some issues observed at the time of completion of the projects were:

- lack of farmer involvement in selecting tube well site and designing the distribution system create the lack of sense of ownership by farmers;
- consequent lack of ownership by the farmers and their attitude that the well belongs to the government who should operate and maintain the system had inhabited the successful collection of water charges;
- in the case of well development, long delays between drilling and commissioning lessen the farmers' interest in tube well development;
- difficulties with managing command areas greater than 60 ha with unlined opened channels by small farmers; and

- unwillingness to pay for electricity charges incurred in operating deep tube wells;
- difficulties with project-appointed operators;
- lack of coordination and cooperation among users.

The old style projects placed the entire burden for planning, construction, O&M on the Government and its limited fiscal resources. To resolve these issues, the Irrigation Policy mandated that farmers are required to pay part of the investment costs of irrigation development and all of the operational charges of the irrigation systems by taking over the systems after completion. Stage III of the Bhairawa Lumbini Project, which was approved by the Board of the World Bank in 1992, was designed in accordance with the Irrigation Policy. The completed Stage I and II were also included in the Stage III project for some remodeling, modifications and turnover to the concerned beneficiary water users' group.

In the Stage III project, the beneficiary farmer groups are required to: (a) request their deep well facility, (b) get involved in the earlier stages through implementation, (c) commit to form a Water Users' Association (WUA) for their deep tube wells,[2] (d) contribute to construction costs in cash and or labor, and (e) take-over responsibility for deep tube well system O&M upon completion. Under the Stage III Project, Stage I and II distribution systems were rehabilitated and handed over to the beneficiary farmers in accordance with the new Irrigation Policy.

The formulation of water users' groups and the participation of the users in the project design and distribution of water, turned over the entire management of the systems to the beneficiaries. However, attempts to turn over the full responsibility of operating pumps and maintenance of the tube well irrigation systems was not fully successful until the system rehabilitation had been fully satisfactory to the users. This was well pronounced in Stages I and II tube well irrigation where the systems development was initiated by the Government without farmer participation. To date, overall progress of rehabilitation and turnover in Stage I has been completed on 60 (out of 64) tube wells. In the case of Stage II, 31 tube wells (out of 38) have been successfully rehabilitated and turned over to water users' groups. The 79 tube wells planned under Stage III followed the "demand-driven" principle right from its inception, and have fewer problems with handing over the completed tube well systems to beneficiaries.

Even though the group approach in deep tube well development seems to be successful, the 120 ha command area system per tube well is still too large for the farmers to manage. The results of the socioeconomic survey conducted elsewhere in the Terai and in the Bhairawa area indicated that the farmers prefer a deep tube well system but

---

[2] SALMAN M. A. SALMAN, THE LEGAL FRAMEWORK FOR WATER USERS' ASSOCIATIONS – A COMPARATIVE STUDY (World Bank Technical Paper No. 360, 1997).

covering no more than 60 ha command area, even though large capacity deep tube wells are less costly per unit of water pumped.

At the time of implementation of the Bhairawa Lumbini Stage III Project, the viability of the Government's new Irrigation Policy, which was based on the participatory approach, was tested through a pilot Irrigation Line of Credit (ILC). ILC was designed under the participatory principle for privately-owned farmer-managed irrigation schemes (FMIS), covering 6,600 ha of land through surface and groundwater. The groundwater irrigation system in the ILC Pilot Project was designed in the western Terai regions for group management and O&M.

The farmers would form water users groups for each shallow, medium, or deep tube well, and for groups[3] or clusters of wells, a farmer irrigation association would be established and registered at the district office to obtain legal status. Three types of tube wells (shallow, medium and deep) were used under the program.

The ILC Pilot Project, which was initially intended to develop 6,600 ha, commenced in 1992 and was completed in 1997. At closure, about 281 surface water Farmer Managed Irrigation Schemes (FMIS), covering about 29,000 ha, and 217 shallow, medium and deep tube well schemes, covering about 4,200 ha, were completed in the three western regions of Nepal. An agro-economic impact assessment survey conducted in 17 surface and 3 groundwater schemes revealed that the cropping intensities, as well as crop yields, were increased. Thus, under the ILC pilot project, the original objectives of the Irrigation Policy were fulfilled in the following manner:

- The sector approach allowed for the inclusion of small FMISs, which would otherwise have been disqualified from funding as stand-alone projects due to their size.
- The irrigation development program was based on the "demand-driven" rather than the traditionally "supply-driven" principle.
- An effective sub-project selection criteria and implementation process and procedures were established.
- Beneficiary participation through all stages of the project cycle was achieved, as well as handing-over the O&M responsibility to them after completion.

Evaluation of the performance of the completed ILC Pilot Project was conducted in the representative 23 schemes. The results were as follows:

---

[3] A cluster composed of groups of tube wells sharing electricity supply from same source of transmission line.

- The overall irrigated command area increased by 58% with potential for a further increase of 25 %.

- Cropping intensity and the crop yields increased by 40 to 50 % and the yields of major crops increased by 50 to 100%. Economic rate of return of surface scheme ranged from 12% to 24%, compared to 18% estimated at appraisal. And the economic rate of return of groundwater scheme was 20%, compared to the appraisal estimate of 18%.

- Water availability increased by 144% and farmers' contribution (in cash or kind) in the groundwater schemes averaged about 14% of the investment costs, as compared to the appraisal estimate of 10% to 12%.

Performance of the Bhairawa Lumbini Irrigation Project for Stage I and part of Stage II tube wells was satisfactory. A mid-term review of the past performance of 60 functioning tube wells in Stage I and 16 tube wells in Stage II was carried out in 1996. In about 10% of tube well area, surface water was mainly available during the rainy season, and 30 to 40% of the tube wells have artesian water supply used in conjunction with the pumping. This shows that farmers are using surface and artesian water wherever possible to save pumping energy cost. Pumping irrigation facilities were used during maximum irrigation demand periods, i.e. transplant and maturing in the *kharif* (rainy season). However, it is used for base irrigation in hot season crops as well. In all cases, the number of pumping hours in both Stages were less than the anticipated 2,000 design hours per year. The number of pumping hours declined after turnover to farmers when they started paying electricity charges.

The effect of water stress to the yield of the crops, which is attributed to less pumping hours, is still unknown. However, there was nearly a twofold increase in yield of all crops before and after the project. The farm income analysis showed that there was an increase in farm income by 45% for artesian/pump combination and over five to six-fold in the pump irrigation alone. Service charges paid by farmers for electricity, O&M, pump operator salaries and water users fees for pump irrigation represents only 4 to 5 % of farm income and 5 to 6% of annual cash income. This indicates that there is a large potential to increase the present rate of service charges if the pumping irrigation is to be fully utilized to reach optimum yield. The re-estimated economic rate of return is around 39% as compared to 24% estimated at appraisal.

The Government's Irrigation Policy resulted in improvements of a number of policies which included improved cost recovery, greater beneficiary participation and an increased rate of transfer of O&M to the beneficiaries after completion. The Government with the support of bilateral and multilateral international funding agencies has launched an intensified groundwater development in the Terai as per Agricultural Perspective Plan. The tube-well-based strategy would be implemented with supporting investments in rural roads, rural electrification and community-group-approach participation in the development.

CONCLUSION

The development of groundwater in Nepal, which began as early as in 1970s, has been public, as well as privately managed, for both shallow tube wells and deep tube wells. However, growth in groundwater irrigation has been slow relative to that of neighboring countries India and Bangladesh. Major constraints to rapid development of groundwater irrigation are: (a) inappropriate technology choice for shallow and medium/deep tube wells as dictated by underlying lithology; (b) poor economies of scale due to land fragmentation and lithology; (c) lack of emphasis on group approaches to tube well development; and (d) lack of beneficiaries' ownership for management and O&M of some tube wells.

Inefficiency in water use is common in all water sub-sectors. The more government intervention is, the poorer the level of performance in the service delivery. The Bank was instrumental in increasing Nepal's emphasis on groundwater development based on beneficiary participation in the Terai. The Bank's financial and technical assistance provided under the pilot ILC, and other projects, have proven the viability of the Government's Irrigation Policy on the ground. The experience gained had led Nepal to further improve the Irrigation Policy twice in 1992, and in 1997. The Bank assistance has also contributed to Nepal's effort to hand over O&M responsibility of tertiary units of the public irrigation systems to beneficiaries in surface irrigation schemes. Based on similar participatory approach and mass participation, Rural Water Supply Sector has successfully introduced a self-reliance and independently developed water supply system in Hill and Mountain region of the country.

The Government has yet to define more clearly in terms of regulatory undertakings and service delivery. Private sector investment in service delivery aspects will be improved as business confidence associated with the stable political environment gains eventually. Except in some sub-sectors (like rural water supply, and some farmer managed irrigation systems), private sector involvement needs further encouragement by proper investment regulations and rules introduced. The current private sector initiatives are more of a beneficiary mass participation nature (Water Users' Groups) than commercialized private sector investment.

BIBLIOGRAPHY

GROUNDWATER DEVELOPMENT CONSULTANTS LTD., CAMBRIDGE, UNITED KINGDOM, REASSESSMENT OF THE GROUNDWATER DEVELOPMENT STRATEGY FOR IRRIGATION IN THE TERAI (1994).

KAHNERT, FRIEDRICH & LEVINE, GILBERT EDS., THE WORLD BANK, GROUNDWATER IRRIGATION AND THE RURAL POOR – OPTIONS FOR DEVELOPMENT IN THE GANGETIC BASIN, World Bank Symposium, Washington, DC, April 12-14, 1989 (1993).

SALMAN, SALMAN M. A., THE LEGAL FRAMEWORK FOR WATER USERS' ASSOCIATIONS – A COMPARATIVE STUDY (World Bank Technical Paper No. 360, 1992).

SINGH, A. M., LESSON LEARNT FROM IRRIGATION LINE OF CREDIT PILOT PROJECT TO NEPAL IRRIGATION SECTOR PROJECT (1997).

The World Bank, Staff Appraisal Report, Bhairawa-Lumbini Groundwater Project - Stage II, Report N0 4038-NEP (1982).

The World Bank, Staff Appraisal Report, Bhairawa Lumbini Groundwater Irrigation III Project, Report No. 8411-NEP (1990).

The World Bank, Groundwater Irrigation III Project, Mid-term Review Mission Report, December 31, 1996.

CHAPTER 9

Groundwater Management in Yemen: Legal and Regulatory Issues

Karen Hudes*

INTRODUCTION

The purpose of this Chapter is to describe the groundwater situation in Yemen and the World Bank's involvement in water resources management there. While Yemen has the most acute shortage of water resources in the world, its institutional capability to manage its water resources is not commensurate with the magnitude of this problem. Sana'a, Yemen's capital city, will run out of water in 10 years; the rest of the country in 50-100 years. The Chapter stresses the urgent need to set up a legal and regulatory framework for water and the environment, reform energy and water pricing and lift the import ban on qat.[1]

WATER SITUATION IN YEMEN

Yemen faces extreme water scarcity, has the lowest supply of renewable water in the world (150 CM/cap/y) and is over-exploiting water at one of the highest paces. Yemen has 2,500 MCM of total renewable freshwater, of which 1,500 MCM is surface water and 1,000 MCM is groundwater. In 1997, the population was about 16.5 million, growing at an annual rate of 3.5%.

The total annual water use in Yemen is estimated at 3,200 MCM. The deficit between water use and renewable water resources was estimated at 400 MCM in 1990, and 700 MCM, or one-third, in 1995. The deficit is made up by overdrawing aquifers, resulting in lowered water tables and declining water quality. The most stressed area is the western part of the country, which contains more than 90% of the population. In the Sana'a basin, use was 224 MCM, while recharge was 42 MCM, or a 400% overdraft. In the summer of 1995, the city of Ta'iz received water once every 40 days, while in Qa' Al Boun near Amran, water levels dropped 60 meters in the last 20 years, and 30 meters in the last five years.

---

* Senior Counsel, East Asia and Pacific Division, Legal Vice Presidency, The World Bank; formerly with the Middle East and North Africa Division of the Legal Vice Presidency, The World Bank, working, *inter alia,* on Yemen.

[1] Qat is a bush whose young leaves are chewed for several hours. It induces euphoria and suppresses appetite.

Agriculture uses about 93% of the water. About 488,000 hectares are irrigated, of which 75% is irrigated by groundwater. Irrigation efficiency is low (30-40%), and Qat alone, on which there is an import ban, accounts for an estimated 30% of water withdrawals. Qat contributes an estimated 25% to Yemen's GDP, and employs 16% of the labor force. Even families below the poverty line spend 10% of household income on qat.

Nationwide, only 45% of urban households are connected to the public water network. In rural areas (with 81% of the population), only 49% have access to safe water, and 19% to safe sanitation. Yemen has the lowest life expectancy in the region (51 years) and the highest infant mortality (11.7% of live births). Women and girls spend up to seven hours a day fetching water.

The World Bank has been trying to ease the water situation in Yemen. However, achievements on the ground are difficult. Water resources management and quality protection in Yemen are problematic. There are five institutions in the water sector: the Ministry of Electricity and Water, the Ministry of Agriculture and Irrigation, the National Water and Sanitation Authority, the General Authority for Rural Electricity and Water Supply, and the recently established National Water Resources Authority.

The Bank's experience in the water sector in Yemen is not fully satisfactory. In the Taiz Water Supply Pilot Project, which was designed to tap the Habir wellfields outside the city, farmers in adjacent rural areas have resisted allowing their local aquifers to be drilled for fear of their depletion. The yields from the Habir wellfields were lower than initially expected, and new exploration activities are delayed.

There is also a serious threat that groundwater will be polluted. In the Sana'a Emergency Power Project, it became apparent that the disposal of oily water and waste oil at the Dhaban power plant posed a risk to aquifers near Sana'a. Stringent mitigation measures were introduced under the Project These examples demonstrate the urgent need for a legal and regulatory framework in a country where groundwater is a matter of survival.

There is no legislation in Yemen which prohibits the improper disposal or burial of pesticides. This should receive urgent priority attention, along with the development of a water law and appropriate regulatory framework for administration of these laws. Some progress has been achieved. The World Bank, in collaboration with UNDP, the Netherlands, Germany and FAO, supported the creation of a National Water Resources Authority (NWRA) in 1995 with responsibility for resources planning and monitoring, regulation and public awareness. In 1998, NWRA, together with other stakeholders, formulated a National Water Resources Strategy, and commenced a program for monitoring the groundwater aquifer in Amran. In 1999, NWRA began a program to register drilling rigs and issue drilling licenses. The Bank also supports the progressive decentralization of water management in spate irrigation, promotes community management of groundwater and private sector participation in water supply.

CONCLUSION

The above description and analysis demonstrate clearly that although some progress has been achieved, a lot still needs to be done to improve the regulatory and legal framework and the economic regime of groundwater resources in Yemen. There is no water law regulating the use of water, and no environmental law to protect aquifers against pollution. There is also a strong need to raise diesel prices and remove the import ban on qat.

BIBLIOGRAPHY

The World Bank, Staff Appraisal Report, Taiz Water Supply Pilot Project, Report No. 15599 -YEM (July 19, 1996).

The World Bank, Project Appraisal Document, Sana'a Emergency Power Project, Report No. 18243 -YEM (September 2, 1998).

Yemen Council of Ministers, National Resources Authority, National Water Strategy, November 1998.

PART IV

INTERNATIONAL GROUNDWATER LAW

CHAPTER 10

International Groundwater Law: Evolution and Context

Stephen McCaffrey*

INTRODUCTION

Previous Chapters have described the importance of groundwater, in terms of its abundance relative to surface water. Groundwater constitutes some 97% of the available supply of fresh water, and is vulnerable to both depletion and contamination. It goes without saying that these characteristics apply equally to international groundwater resources. In fact, internationally shared groundwater is, if anything, even more vulnerable than that which is not shared by two or more states. The reasons for this have to do both with lack of full understanding or awareness of the characteristics and extent of groundwater, and with the rather embryonic nature of the law in this area, which is in part a consequence of the first reason.

The objective of this Chapter is to review the legal principles and rules that govern the use of shared groundwater resources – or at least some of those resources. While those rules derive principally from the work of the International Law Commission of the United Nations (ILC) and the resulting United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses,[1] a full understanding of the law in this area requires that it be placed in context. Therefore, I will first discuss the scope of this topic, that is, the kinds of groundwater that fall within the category of international groundwater for the purposes of regulation by international law. I will next review the treatment of groundwater in state practice, and in the work of international non-governmental organizations and expert groups. Finally, I will examine the relevance for international groundwater law of the work of the ILC, and the 1997 UN Convention that is based on that work.

---

* Professor of Law, University of the Pacific, McGeorge School of Law Sacramento, California, USA.

[1] Convention on the Law of the Non-Navigational Uses of International Watercourses, 21 May 1997, U.N. Doc. A/RES/51/229, July 8, 1997 (hereinafter referred to as "UN Convention"). *See* generally Lucius Caflisch, *La Convention du 21 May 1997 sur l'utilisation des cours d'eau internationaux à des fins autre que la navigation*, 43 ANN. FR. DE DROIT INT'L 751 (1997); John Crook & Stephen McCaffrey, *The United Nations Starts Work on a Watercourses Convention*, 91 AM. J. INT'L L. 374 (1997); Stephen McCaffrey & Mpazi Sinjela, *The 1997 United Nations Convention on International Watercourses*, 92 AM. J. INT'L L. 97 (1998); Lucius Caflisch, *Regulations of the Uses of International Watercourses*, and Stephen McCaffrey, *The UN Convention on the Law of the Non-Navigational Uses of International Watercourses: Prospects and Pitfalls*, both *in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT, at 3 and 17 (World Bank Technical Paper No. 414, 1998).

THE NATURE OF SHARED GROUNDWATER RESOURCES AND THE CHALLENGES FOR INTERNATIONAL LEGAL REGULATION

The manifestations of groundwater that may be considered as proper objects of international legal regulation are diverse. To attempt to define the types of groundwater with which international law should be concerned, we must inquire as to the purpose or function of the law in the field of international watercourses generally, which is well expressed in the preamble to the 1997 UN Convention. The preamble, *inter alia*, states that successful codification and progressive development of the law in the field "would assist in promoting and implementing the purposes and principles set forth in Articles 1 and 2 of the Charter of the United Nations."[2] Those purposes and principles include provisions concerning the most fundamental interests of the international community, namely, maintenance of international peace and security; development of friendly relations among nations; achievement of international cooperation on problems of an economic, social, cultural or humanitarian character; sovereign equality of all member states; and peaceful settlement of disputes. The preamble of the UN Convention goes on to refer to the "conviction" that a framework convention on international watercourses, setting forth clear principles and rules in the field, "will ensure the utilization, development, conservation, management and protection of international watercourses and the promotion of the optimal and sustainable utilization thereof for present and future generations."[3] Finally, paragraph 10 of the preamble affirms "the importance of international cooperation and good-neighborliness in this field."

All of these considerations suggest that international law is properly concerned with the regulation of groundwater when activities in one state affect groundwater in such a way as to affect other states or international watercourse systems themselves. The following possibilities, framed by Mr. Barberis, illustrate how groundwater in one State may be related to ground- or surface water in another State:

> (i) ...where a confined aquifer is intersected by an international boundary...;
>
> (ii) where an aquifer lies entirely within the territory of one State but is hydraulically linked with an international river. Here it is necessary to distinguish between the situations where the river is influent and where it is effluent. Thus,
>
> - if one is dealing with an influent river and the aquifer lies in the downstream State, the use of the river water by an upstream State may affect the recharge regime; and

---

[2] UN Convention, Preamble, para. 3, *supra* note 1.

[3] *Id.* para. 5.

- if the river is effluent, excessive withdrawals from the aquifer feeding it may reduce the volume of flow in the latter. ...

(iii) where the aquifer is situated entirely within the territory of a single State and is linked hydraulically with another aquifer in a neighboring State, the connection may arise through the presence of a semi-permeable layer of, for example, clayey loam. ...

(iv) where an aquifer is situated entirely within the territory of a given State but has its recharge zone in another State.[4]

In this Chapter, the term "international groundwater" will be used to comprise all of these different situations.

It is clear from Mr. Barberis' catalogue that activities in one state may affect groundwater there or in other states in a variety of different ways. And therein lies the challenge for international legal regulation.[5] State practice with respect to groundwater has lagged behind that concerning surface water. This appears to be the case in large part because states have until recently been largely unaware of the physical interrelationships to which I have referred. However, as we now know, surface water, in relation to groundwater, is the veritable tip of the iceberg – both in terms of its visibility, in contrast to the "invisibility" of groundwater, and in terms of its quantity vis-à-vis that of groundwater. But it is perhaps the first of these characteristics, groundwater's "invisibility," that is chiefly responsible for the inattention of states to this critical and comparatively vast resource.

There is another important factor that bears upon international legal regulation of groundwater, and that is the notion of territorial sovereignty. Groundwater is, by definition, in the ground, and no one disputes that states are sovereign with respect to

---

[4] JULIO A. BARBERIS, INTERNATIONAL GROUNDWATER RESOURCES LAW 36 (FAO Legislative Study No. 40, 1986).

[5] A United Nations expert group report on "Strategic Issues Concerning Transboundary Water Resources" identified the following specific characteristics of, and necessary actions concerning, groundwater resources in transboundary settings, among others:

1. They have "three-dimensional flow domains," in addition to the well-accepted hydraulic interdependence between surface waters and shallow groundwater;
2. they are vulnerable to long-term, if not permanent, contamination, land subsidence and saline intrusion;
3. it is necessary to identify and protect recharge zones; and
4. problems may arise from cross-boundary exploitation of aquifers, *inter alia* through directional drilling or over-pumping.

Ad Hoc Expert Group Meeting on Strategic Issues Concerning Transboundary Water Resources, New York, 14 May 1996, U.N. Doc. WA/SEM.97.1, at 4-5.

their soil.[6] It may therefore be difficult for states to recognize that they are not absolutely sovereign with respect to groundwater within their borders, despite the fact that it is, in reality, shared in some way with other states. While states now accept that they have obligations vis-à-vis other riparian states with regard to internationally shared surface water flowing through their territories or along their boundaries,[7] a state may be slower to accept that other states, in effect, have rights with regard to the way in which it uses groundwater in its territory. These concerns were evident within the International Law Commission, but members of the ILC ultimately concluded that since most groundwater also flows – albeit at slower rates – and is related to surface water, it should be included in the legal regime governing international watercourses. They also recognized that to exclude groundwater from the Commission's draft articles would be to subvert the entire regime they establish. The following section will examine the treatment of groundwater in the practice of states.

GROUNDWATER IN STATE PRACTICE

This section will first review illustrations of international agreements relating to groundwater. It will then discuss two cases involving groundwater, one decided in the 1920s by a national court in a federal system according to principles of international law, and another decided recently by the International Court of Justice.

International Agreements[8]

Perhaps because the characteristics and extent of groundwater have until recently been little understood, this integral part of watercourse systems has often been ignored in State treaty practice concerning international fresh water resources. Nevertheless, a number of international agreements do address groundwater, or at least include it within their scope. One study contains a compilation of treaties concerning international groundwater which are arranged in the following categories: "International Agreements Concerning the Use of Wells and Springs in Frontier Areas;"[9] "Frontier Waters Agreements Indirectly Protecting Ground Waters;"[10] "Comprehensive Agreements

---

[6] By this I do not mean at all to imply that states have no duties to other states with regard to how they treat their soil. *See*, e.g., the Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 17 June 1994, preamble (referring to Principle 2 of the Rio Declaration), U.N. Doc. A/AC.241/15/Rev.3, *reprinted in* 33 I.L.M. 1332 (1994).

[7] Thus, the "Harmon Doctrine" of absolute sovereignty is generally rejected. *See* generally Stephen McCaffrey, *The Harmon Doctrine One Hundred Years Later: Buried, Not Praised*, 36 NAT. RESOURCES J. 965 (1996).

[8] *See* generally the compilation of treaties relating to groundwater *in* LUDWIK A. TECLAFF & ALBERT E. UTTON EDS., INTERNATIONAL GROUNDWATER LAW 189 (1981), hereinafter referred to as INTERNATIONAL GROUNDWATER LAW; and the analytical survey of treaty provisions concerning groundwater *in* JULIO A. BARBERIS, *supra* note 4, at 20.

[9] INTERNATIONAL GROUNDWATER LAW, *supra* note 8, at 193-211.

[10] *Id.* at 213-220.

Specifically Including Ground Waters Within Their Scope;"[11] and "Agreements Recognizing the Effects of Surface Water Development on Ground Waters, and of Ground Water Development Upon Surface Waters."[12] It may be surprising that some of these treaties date back to the early part of the 20th century.

The former Yugoslavia was a party to several agreements (with Hungary, Albania, and Bulgaria, respectively) which apply to "all water economy questions, measures and works on watercourses which form the State frontier and watercourses and water systems intersected by the State frontier, and in particular to: ...(g) Questions of ground water ...."[13] The agreements of the former Yugoslavia with Albania and Hungary define the expression "water system" to mean "all watercourses (surface or underground, natural or artificial), installations, measures and works which may affect watercourses from the standpoint of water economy, and installations forming or intersected by the State frontier."[14] Similarly, the 1964 Treaty between Poland and the Soviet Union defines "frontier waters" to include "ground waters intersected by the State frontier"[15] and provides that the parties will cooperate with regard to "the protection of surface and ground waters against depletion and pollution."[16]

The 1968 African Convention on the Conservation of Nature and Natural Resources recognizes the importance of common groundwater resources in its Article 5:

> Where surface or underground water resources are shared by two or more of the Contracting States, the latter shall act in consultation, and if the need arises, set up inter-State Commissions to study and resolve problems

---

[11] *Id.* at 221-246. There are five agreements contained in this category.

[12] *Id.* at 247-281. This category contains ten agreements.

[13] *See* UNITED NATIONS, LEGISLATIVE TEXTS AND TREATY PROVISIONS CONCERNING THE UTILIZATION OF INTERNATIONAL RIVERS FOR OTHER PURPOSES THAN NAVIGATION, Treaty Nos. 228, 128 and 161, U.N. Doc. ST/LEG/SER.B/12 (1963) (hereinafter referred to as LEGISLATIVE TEXTS). The quotation is from the agreement between Hungary and Yugoslavia of August 8, 1955; the other agreements mentioned contain similar language, although the paragraph designation may be different. For example, the agreement between Bulgaria and Yugoslavia of April 4, 1958, refers in its Article 1, paragraph 2(f) to "The study and utilization of ground-water...." *id.* Treaty No. 161.

[14] *Id.* Treaty Nos. 128 and 228, Article 1, para. 3.

[15] Article 2, para. 3, 552 U.N.T.S. 175.

[16] *Id.* Article 3, para. 7. *See* also the 1972 Convention between Switzerland and Italy concerning the protection of frontier waters against pollution, which provides for the establishment of a joint commission to investigate the pollution of surface and groundwaters, REV. GEN. DE DROIT INT'L PUBL. 265 (1975); and the Frontier Rivers Agreement of September 16, 1971, between Finland and Sweden, Chapter 3, Article 1, which provides that the provisions of that Chapter apply, *inter alia*, to "measures taken in any waters which may affect ground water conditions." 825 U.N.T.S. 272. The latter treaty (but not the provision in question) is summarized in 2 Y.B. INT'L L. COMM'N 319 (1974), U.N. Doc. A/CN.4/274 (1974), para. 307.

arising from the joint use of these resources, and for the joint development and conservation thereof.[17]

Article 1(1) of the 1995 Protocol on Shared Watercourse Systems in the Southern African Development Community (SADC) Region defines the term "drainage basin" to mean: "a geographical area determined by the watershed limits of a system of waters including underground waters flowing into a common terminus."[18] (This "common terminus" requirement probably excludes so-called confined transboundary groundwater from the scope of the SADC Protocol.)

The 1992 ECE Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes defines "transboundary waters" to mean: "any surface or ground waters which mark, cross or are located on boundaries between two or more States;...."[19]

Aquifers are an important water source in the arid region along the border between Mexico and the United States.[20] In an effort to "control the adverse effect which pumping near the border by one country has on the other,"[21] a 1973 agreement between Mexico and the United States limits groundwater pumping to 160,000 acre-feet (197,558 m^3) annually within five miles (eight kilometers) on either side of the Arizona-Sonora boundary.[22] The agreement further requires the two countries to consult each other "prior to the undertaking of any new development of either the surface or the ground water resources ... in its own territory in the border area that might adversely affect the other country."[23]

A current problem in this region concerns the question of lining the "All-American Canal." This is a situation created by human intervention in natural water systems. The so-called "All American Canal" began operation in 1942 as a water transfer scheme within the United States. But seepage from the canal contributed significantly to

---

[17] African Convention on the Conservation of Nature and Natural Resources, Algiers, September 15, 1968, Article 5, para. 2, reprinted *in* U.N. D.T.C.D., TREATIES CONCERNING THE UTILIZATION OF INTERNATIONAL WATER COURSES FOR OTHER PURPOSES THAN NAVIGATION, AFRICA, at 2 (U.N. D.T.C.D Natural Resources/Water Series No. 13, 1984).

[18] Maseru, May 16, 1995.

[19] Helsinki, March 17, 1992, 31 I.L.M. 1312 (1992). *See* also SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT, ANNEX 3, at 203 (World Bank Technical Paper No. 414, 1998).

[20] For a survey of the literature concerning groundwater between Mexico and the United States *see* Julio A. Barberis, *supra* note 4, at 60, referring to fifteen studies.

[21] A. ROVINE, DIGEST OF UNITED STATES PRACTICE IN INTERNATIONAL LAW 1973, at 426 (U.S. Department of State Publication, 1974).

[22] Agreement between the United States and Mexico of August 30, 1973, approving Minute 242 of the International Boundary and Water Commission, setting forth a permanent and definitive solution to the international problem of the salinity of the Colorado River, 24 U.S.T. 1968.

[23] *Id.*

groundwater supplies in Mexico (offsetting to some extent the losses of Colorado River water to American users). To prevent loss of water from the canal, US authorities have proposed lining it. This would reduce the amount of groundwater available to Mexican agricultural users in the Mexicali Valley, who have come to rely upon it. This is a rather unusual case, since the groundwater in question has its source in an artificial water-transfer scheme. It is not entirely unique, however, as illustrated by Asit Biswas' description of the canal lining in the Indian state of Tamil Nadu, which, while done in the name of efficiency, results in what he characterized as a de facto reallocation of water from the agricultural sector to the urban sector.[24]

The case reviewed in the following part of this section involves allegations of actions having transborder effects, and illustrates the complex interplay between surface and groundwater.

The Donauversinkung Case

In 1927 the German *Staatsgerichtshof*, or highest court, decided a case in which the German states of Württemberg and Prussia sued the state of Baden seeking relief from the phenomenon of the "sinking of the Danube," or *Donauversinkung*.[25] In deciding the case, the *Staatsgerichtshof* applied rules of international law, it having found that it was impossible to apply the municipal law of one of the federal states, and that there were no applicable provisions of the German constitution.[26] The facts of the case were as follows: After emerging from the Black Forest, the Danube in its upper reaches passes the Swabian Jura mountains between Baden and Württemberg, the latter state lying downstream of the former. The court explained that, while in the state of Baden, the Danube

> ...loses during certain periods of the year a considerable part of its water in consequence of the water sinking under the bed of the river and flowing to the lower levels of the Lake of Constance and of the Rhine. The reason

---

[24] Asit Biswas, Keynote Address, "Looking Ahead: Water in the Next Millennium," World Bank Seminar, "Groundwater: Legal and Policy Perspectives," April 19, 1999; oral presentation. This portion of the presentation is not included in the "Introduction" of this Report.

[25] Württemberg and Prussia v. Baden (The *Donauversinkung* Case), German *Staatsgerichtshof*, June 18, 1927, *Entscheidungen des Reichsgerichts in Zivilsachen*, 116 RGZ, Appendix, at 18-45. The report of the case upon which the following discussion is based is found in ARNOLD MCNAIR & HERSCH LAUTERPACHT EDS., ANNUAL DIGEST OF PUBLIC INTERNATIONAL LAW CASES - YEARS 1927 AND 1928, at 128 (hereafter referred to as ANNUAL DIGEST). The case is discussed in Lederle, *Die Donauversinkung, in* ANNALEN DES DEUTSCHEN REICHS, at 693 (1927). *See* also the discussion of this case in Julio A. Barberis, *supra* note 4, at 40-41. Today Württemberg and Baden are combined, forming the Land of Baden-Württemberg.

[26] The court found that "[t]he members of the [German] Federation have, subject to considerable limitations, preserved their position as independent States. ...[I]n matters subject to State legislation they may, subject to the confirmation of the *Reich*, conclude treaties with foreign Powers. In so far, therefore, as these States act as independent communities, i.e., in matters reserved for their exclusive competence, their relations are governed by international law...." *Id.* ANNUAL DIGEST, at 130.

> for this loss of water ... is the geological composition of the banks and of the bed of the river. They are composed of chalk through the cracks and pores of which the water of the Danube in this section flows south in subterranean passages in order to emerge eventually as the source of the river Aach in Baden.[27]

In hydrologic terms, the flow from the Danube into the aquifer would be described as "influent" flow, or seepage, and that from the aquifer into the Aach as "effluent" flow.[28] As the above passage makes clear, the infiltration of the Danube waters occurred in Baden, and the waters reappeared in the same state but flowed into a different drainage basin, that of the Rhine river; they did not return to the Danube basin. The court described the source of the river Aach, formed by Danube waters, as "one of the most powerful in Germany. As [a] result, the river Aach, in ... its short course through Baden terminating in the Lake of Constance, is very rich in water which is extensively utilised for industrial purposes."[29] In Württemberg, on the other hand, "in a portion of the river extending from 10 to 12 kilometres, there occurs, for varying periods of time, a so-called total sinking of the Danube, that is, a complete drying up of the river."[30]

Württemberg asked the court to grant an "injunction restraining Baden from constructing and maintaining certain [works] . . . as well as for an order instructing Baden to render possible, by removing the natural obstacles which accumulate in the bed and on the banks of the river..., an unimpeded flow of water." For its part, Baden requested an injunction restraining Württemberg from constructing and maintaining certain works that were allegedly intended to prevent the natural flow of the Danube waters to the Aach. Prussia, which was then downstream of Württemberg and was also injured by the loss of water from the Danube, intervened in the suit on the side of Württemberg.

The court held that "Baden must refrain from causing such increase in the natural sinking of the waters of the Danube as is due (a) to the artificially erected ... work ... and (b) to the accumulation of sand and gravel in the bed of the Danube..., but that it is not bound to undertake the responsibility for the permanent improvement of the bed of the river;"[31] and that Württemberg was required to refrain from causing such decrease in the natural sinking of Danube waters as was due to certain works and artificial damming of avenues of sinking.

In its decision, the court made several interesting statements concerning relevant legal principles and the way in which they applied to the case before it:

---

[27] *Id.* 128.

[28] R. WARD, PRINCIPLES OF HYDROLOGY 194 (London, McGraw-Hill, 2d ed. 1975).

[29] ANNUAL DIGEST, *supra* note 25, at 128-129.

[30] *Id.* 129. "The number of days on which the river was thus dried up was 309 in 1921, 29 in 1922, 148 in 1923."

[31] *Id.*

C. *The Rule of International Law as to the Utilisation of the Flow of International Rivers. The Duty to Abstain from Injurious Interference.* - 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 interests of other members of the international community. ... No State may substantially impair the natural use of the flow of such a river by its neighbour. This principle has gained increased recognition in international relations. ... The application of this principle is governed by the circumstances of each particular case. The interests of the States in question must be weighed in an equitable manner against one another. ...

D. *The Duty to Perform Positive Acts.* - The above principle merely prohibits artificial alterations in the flow of the river. It follows that every State must submit to the natural flow of the water in spite of its consequences. Barring an express contractual undertaking, no State is under a duty to interfere, in favour of another State, with the natural flow of the water. ... The sinking of the Danube is a natural, though rare, phenomenon, and Württemberg and Prussia must submit to it. They cannot demand from Baden that it should close the cracks which suck away the water of the Danube. Neither is Baden bound to counteract such diminution in the waters of the Danube as is due to the natural enlargement of and accretion to the banks. It is only within certain closely defined limits that Baden is bound to act in a positive manner.

The principle that a State is under no duty to regulate, in the interest of another State, the natural phenomena affecting an international river, is subject to one limitation grounded in the modern practice of States in regard to rivers. Rivers, including those which are non-navigable, are today no longer merely the product of natural forces. Their banks are inhabited, and it is in the interest of the inhabitants, both in the upper and lower parts of the rivers, that the banks be strengthened and that the flow of the water be subject to regulation, not only on account of possible inundation, but as a matter of normal policy. Thus, while a State is under a duty to abstain from altering the flow of the river to the detriment of its neighbours, it must not fail to do what civilised States nowadays do in regard to their rivers. If a Government fails to undertake, or even prohibits, measures which it must be expected to undertake in accordance with generally recognised rules of law and economic policy - with the intention or with the result that the interests of persons outside its territory are thereby injuriously affected - then such an attitude cannot be regarded as being in accordance with the nature of a community of nations. This ceases to be a mere passive attitude, and becomes an unlawful furthering, through acts of omission, of certain natural events. This duty to perform positive acts has been clearly recognised in regard to the requirements of navigation on international rivers. There is no reason why it should not

apply to questions relating to the utilisation of the flow of rivers for industrial purposes.[32]

The legal principles applied by the court are generally consonant with those contained in the UN Convention - especially those of equitable utilization and the obligation to prevent significant harm. The court's discussion of the duty to regulate natural phenomena through the performance of positive acts would appear to go somewhat beyond the article of the UN Convention on "Regulation" (Article 25), which merely calls for cooperation, "where appropriate, to respond to needs or opportunities for regulation of the flow of the waters of an international watercourse."

The agreements referred to in the first part of this section do not all evidence an appreciation of the close interrelationship between surface and groundwaters of the kind involved in the *Donauversinkung* case; but they do demonstrate that States have for some time been aware of the importance of protecting groundwater resources.

The Gabcíkovo-Nagymaros Case

On September 25, 1997, the International Court of Justice rendered its judgment in the case concerning the Gabcíkovo-Nagymaros Project (Hungary v. Slovakia).[33] Briefly, the case concerned a project on the Danube River, consisting of a series of dams and other works, that was to have been constructed pursuant to a 1977 treaty between Hungary and Czechoslovakia. The project covered approximately 200 kilometers of the Danube between Bratislava and Budapest. It included a barrage at the Slovak city of Gabcíkovo on a 31-kilometer-bypass canal in Czechoslovak (now Slovak) territory. Hungary suspended work on the project in 1989, subsequently abandoned work on the project, and purported to terminate the 1977 treaty unilaterally in 1992.

Included in Hungary's grounds for stopping work on the project and terminating the treaty were contentions that the project posed ecological dangers. Some of these dangers related to groundwater. In the words of the Court, Hungary contended, *inter alia*, that as a result of a reduction of the flow in the old bed of the Danube by diversion of water into the bypass canal:

> [T]he groundwater level would have fallen in most of the Szigetköz [area of Hungary, opposite the bypass canal]. Furthermore, the groundwater would then no longer have been supplied by the Danube – which, on the contrary, would have acted as a drain – but by the reservoir of stagnant water at Dunakiliti [the site of the dam that would divert water into the bypass canal] and [by] the side-arms which would have become silted up.

---

[32] *Id.* at 131-132.

[33] Case Concerning the Gabcíkovo-Nagymaros Project (Hungary v. Slovakia), 1997 I.C.J. 7 (September 25); *see* also Philippe Sands, *Watercourses, Environment and the International Court of Justice: The Gabcicovo-Nagymaros Case, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., *supra* note 1, at 103.

> In the long term, the quality of the water would have been seriously impaired. ...
>
> As for [the barrage further downstream in Hungarian territory at] Nagymaros, Hungary argued that, if that dam had been built, the bed of the Danube upstream would have silted up and, consequently, the quality of the water collected in the bank-filtered wells would have deteriorated in this sector. ... Furthermore, the construction and operation of the Nagymaros dam would have caused the erosion of the riverbed downstream, along Szentendre Island. The water level of the river would therefore have fallen in this section and the yield of the bank-filtered wells providing two-thirds of the water supply of the city of Budapest would have appreciably diminished. The filter layer would also have shrunk or perhaps even disappeared, and fine sediments would have been deposited in certain pockets in the river. For this twofold reason, the quality of the infiltrating water would have been severely jeopardized.
>
> From all these predictions, in support of which it quoted a variety of scientific studies, Hungary concluded that a "state of ecological necessity" [existed] in 1989.[34]

Slovakia, for its part:

> denied that there had been any kind of "ecological state of necessity" in this case either in 1989 or subsequently. It invoked the authority of various scientific studies when it claimed that Hungary had given an exaggeratedly pessimistic description of the situation. Slovakia did not, of course, deny that ecological problems could have arisen. However, it asserted that they could to a large extent have been remedied.[35]

Slovakia also contended that the ecological threats alleged by Hungary could be avoided through the monitoring system Slovakia had installed, and that the project had been modified in various ways since 1977 and could be modified further to address Hungary's concerns.

The Court, in ruling on the parties' contentions, found that Hungary had not established a case of an "ecological state of necessity" that would allow it to abandon the project, or to terminate the treaty. It recalled, however, that it had:

> ...recently had occasion to stress, in the following terms, the great significance that it attaches to respect for the environment, not only for States but also for the whole of mankind:

---

[34] *Id.* para. 40, at 35-36.

[35] *Id.* para. 44, at 37.

> 'the environment is not an abstraction but represents the living space, the quality of life and the very health of human beings, including generations unborn. The existence of the general obligation of states to ensure that activities within their jurisdiction and control respect the environment of other States or of areas beyond national control is now part of the corpus of international law relating to the environment.' (*Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, I.C.J. Reports 1996, pp. 241-242, para. 29.)'*[36]

In the present case, however, Hungary was unable to establish to the satisfaction of the Court that the "peril" it perceived from the project was sufficiently "imminent" to justify its withdrawal from the project and the treaty. While the Court did not exclude that a "peril" appearing in the long term could be considered "imminent" if it were established that it would inevitably materialize, the Court found that this had not been established in the present case – especially since Hungary itself had admitted that the peril remained uncertain:

> As Hungary itself acknowledges, the damage that it apprehended had primarily to be the result of some relatively slow natural processes, the effects of which could not easily be assessed.[37]

The Court also concluded that Hungary could have resorted to other means of responding to the apprehended dangers, means that were within the treaty framework.[38]

This case illustrates the problems of proof a state might encounter in making a successful claim concerning apprehended prospective harm to groundwater resources, or even to surface water resources as a result of contamination of, or abstraction from, groundwater in another state. However, it must be recalled that the Court in this case was evaluating Hungary's claims in the context of a technical doctrine of the law of state responsibility, namely, the "state of necessity" as a circumstance precluding wrongfulness. For what Hungary had argued was that the project gave rise to a state of ecological necessity that precluded what would otherwise have been the wrongfulness of its work stoppage and purported termination of the treaty.[39] One of the requirements of this defense is, as suggested above, that the perceived peril be "imminent." This requirement would not apply in other contexts, as where, e.g.: State A requested information from State B concerning a proposed project in the latter state that State A believed would affect shared groundwater resources; State A requested State B to prepare

---

[36] *Id.* para. 53, at 41.

[37] *Id.* para. 56, at 43-44.

[38] *Id.* para. 57, at 45.

[39] The Court agreed with Slovakia that a state of necessity "is not a ground for the termination of a treaty." *Id.* para. 101, at 63. Instead, the treaty may, in effect, become "dormant," but "it continues to exist. As soon as the state of necessity ceases to exist, the duty to comply with treaty obligations revives."

an impact assessment concerning that project; or where State A demanded that State B cease an activity that would result in significant harm to State A. But what the Court described as "relatively slow natural processes, the effects of which could not easily be assessed," would presumably be involved in many, if not most, disputes concerning groundwater, and would increase the legal burden on the state that was injured or threatened.

THE WORK OF INTERNATIONAL NON-GOVERNMENTAL ORGANIZATIONS AND EXPERT GROUPS

A number of aquifers relied upon by human populations are intersected by international boundaries. Some of the most important of these are situated in North Africa, where they may underlie as many as four or more States.[40] This fact, together with the interrelationship between surface and groundwaters discussed above, has led various organizations and groups of experts to prepare draft rules or agreements concerning international, or transboundary groundwaters. In the words of the Rapporteur for the efforts of the International Law Association (ILA) in this field,

> The growing groundwater crisis, the legal implications of surface-underground interactions, and the characteristics of aquifers and their waters have moved States generally to prescribe uncommon measures internally and, now, to call for analogous treatment for those transboundary aquifers already under stress.[41]

Indeed, the Helsinki Rules, adopted by the ILA in 1966, defined the term "international drainage basin" as being "determined by the watershed limits of the system of waters, including surface and *underground waters*, flowing into a common terminus."[42] Thus, groundwater was expressly included within the scope of that important

---

[40] Examples are the Nubian Sandstone Aquifer beneath portions of Chad, Egypt, Libya and Sudan; the aquifer in the Northern Sahara basin shared by Algeria, Tunisia and Libya; the Chad Aquifer underlying parts of Chad, Niger, Sudan, the Central African Republic, Nigeria and Cameroon; and the Maestrichian basin shared by Senegal, Gambia, Guinea Bissau and Mauritania. Dante A. Caponera & Dominique Alheritiere, *Principles for International Groundwater Law*, 18 NAT. RESOURCES J. 590 (1978); Albert E. Utton, *The Development of International Ground Water Law*, 22 NAT. RESOURCES J. 100, 103 (1982); and U. N. DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT, TRANSNATIONAL PROJECT ON THE MAJOR REGIONAL AQUIFER IN NORTH-EAST AFRICA, EGYPT AND THE SUDAN, PROJECT FINDINGS AND RECOMMENDATIONS, at 7, U.N. Doc. DP/UN/RAB-82-013/1 (1988).

[41] International Law Association, *International Water Resources Law - Report of the Committee, in* ILA, REPORT OF THE SIXTY-SECOND CONFERENCE HELD AT SEOUL AUGUST 24TH TO AUGUST 30TH, 1986, at 231 (1987) (hereinafter referred to as ILA SEOUL REPORT). The Rapporteur, Professor Robert Hayton, has explained to the author that the word "uncommon" as used here refers to the fact that, at least at the time, it was still relatively unusual for States to recognize the interdependence of surface and groundwaters and the special characteristics of groundwater and aquifers.

[42] Helsinki Rules on the Uses of the Waters of International Rivers, Article II, *in* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE FIFTY-SECOND CONFERENCE HELD AT HELSINKI AUGUST 14TH TO AUGUST 20TH, 1966 477, at 484 (1967).

set of draft rules concerning international watercourses, but only such groundwater as was related to surface water or that otherwise "flow[s] into a common terminus."

The ILA's Seoul Rules on International Groundwaters

The ILA's Rules on International Groundwaters, adopted at the Seoul Conference of the Association in 1986, consist of four articles. These articles (the "Seoul Rules") deal specifically with aquifers that are intersected by international boundaries,[43] since these would not have been covered by the Helsinki Rules unless they constituted a part of a system of waters, "including surface ... waters...."[44] The articles provide that the States within whose territories such groundwaters are located are "basin States" within the meaning of the Helsinki Rules (Article 1).[45] By including States that share an international aquifer within the term "basin States," this key provision makes the Helsinki Rules applicable to the use of international groundwaters;[46] it thus represents the considered judgment of the ILA and its committee of specialists on international water resources law that the rules governing surface waters are applicable not only to the entire *system* of waters, including groundwater - a fundamental principle underlying the Helsinki Rules - but also to those groundwaters which do not "form with surface waters part of a hydraulic system flowing into a common terminus."[47] This would support inclusion of shared groundwater resources in the international legal regime, whether or not it was related to surface water.

---

[43] Rules on International Groundwaters, Article 1, *in* ILA SEOUL REPORT, *supra* note 41, at 251.

[44] *Id.* at 259, Article 2. Thus, the Seoul Rules both apply the Helsinki Rules to aquifers that are not related to significant international surface waters and prescribe specific rules concerning international groundwater, whether or not related to surface water.

[45] Article 1 provides as follows:

> Article 1
>
> THE WATERS OF INTERNATIONAL AQUIFERS*
>
> The waters of an aquifer that is intersected by the boundary between two or more States are international groundwaters and such an aquifer with its waters forms an international basin or part thereof. Those States are basin States within the meaning of the Helsinki Rules whether or not the aquifer and its waters form with surface waters part of a hydraulic system flowing into a common terminus.
>
> * The term 'aquifer' as here employed comprehends all underground water bearing strata capable of yielding water on a practicable basis, whether these are in other instruments or contexts called by another name such as 'groundwater reservoir,' 'groundwater catchment area,' etc., including the waters in fissured or fractured rock formations and the structures containing deep, so-called 'fossil waters.'"

ILA SEOUL REPORT, *supra* note 41, at 251.

[46] *Id.*

[47] The quoted language is from Article 1 of the Seoul Rules. Article 2 of the Rules specifically provides that "[a]n aquifer intersected by the boundary between two or more States that does not contribute water to, or receive water from, surface waters of an international drainage basin constitutes an international drainage basin for the purpose of the Helsinki Rules." Article 2, para. 2, ILA SEOUL REPORT, *supra* note 41, at 259.

Further demonstrating special concern with international groundwater are the provisions of the Seoul Rules dealing with "Hydraulic Interdependence" (Article 2),[48] "Protection of Groundwater" (Article 3)[49] and "Groundwater Management and Surface Waters" (Article 4).[50]

---

[48] Article 2 provides as follows:

Article 2

HYDRAULIC INTERDEPENDENCE

1. An aquifer that contributes water to, or receives water from, surface waters of an international basin constitutes part of that international basin for the purposes of the Helsinki Rules.
2. An aquifer intersected by the boundary between two or more States that does not contribute water to, or receive water from, surface waters of an international drainage basin constitutes an international drainage basin for the purpose of the Helsinki Rules.
3. Basin States, in exercising their rights and performing their duties under international law, shall take into account any interdependence of the groundwater and other waters, including any interconnections between aquifers, and any leaching into aquifers caused by activities in areas under their jurisdiction.

Id. at 259.

[49] Article 3 provides as follows:

Article 3

PROTECTION OF GROUNDWATER

1. Basin States shall prevent or abate the pollution of international groundwaters in accordance with international law applicable to existing, new, increased and highly dangerous pollution. Special consideration shall be given to the long-term effects of the pollution of groundwater.
2. Basin States shall consult and exchange relevant available information and data at the request of any one of them
   (a) for the purpose of preserving the groundwaters of the basin from degradation and protecting from impairment the geologic structure of the aquifers, including recharge areas;
   (b) for the purpose of considering joint or parallel quality standards and environmental protection measures applicable to international groundwaters and their aquifers.
3. Basin States shall co-operate, at the request of any one of them, for the purpose of collecting and analyzing additional needed information and data pertinent to the international groundwaters or their aquifers.

Id. at 268.

[50] Article 4 provides as follows:

Article 4

GROUNDWATER MANAGEMENT AND SURFACE WATERS

Basin States should consider the integrated management, including conjunctive use with surface waters, of their international groundwaters at the request of any one of them.

Id. at 272.

The Bellagio Draft Treaty

Another major effort to formulate legal rules concerning the use, protection and management of international groundwater resources is the Bellagio Draft Treaty concerning the Use of Transboundary Groundwaters.[51] Prepared by an independent group of international experts, this instrument consists of a complete draft treaty containing twenty articles together with supporting commentaries. As such, rather than attempting to restate the rules of general international law concerning shared groundwater, the Bellagio Draft Treaty lays out principles and mechanisms states may wish to adopt, in treaty form, to manage their shared groundwater resources. Article II, "General Purposes," provides that "[t]he Parties recognize their common interest and responsibility in ensuring the reasonable and equitable development and management of groundwaters in the border region for the well being of their Peoples."[52] The Draft contemplates the establishment of a joint commission for the implementation of the provisions of the articles (Article III), or the use of an existing body for this purpose.[53] It further provides, *inter alia*, for the establishment and maintenance of a database (Article V) – something that is especially important in the case of groundwater,[54] water quality protection (Article VI), the establishment of transboundary groundwater conservation areas (Article VII), the preparation of comprehensive management plans (Article VIII), measures to deal with public health emergencies (Article IX), planning for drought (Article XII), public participation (Article XIII), accommodation of differences (Article XV), and resolution of disputes (Article XVI).

The Bellagio Draft Treaty highlights the special usefulness of joint commissions in the case of groundwater. For example, the draft provides in Article III(7) that any party may request the assistance of the Commission concerning matters originating in the requesting state's territory. As examples of the types of assistance that might be requested, the commentary gives assessment of the transboundary impact of a planned project – which could require data from both sides of the border – and the question whether a use of, or affecting, international groundwater resources is within the requesting state's rights of equitable utilization.

---

[51] For the full text of the Bellagio Draft Treaty *see* Robert D. Hayton & Albert E. Utton, *Transboundary Groundwaters: The Bellagio Draft Treaty*, 29 NAT. RESOURCES J. 643, at 676 (1989); *see* also ANNEX 3 of this Report.

[52] *Id.* Article II, para. 1, at 682.

[53] If a joint commission already existed, the Draft contemplates that its "powers and functions may readily be expanded to deal with the added responsibilities of transnational groundwater." Comment 1 to Article II, *id.* at 684-685.

[54] The importance of a shared set of data concerning international groundwater resources has been recognized by the United States and Mexico, which recently compiled and published a report containing data concerning one of the most critical areas along their common border. UNITED STATES OF AMERICA AND ESTADOS UNIDOS MEXICANOS, TRANSBOUNDARY AQUIFERS AND BINATIONAL GROUND-WATER DATA BASE, CITY OF EL PASO/CIUDAD JUAREZ AREA, FINAL REPORT, January, 1998.

The Bellagio Draft Treaty is an important model treaty, containing a set of proposed rules and institutional mechanisms for the rational use, protection and management of international groundwater resources. It reflects the belief of a multidisciplinary group of water resource specialists[55] that international groundwater must be included within water resources planning and management efforts if it is to be adequately protected, and utilized in an equitable and reasonable manner by the States concerned. This kind of approach, based on anticipation, planning and prevention, is especially important in the case of groundwater, since the residual remedies provided by the law are reactive in nature and thus of only limited use where international groundwater resources have been contaminated or seriously over-drafted.

THE WORK OF THE INTERNATIONAL LAW COMMISSION AND THE UNITED NATIONS CONVENTION

The Definition of "International Watercourse"

In 1994, the International Law Commission of the United Nations (ILC) completed its work on the Law of the Non-Navigational Uses of International Watercourses and transmitted a complete set of draft articles on the subject to the United Nations General Assembly for its consideration.[56] On May 25, 1997, the General Assembly adopted the UN Convention on the Law of the Non-Navigational Uses of International Watercourses.[57] The UN Convention was prepared by a Working Group of the Whole of the Sixth (Legal) Committee of the General Assembly, on the basis of the ILC's draft articles. The Working Group made some changes to the Commission's text, but preserved the basic structure of the draft and left many of the articles unaltered. On the question of groundwater, the Working Group made no significant changes.

The UN Convention's definition of "international watercourse" is, in effect,[58] a broad one, encompassing the entire "system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus."[59] The definition takes into account the usual interconnection between surface and underground water. It should be emphasized that the way in which the scope of the UN Convention is defined means that a particular aquifer need not be intersected by a border in order for it to be covered by the Convention's provisions; it is

---

[55] Those participating in the preparation of the Draft or earlier formulations are listed in Robert D. Hayton & Albert E. Utton, *supra* note 5, at 666, footnote 2.

[56] The draft articles are contained in the ILC's report to the General Assembly on the work of its forty-sixth session, U.N. Doc. A/49/10 (1994), *see* also in 2 Y.B. INT'L L. COMM'N 89 (1994), and ANNEX 1, *in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., *supra* note 1, at 173.

[57] *Supra* note1.

[58] Strictly speaking, the UN Convention defines the term "watercourse" broadly in Article (2)(a), then provides in Article (2)(b) that an "international watercourse" is "a watercourse, parts of which are situated in different States," *id.* Article 2(b).

[59] *Id.* Article 2(a).

enough if the aquifer is related to surface water that does cross or flow along a border. This would presumably include a recharge zone in one state that feeds an aquifer in another.

Of the various possible situations identified by Mr. Barberis,[60] the only one that would not be covered by the UN Convention is the first, the case of a so-called "confined aquifer." What this means is that the basic principles and rules contained in the UN Convention would apply to all forms of groundwater except these confined aquifers. Thus, the principles of equitable utilization, prevention of significant harm, prior notification concerning planned measures, and protection of aquatic ecosystems, in addition to the other provisions of the UN Convention, all apply to ground- and surface waters alike. Their application to aquifers may in some respects be more difficult as a practical matter, given that the influences of human activity on groundwater are generally more subtle and may take more time to manifest themselves than is true of surface water. But difficulty of practical implementation in no way affects the applicability of the principles and rules of the UN Convention as a matter of law.

An area in need of further study and clarification is whether the same set of rules are indeed suited to be applied equally to surface water and groundwater. It would seem that at the very least, some of the Convention's rules may be more stringent in the case of groundwater than they are when applied to surface water. The rules that come foremost to mind in this respect are the obligation to prevent significant harm (Article 7) and the obligation to protect shared freshwater resources from pollution and other forms of degradation (Articles 20 and 21). It seems clear that these provisions express obligations of due diligence.[61] They may have special force with regard to groundwater because, unlike surface water, it moves slowly and thus, once contaminated, may take years, even generations, to purify itself.[62]

This implies a heightened standard of diligence in the case of groundwater, one that may approach very nearly "strict liability" or "objective responsibility" for harm in one state (the "affected state") due to activities in another state (the "source state") that affect international groundwater. What this means is that a source state will have a heavy burden of proof once an affected state has made a *prima facie* showing that it has sustained significant harm as a result of the source state's contamination of an aquifer. A question that merits careful consideration is whether Articles 5, 6 and 7 of the UN Convention apply the same way to groundwater as to surface water. A strong argument could be made that because of the unique characteristics of groundwater, an exception

---

[60] *Supra* note 4.

[61] With regard to Article 7, *see* McCaffrey & Sinjela, *supra* note 1, 100. With regard to Article 21, *see* the "Statement of Understanding" adopted by the Working Group, stating that that Article, *inter alia*, "impose[s] a due diligence standard on watercourse States." Report of the Sixth Committee convening as the Working Group of the Whole, U.N. Doc. A/51/869, April 11, 1997, at 5. If Article 21 imposes such a standard, it would seem that, *a fortiori*, Article 20 does also.

[62] *See* Stephen Foster, Chapter 1 of this Report.

should be made to the normal priority given to equitable utilization (Articles 5 and 6) over prevention of harm (Article 7). But as the UN Convention stands, both surface and groundwater are governed by the system set forth in Articles 5 to 7, which appears to subordinate the prevention of harm to equitable utilization, where the two come into conflict. However, the anticipatory approach of the Convention's provisions concerning pollution,[63] which are not qualified by the equitable utilization principle, would of course apply equally to surface water and groundwater. As far as prior notification and consultation concerning planned measures are concerned, states will obviously have to be much more careful in the case of groundwater to anticipate and assess the potential impacts of planned measures on those resources. Such impacts are likely to be much less obvious in the case of international groundwater than where only surface water is involved.

The ILC's Resolution on "Confined Transboundary Groundwater"

The question of "confined groundwater"[64] was the subject of debate within the ILC during the last year of its work on the subject of international watercourses. The Special Rapporteur, Mr. Robert Rosenstock, had proposed including confined transboundary aquifers within the scope of the draft articles.[65] Referring to groundwater that does not interact with surface water, he argued that: "Inclusion of 'unrelated' confined groundwaters is the bare minimum in the overall scheme of the management of all water resources in an integrated manner."[66] He further stated that he was "convinced that the principles and norms applicable, in a framework convention or model rules, to watercourses and related groundwaters are equally applicable to unrelated confined groundwaters."[67]

In the end, however, the ILC did not accept the recommendation of the special rapporteur. Instead, it adopted a "Resolution on Confined Transboundary Groundwater."[68] The resolution "[c]ommends States to be guided by the principles contained in the draft articles on the law of the non-navigational uses of international watercourses, where appropriate, in regulating transboundary groundwater;..."[69] Furthermore, the preamble records the ILC's "...view that the principles contained in its draft articles on the law of the non-navigational uses of international watercourses may be

---

[63] Article 21 provides that watercourse states must "prevent, reduce and control pollution of an international watercourse and *may* cause significant harm to other watercourse States or to their environment...." *See supra* note 1, UN Convention, Art. 21(2) (emphasis added).

[64] It should be noted that this term may be used differently by lawyers and hydrologists. This is another indication of the need for greater attention by lawyers to the subject of groundwater.

[65] *See* Rosenstock's First and Second Reports, U.N. Doc. A/CN.4/451, para. 11, and U.N. Doc. A/CN.4/462, paras. 2-11.

[66] U.N. A/CN.4/462, para. 3, at 4.

[67] *Id.* para. 4.

[68] 2 Y.B. INT'L L. COMM'N 135 (1994); *see* also ANNEX 4 of this Report.

[69] *Id.* para. 1.

applied to transboundary confined groundwater,..."[70] Having gone this far, the ILC, one would think, could have taken the next step and included "confined transboundary groundwater" within the scope of the draft articles. But members of the ILC may have been uneasy about applying the principles and rules contained in the draft articles to something they had not had in mind when formulating the texts containing those principles and rules. After all, it was only in the last year of the ILC's work on the draft articles as adopted on first reading, *viz.*, 1991, that the ILC decided to include groundwater of any kind within the scope of the draft; extending the scope further to cover a form of groundwater that was, by definition, not related at all to surface water was evidently more than members of the ILC could accept. However, it is interesting to note that at its 1998 session, the ILC took note of the report of its Planning Group, which identified as one of the topics for inclusion in the ILC's long-term program of work, "[s]hared natural resources (confined groundwater and single geological structures of oil and gas)."[71] This suggests that the ILC may well turn its attention to the subject of confined transboundary groundwater once it has completed work on some of the topics on its current agenda.

The question therefore arises, what are the rules of international law that govern the protection and use of these so-called "transboundary confined aquifers?" The best evidence of those rules that is available would seem to consist of (a) the International Law Commission's Resolution on Confined Transboundary Groundwater, and (b) the International Law Association's Seoul Rules. Both of these instruments take the position that the principles and rules of international law governing the protection and use of surface waters are equally applicable to groundwaters. In the absence of any contradictory opinion of equal weight, or of significant state practice that is inconsistent with this proposition, one is led to conclude that the proposition itself is sound. Moreover, the fundamental policy considerations underlying the legal regime of surface and related groundwaters would seem to apply equally to confined transboundary aquifers. Indeed, in view of the more static quality of confined groundwater, some of these considerations would apply with even greater force to that form of groundwater, especially those concerning protection and sustainable use.

CONCLUSION

This Chapter has examined the present state of international law relating to internationally-shared groundwater resources. On the basis of the available evidence of state practice as well as recent codification and the 1997 UN Convention, it may be concluded that the law in this field has only progressed to the point that the general principles and rules governing the non-navigational uses of internationally shared surface water are applied to internationally shared groundwater resources as well, regardless of their form. As such, the law of international groundwater may only be said to be, at best, in the embryonic stages of development. The different characteristics and behavior of

---

[70] *Id.* last preambular para.

[71] ILC Report 1998, para. 554., at 218, para. 554.

groundwater would seem to justify stricter standards and more stringent protection than is applicable to surface water. The current legal regime governing surface water, as expressed in the 1997 UN Convention, may be sufficiently flexible as to be capable of adaptation to the particular requirements of groundwater, but this situation should prevail only until a special regime can be tailored for international groundwater. The legal regime applicable to so-called confined transboundary groundwater is perhaps even less clear than that applicable to international groundwater that is related to surface water, but there is support for applying the same rules to the former type of groundwater as to the other forms discussed in this Chapter.[72]

[72] *See*, in particular, the ILA's Seoul Rules, *supra* note 41, at 251; and the ILC's Resolution on Confined Transboundary Groundwater, *supra* note 68.

BIBLIOGRAPHY (Selected)

BARBERIS, JULIO A., INTERNATIONAL GROUNDWATER RESOURCES LAW 36 (FAO Legislative Study No. 40, 1986).

Caflisch, Lucius, *La Convention du 21 May 1997 sur l'utilisation des cours d'eau internationaux à des fins autre que la navigation*, 43 ANN. FR. DE DROIT INT'L 751 (1997).

Caflisch, Lucius, *Regulations of the Uses of International Watercourses, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT 3 (World Bank Technical Paper No. 414, 1998).

Caponera, Dante A. & Alheritiere, Dominique, *Principles for International Groundwater Law*, 18 NAT. RESOURCES J. 590 (1978).

Crook, John & McCaffrey, Stephen, *The United Nations Starts Work on a Watercourses Convention*, 91 AM. J. INT'L L. 374 (1997).

Hayton, Robert D. & Utton, Albert E., *Transboundary Groundwaters: The Bellagio Draft Treaty*, 29 NAT. RESOURCES J. 643 (1989).

Helsinki Rules on the Uses of the Waters of International Rivers, *in* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE FIFTY-SECOND CONFERENCE HELD AT HELSINKI AUGUST 14TH TO AUGUST 20TH, 1966 (1967).

International Law Association, *International Water Resources Law - Report of the Committee, in* ILA, REPORT OF THE SIXTY-SECOND CONFERENCE HELD AT SEOUL AUGUST 24TH TO AUGUST 30TH, 1986 231 (1987).

Lederle, *Die Donauversinkung, in* ANNALEN DES DEUTSCHEN REICHS 693 (1927).

McCaffrey, Stephen, *The Harmon Doctrine One Hundred Years Later: Buried, Not Praised*, 36 NAT. RESOURCES J. 965 (1996).

McCaffrey, Stephen, *The UN Convention on the Law of the Non-Navigational Uses of International Watercourses: Prospects and Pitfalls, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT 17 (World Bank Technical Paper No. 414, 1998).

McCaffrey, Stephen & Sinjela, Mpazi, *The 1997 United Nations Convention on International Watercourses*, 92 AM. J. INT'L L. 97 (1998).

MCNAIR, ARNOLD & LAUTERPACHT, HERSCH EDS., ANNUAL DIGEST OF PUBLIC INTERNATIONAL LAW CASES - YEARS 1927 AND 1928.

ROVINE, A., DIGEST OF UNITED STATES PRACTICE IN INTERNATIONAL LAW 1973 426 (U.S. Department of State Publication, 1974).

Sands, Philippe, *Watercourses, Environment and the International Court of Justice: The Gabcicovo-Nagymaros Case, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT 103 (World Bank Technical Paper No. 414, 1998).

TECLAFF, LUDWIK A. & UTTON, ALBERT E. EDS., INTERNATIONAL GROUNDWATER LAW (1981).

UNITED NATIONS, LEGISLATIVE TEXTS AND TREATY PROVISIONS CONCERNING THE UTILIZATION OF INTERNATIONAL RIVERS FOR OTHER PURPOSES THAN NAVIGATION, Treaty Nos. 228, 128 and 161, U.N. Doc. ST/LEG/SER.B/12 (1963).

UNITED STATES OF AMERICA AND ESTADOS UNIDOS MEXICANOS, TRANSBOUNDARY AQUIFERS AND BINATIONAL GROUND-WATER DATA BASE, CITY OF EL PASO/CIUDAD JUAREZ AREA, FINAL REPORT, January, 1998.

Utton, Albert E., *The Development of International Ground Water Law*, 22 NAT. RESOURCES J. 100 (1982).

WARD, R., PRINCIPLES OF HYDROLOGY (London, McGraw-Hill, 2d ed. 1975).

CHAPTER 11

International Groundwater Law and the World Bank Policy for Projects on Transboundary Groundwater

Raj Krishna and Salman M. A. Salman*

INTRODUCTION

The legal regime for international watercourses generally, and for transboundary groundwater in particular, has been developing very slowly, and is still in the infancy stage. The regime has not sufficiently developed to address the challenges of shared water resources, and particularly transboundary groundwater. The absence of a universal treaty dealing with shared watercourses is indicative of this situation. Although the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses[1] has been adopted by the United Nations on May 21, 1997, it still has not entered into force. Some of the different, and conflicting, theories that dominated the thinking over international waters, including the doctrine of "absolute territorial sovereignty" have contributed to the slow development of the legal regime for transboundary waters. The inadequacy of scientific data and complexity of the issues of groundwater have been additional reasons for such slow development.

The World Bank Operational Policy and Bank Procedures 7.50, "Projects on International Waterways" issued in 1994,[2] as well as all operational directives that preceded it,[3] are all specifically designed for surface water, with no mention of groundwater. The main reasons for exclusion of groundwater have been the complexity of the scientific issues, the hydro-political problems related to groundwater, and the absence of a detailed international legal regime on groundwater.

The purpose of this Chapter is to review and analyze the developments of both, the international law regime for transboundary groundwater, and the World Bank Policy

---

* Raj Krishna is a former International Law Adviser (Operations), Legal Vice Presidency, The World Bank; Salman M. A. Salman is a Senior Counsel, South Asia Division, Legal Vice Presidency, The World Bank.

[1] Convention on the Law of the Non-Navigational Uses of International Watercourses, May 21, 1997, U.N. Doc. A/RES/51/229, July 8, 1997. *See* generally SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT (World Bank Technical Paper No. 414, 1998).

[2] The World Bank, *The Operational Manual* (visited June 30, 1999) <http://wbln0011.worldbank.org/Institutional/Manuals/OpManual.nsf>.

[3] Operational Directive 7.50 and Annex A: Technical Advice of Independent Experts (April 30, 1990); Operational Directive 7.50.01: Maps for Projects on International Waterways (April 30, 1991) were reissued in 1994 as OP/BP/GP 7.50.

for projects on such transboundary groundwater, and identify the interconnections between the two. The paper also argues that the Bank Policy needs to be revised to take account of the developments in the international law regime, and to codify its existing case law.

GROUNDWATER: ITS GROWING IMPORTANCE AND INTERNATIONAL RELEVANCE

Groundwater is water existing below the surface of the earth. Not all the water below the surface of the earth is of interest for water resources development. It is only the water in aquifers that is of relevance. An aquifer has been defined as "the water bearing material in which groundwater is stored and through which it flows."[4] An aquifer can have interconnections, and hence interdependence, with surface water or it can be isolated from such surface waters. Some aquifers can be recharged from various sources of precipitation, while others may not have any, or may have very small, recharge sources and are, therefore, non-rechargeable or depletable.[5] The latter is also known as fossil, or non-renewable, groundwater. The recharge for renewable aquifers can be from rain, lakes or rivers. "Aquifers can consist of unconsolidated material such as sand and gravel, or consolidated rock such as sandstone. Unconsolidated materials can store large volumes of water. Sands can for example store up to 30% of their volume as water. Consolidated materials may also be very porous in that they can store large volumes of water but their pores are usually too small to allow the water to flow easily through the material."[6]

It is generally accepted today that, except in the case of fossil groundwater, all other groundwater forms part of the hydrologic cycle. It is estimated that 97% of the earth's fresh water, excluding the water locked in polar ice caps and glaciers, is underground.[7] Two thirds of these groundwater supplies are situated in aquifers which have a depth of more than 750 meters in the ground.[8] Only one tenth of 1% of all the groundwater reserve participates in the hydrologic cycle in an average year.[9] Thus, it appears that an enormous quantity of the groundwater reserve may consist of fossil

---

[4] ROBIN CLARKE ET AL., GROUNDWATER: A THREATENED RESOURCE 7 (UNEP Environment Library No. 15, 1996). For the full text of the Bellagio Draft Treaty *see* Robert D. Hayton & Albert E. Utton, *Transboundary Groundwaters: The Bellagio Draft Treaty*, 29 NAT. RESOURCES J. 663, at 676 (1989), and ANNEX 3 of this Report. Article I(1) of the Bellagio Draft Treaty (Agreement Concerning the Use of Transboundary Groundwaters) defines an aquifer as "a sub-surface water bearing geological formation from which significant quantities of water may be extracted."

[5] For a more detailed discussion of the topic, *see* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE SIXTY-SECOND CONFERENCE HELD AT SEOUL AUGUST 24TH TO AUGUST 30TH, 1986, 251, at 252-255 (1987).

[6] *See* GROUNDWATER: A THREATENED RESOURCE, *supra* note 4, at 6.

[7] STEPHEN FOSTER ET AL., GROUNDWATER IN URBAN DEVELOPMENT 9 (World Bank Technical Paper No. 390, 1998).

[8] Albert E. Utton, *The Development of International Groundwater Law*, 22 NAT. RESOURCES J. 93 (1982).

[9] *Id.*

groundwater contained in confined aquifers isolated from surface waters and the hydrologic cycle in general.

The increasing world population is creating immense pressure on both surface and groundwater, as well as on the environment as a whole. Apart from those arid areas of the world where dependence on groundwaters is heavy, more and more use of groundwater is being made in non-arid areas also. This is because available surface water is becoming increasingly insufficient to support the ever-increasing population of the world, specially with the increased urbanization of the population. Another reason for the increasing use of groundwater is its quality, which is, by and large, superior to that of surface water. As an example of increased use of groundwater, "of the 23 mega-cities estimated to have population over 10 million by the year 2000, 12 are heavily dependent on groundwater and with the exception of London, all are in the developing world."[10] In many areas of the world today, groundwater is being extracted in excess of the recharge of such groundwater, resulting in a large number of dry aquifers. Moreover, groundwater is being subjected in an increasing manner to pollution from different sources. Thus, as use and impact on groundwater increase, so does the need to develop methods of management and institutions for groundwater.

Given the growing scarcity of surface water in the world today, there is widespread belief among experts that the management of both ground and surface water resources should be integrated, and that they should be used conjunctively. Conjunctive use is a method designed to establish an integrated supply of both surface and groundwaters to ensure an even and reliable supply of water. It is applied in situations where there are interconnections and interdependencies between surface and groundwaters so that the combined resources form a common pool which can be managed and exploited for interchangeable uses.[11]

Integration does not, however, mean that all the management problems of groundwater are identical with that of surface water. Some of the special problems that can occur as a result of improper use or abstraction of groundwater are depletion of aquifers, deterioration of groundwater quality and salt water intrusions. Besides, groundwater is susceptible to pollution from other human activities not connected with its use or abstraction, such as the use of pesticides and fertilizers, as well as the dumping of industrial waste and mining activities. Pollution of groundwater, particularly of groundwater in confined aquifers, needs to be emphasized since, once it occurs, it is practically irreversible. The most serious of such pollution problems is arsenic contamination that has been reported recently as a major health hazard in Bangladesh. "Bangladesh is in the midst of what experts say could be the biggest mass poisoning in

---

[10] *SEE* U.N. D.E.S.A. & I.S.E.T., GROUNDWATER AND SOCIETY: RESOURCES, TENSIONS AND OPPORTUNITIES – THEMES IN GROUNDWATER MANAGEMENT FOR THE 21ST CENTURY 1 (1999). The study (footnote 1) lists those cities as Tehran, Buenos Aires, Jakarta, Karachi, Dhaka, Manila, Cairo, Bangkok, London, and Beijing.

[11] LUDWIK A. TECLAFF, WATER LAW IN HISTORICAL PERSPECTIVES 199 (1985).

history. Dangerous levels of arsenic have been found in the groundwater and have entered millions of homes from a vast system of tubewells."[12] A number of other countries, including India, Taiwan, Japan, and China, are also facing this problem of arsenic contamination, although not to the serious level faced by Bangladesh.[13]

INTERNATIONAL GROUNDWATER LAW

Theories, Treaties and Conventions

One of the basic, and difficult questions, that needs to be raised at the outset is when would an aquifer acquire international character. According to Mr. Barberis, groundwater may become of international relevance in the following situations:[14]

(i) where a confined aquifer is intersected by an international boundary;

(ii) where an aquifer lies entirely within the territory of one state but has interconnections and interdependence with an international watercourse;

(iii) where the aquifer is entirely situated within the territory of one state but has interconnections and interdependencies with another aquifer in another state; and

(iv) where an aquifer is entirely situated within the territory of one state but is getting recharged in another state.[15]

There are a large number of aquifers that are shared by two or more countries. "For example, there is the Northeastern African Aquifer which underlies Libya, Egypt and the Sudan, and on the Arabian peninsula there are the aquifers shared by Saudi Arabia, Bahrain and perhaps Qatar and the United Arab Emirate.... Other important international aquifers are the northern Sahara basin shared by Algeria, Tunisia and Libya, and the Chad aquifers shared by Chad, Niger, Sudan and the Central African Empire, Nigeria and the Cameroon. There are also the Taoudeni Basin in Chad, Egypt, Libya and

---

[12] *See* Barry Bearak, *Arsenic in Drinking Water*, FRONTLINE, January 1, 1999, at 70. The report estimates that a higher level of arsenic in drinking water than that prescribed by the World Health Organization exists in 43 out of Bangladesh's 64 districts. The World Bank has provided a 35 million dollar credit to Bangladesh for an "Arsenic Mitigation – Water Supply Project." The objective of the Project is to reduce mortality and morbidity in rural and urban population caused by arsenic contamination of groundwater. The Development Credit Agreement for the Project (Credit Number 3124 BD) between the Peoples' Republic of Bangladesh and the International Development Association (IDA) was signed on September 21, 1998; for a detailed discussion of the Project, *see* Chapter 5 of this Report.

[13] *Id.* at 74.

[14] JULIO A. BARBERIS, INTERNATIONAL GROUNDWATER RESOURCES LAW 36 (FAO Legislative Study No. 40, 1986).

[15] One situation that needs to be clarified is whether a watercourse that runs exclusively in one state, but has connection to an international aquifer would be considered as an international watercourse.

the Sudan, and the Maestrichian Basin shared by Senegal, Gambia, Guinea Bissau and Mauritania."[16] In addition to those, there are also the aquifers shared by the United States and Mexico, the Mountain Aquifer shared by Israel and the West Bank, and the one shared by Israel and the Gaza Strip. Jordan and Saudi Arabia share a large aquifer called the Qa Disi, while Jordan and Syria share the Azrag Aquifer.[17] There are also the aquifers that "...underlie the Indus and Ganges basins in South Asia."[18]

As mentioned earlier, the state of the law with regard to shared groundwater resources is less developed than surface water. While, with respect to surface water resources, the compromise doctrine of limited territorial sovereignty has received widespread acceptance, there seems to be no such well accepted theory which could be considered applicable to groundwater resources.

It should be pointed out, however, that in the case of fossil groundwater resources, the application of theories developed for such minerals in their international context has been suggested. Similar to those theories which are considered applicable to shared surface water resources, the point of departure for the compromise theory concerning liquid minerals are, again, those of absolute territorial sovereignty and absolute territorial integrity.[19] Although these two theories could reasonably and logically be applied to solid mineral deposits (having no fugitive character), they are not adequate to deal with liquid mineral deposits astride boundaries. This is because it is impossible to determine and exploit the exact share of each sharing State without the cooperation of the other and, also because unilateral exploitation may lead to permanent loss of the equal right of the other State to utilize the same deposit.[20] Permanent loss of the right to utilize one's share is bound to occur because of the particular characteristics of the geologic formations holding mineral deposits. In such a situation a State may not be able to extract its share from its side of the boundary "even if the first has extracted only that portion originally situated in its territory...."[21]

Thus, it has been suggested, as a compromise, that the principle of territorial sovereignty (over the sub-soil), the principle of territorial integrity (i.e. obligation not to cause material damage to another state), and the duty to exchange information and carry out consultation should be applied all together.[22] This theory is not really different from

---

[16] Albert E. Utton, *The Development of International Groundwater Law, in* LUDWIK A. TECLAFF & ALBERT E. UTTON EDS., INTERNATIONAL GROUNDWATER LAW 1, 9 (1981). The aquifer shared by Libya, Egypt, Sudan and Chad is also called the Nubian Aquifer; *see* GREG SHAPLAND, RIVERS OF DISCORD – INTERNATIONAL WATER DISPUTES IN THE MIDDLE EAST, at 151 (1997).

[17] For a discussion of those aquifers *see id.* GREG SHAPLAND, at 11 and 148-151.

[18] GROUNDWATER: A THREATENED RESOURCE, *supra* note 4, at 8.

[19] Rainer Lagoni, *Oil and Gas Deposits Across National Frontiers*, 73 AM. J. INT'L L. 215 (1979).

[20] *Id.* at 217.

[21] *Id.*

[22] For a discussion of the theoretical development in this area, *see id.* at 219-221.

the principle of limited territorial sovereignty except that it incorporates the additional principle of a duty to exchange information and to consult.

The situation is no better with regard to judicial decisions and treaties. A survey by Messrs. Caponera and Alheritiere indicates that not only it is not possible to "find any decisions of international courts specifically on the question of groundwater" but also that reference about shared groundwater resources in treaties are "scant and too limited in scope to propose them in terms of customary laws."[23]

Among the treaties and conventions that were concluded before the 1970s, groundwater was mentioned only in passing in a few of them. Examples are the agreement between Yugoslavia and Bulgaria on water economy question of 1958 and the agreement between Poland and the Soviet Union concerning the use of frontier waters of 1964.[24]

However, the more recent treaties tend to recognize and give importance to issues of shared groundwater resources. In such treaties there are indications that general rules and principles already developed for shared surface waters tend to be applied. For example, there are treaties which include "reference to the rule which requires that no appreciable harm shall be caused."[25] In this connection, attention may be invited to the Statute of the Lake Chad Commission Article 5 of the Statute reads:

> The Member States undertake to refrain from adopting, without referring to the Commission beforehand, any measures likely to exert a marked influence either upon the extent of water losses, or upon the form of the annual hydrograph and limnograph and certain other characteristics of the Lake, upon the conditions of their exploitation by other bordering States, upon the sanitary condition of the water resources or upon the biological characteristics of the fauna and flora of the Basin."[26]

There are also instruments embodying principles designed to bring about an equitable situation in the use of shared groundwater resources, e.g. the convention of June 9, 1978 between the Canton of Geneva and the Department of Haute-Savoie on the Geneva Water Table.[27] Again, there are examples of conventions which incorporate the principle of prior notification, consultation and duty to negotiate with regard to shared

---

[23] Dante A. Caponera and Dominique Alheritiere, *Principles of International Groundwater Law, in* LUDWIK A. TECLAFF & ALBERT E. UTTON EDS., INTERNATIONAL GROUNDWATER LAW 25, 55 (1981).

[24] *Id.* at 29.

[25] *Supra* note 14, at 40.

[26] U.N. D.T.C.D., *Conventions Statutes Realating to the Chad Basin,* II. Statutes, Chapter II, Article 5, *in* U.N. DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT, TREATIES CONCERNING THE UTILIZATION OF INTERNATIONAL WATER COURSES FOR OTHER PURPOSES THEN NAVIGATION - AFRICA, at 11 (Natural Resources/Water Series No. 13, 1984).

[27] *Supra* note 14, at 51.

groundwater resources, e.g. the African Convention on the Conservation of Nature and Natural Resources, and the Statute of the Lake Chad Commission.[28] For example Article V of the African Convention on the Conservation of Nature and Natural Resources states that "Where surface and underground water resources are shared by two or more of the contracting States, the latter shall act in consultation...," thus incorporating not only the principle of consultation but also, impliedly, the principles of notification and negotiations in good faith.[29]

Some of these treaties also contain specific provisions designed to cater to the special characteristics of groundwater such as the need for controlled extraction (which is required to balance withdrawal with recharge, or, as in the case of non-rechargeable aquifers, to implement programs of planned depletion), and artificial recharge. For example the Geneva Water Table Convention contains detailed provisions of this kind.

Another notable feature of some of the recent treaties is the recognition of the need for some kind of joint mechanism such as mixed or joint commissions in order to cooperatively implement or monitor the implementation of the rules, principles or programs, as the case may be, that have been agreed upon.[30] Article 1 of the Geneva Water Table convention provides for such a commission by providing as follows:

> Il est institue une Commission d'exploitation de la nappe souterraine du Genevois, composee de trois membres suisse et trois membres francais designes respectivement par le Conseil d'Etat de la Republiqueet canton de Geneve et par le Prefet de la Haute-Savoie.[31]

Similarly, the Israeli-Palestinian Interim Agreement on the West Bank and Gaza Strip includes provisions for the establishment of a Joint Water Commission to implement the undertakings under Article 40 of Annex III of the Agreement which deals specifically with 'Water and Sewage.'[32] Although the Commission is intended under the Agreement to function solely within the West Bank, it should be noted that 'the renewable water resources of the West Bank, Gaza and Israel are interconnected and, for the most part, qualify as common international resource.'[33] Accordingly, the function of the Commission includes coordinated management and protection of water resources,

---

[28] *Id.* at 55.

[29] *Supra* note 26, at 2.

[30] U.N. D.T.C.D., *Groundwater Regulation: The International Dimension, in* U.N. DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT, INTERNATIONAL RIVERS AND LAKES 3, at 4 (Newsletter of June 1985).

[31] Ludwik A. Teclaff & Eileen Teclaff, *Documents, in* LUDWIK A. TECLAFF & ALBERT E. UTTON EDS., INTERNATIONAL GROUNDWATER LAW 189, 464 (1981).

[32] Israeli-Palestinian Interim Agreement on the West Bank and Gaza Strip, dated September 28, 1995, *reprinted in* 36 I.L.M. 551 (1997).

[33] SHARIF S. ELMUSA, WATER CONFLICT - ECONOMICS, POLITICS, LAW AND PALESTINIAN-ISRAELI WATER RESOURCES 26, 27 (1997).

water and sewage; exchange of information relating to water and sewage laws and regulations; resolution of water and sewage related disputes; and arrangements for water supply from one side to the other.[34] Hence, it is not surprising that the Commission was given authority over some joint issues such as arrangements of water supply from one side to the other.[35]

However, because the treaties relevant to shared groundwater resources, besides being few in number, are fragmentary and do not treat the subject matter comprehensively, they can only be considered as indicative of a trend that is emerging slowly.

Currently there is considerable pressure from various quarters for the rapid development of international rules and principles applicable to shared groundwater and, if possible, their integration with rules for shared surface water resources so as to form a single legal regime. Resolutions, recommendations and studies made by intergovernmental and non-governmental international organizations, writings of scholars or publicists indicate the trend that is emerging in this regard.

Contribution of the International Law Association

Of significant importance is the work of the International Law Association (ILA) in the field of transboundary water law. The ILA is a scholarly non-governmental international organization which has made significant contribution to the development of the emerging rules of international law.

The ILA included, in its well known Helsinki Rules of 1966, groundwater that is connected to surface water. Article II defines an international drainage basin as "a geographical area extending over two or more States determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus."[36] The Comment clarified the provisions of this Article by stating "The underground waters constituting a part of the drainage basin described in this article are those that contribute to its principal river, a stream or lake or other common terminus."[37] As such, confined groundwater, that is groundwater which is not connected to surface water, is not dealt with under the Helsinki Rules.

Realizing this lacuna in the definition of international drainage basins which left confined aquifers out of the ambit of the Helsinki Rules, the ILA addressed the issue

---

[34] *Supra* note 32, Annex III, Article 40, Section 12, 551, at 625-626. *See* also ERAN FEITELSON & MARWAN HADDAD, IDENTIFICATION OF JOINT MANAGEMENT STRUCTURES FOR SHARED AQUIFERS – A COOPERATIVE PALESTINIAN ISRAELI EFFORT (World Bank Technical Paper No. 415, 1998).

[35] *Id.* FEITELSON & HADDAD, at 20. Feiltelson and Haddad indicate however, that the Commission has not fulfilled any of its responsibilities.

[36] The Helsinki Rules, Chapter 1, Article II, *in* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE FIFTY-SECOND CONFERENCE HELD AT HELSINKI, AUGUST 14TH TO AUGUST 20TH, 1966, 484, 485 (1967).

[37] *Id.*

again twenty years later. During its sixty-second conference held in 1986 in Seoul, Korea, the ILA proposed four articles to fill the gap that existed in the Helsinki Rules with respect to shared groundwater resources. Those four articles were called "The Seoul Rules on International Groundwaters, 1986."[38] It is worth noting that the Rules use the terms "groundwater" and "aquifer" interchangeably, and that the title of the first article is "the waters of international aquifers." The footnote to the article defines "aquifer" to comprehend "all underground water bearing strata capable of yielding water on a practicable basis, whether these are in other instruments or contexts called by another name such as "groundwater reservoir," "groundwater catchment area," etc. including the waters in fissured or fractured rock formations and the structures containing deep, so-called fossil waters."

Article 1 defines international groundwaters as "[t]he waters of an aquifer that is intersected by the boundary between two or more States..." and goes on to state that "...such an aquifer with its waters forms an international basin or part thereof."[39] The Article goes on to characterize such states as basin states within the meaning of Helsinki Rules "...whether or not the aquifer and its waters form with surface waters part of a hydraulic system flowing into a common terminus."[40] Article 2(1) deals with connected aquifers, and defines such aquifer as "[a]n aquifer that contributes waters to, or receives water from, surface waters of an international basin ... for the purposes of the Helsinki Rules."[41]

Confined groundwater is dealt with in Article 2(2) of the Seoul Rules. This Article states that "[a]n aquifer intersected by the boundary between two or more States that does not contribute water to, or receive water from, surface waters of international drainage basin constitutes an international drainage basin for the purpose of the Helsinki Rules."[42] Just as the Helsinki Rules pioneered the development of international law rules relating to transboundary rivers, the Seoul Rules laid down, for the first time, rules related to groundwater, both in confined and connected aquifers.[43]

---

[38] For a detailed discussion of the Seoul Rules on International Groundwaters, *see* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE SIXTY-SECOND CONFERENCE HELD AT SEOUL, AUGUST 24TH TO AUGUST 30TH, 1986 (1987).

[39] *Supra* note 5, Article 1, at 251; *see* also ANNEX 2 of this Report.

[40] *Id.*

[41] *Id.*

[42] *Id.*

[43] It should be noted that the Helsinki Rules were preceded by the Resolution of the Institute of International Law on the "Utilization of Non-Maritime International Waters" adopted at Salzburg, in 1961. The Resolution, which consisted of nine short articles, stressed the idea of equitable utilization of international waters, the no harm doctrine, notification on planned works, settlement of disputes on the basis of equity. Article 1 of the Resolution indicates that "the present rules and recommendations are applicable to the utilization of waters which form part of a watercourse or hydrographic basin which extends over the territory of two or more States." However, the terms "watercourse" and "hydrographic basin" are not defined. The Resolution was overshadowed by the Helsinki Rules because those rules are more detailed and

In addition, the Seoul Rules lay down more elaborate provisions requiring States to take into consideration "any interdependence of the groundwater and other waters, including any interconnections between aquifers, and leaching into aquifers caused by activities in areas under their jurisdiction."[44] Protection of shared groundwater from pollution is also emphasized and States are required, under Article 3,[45] to prevent or abate such pollution in accordance with international law. In this connection the draft articles include obligations of States to consult and exchange information and data for the purpose of preserving the groundwaters from degradation, and protecting from impairment, the geologic structure of the aquifers, including recharge areas, as well as for the purpose of considering joint or parallel quality standards and environmental protection measures. Article 3(3) also includes the obligation to cooperate "...at the request of any one of them,..."[46] in the collection and analysis of data pertaining to groundwater or their aquifers. Article 4 recommends that the integrated management of shared groundwater resources, including conjunctive use with surface waters, should be considered by the States at the request of one of them.

The accompanying report justifies the proposed articles on the following considerations:[47]

- The growing groundwater crisis, the legal implications of surface underground interactions and the characteristics of aquifers and their water have moved States generally to prescribe uncommon measures internally and, now, to call for analogous treatment for those transboundary aquifers already under stress.

- The number of international agreements expressly taking groundwaters into account is no longer negligible.

- State practice is demonstrating increasing willingness to accept the underground dimension of "transnational water resources."

- The UN International Law Commission has expressly acknowledged, in 1980, groundwater as a hydrographic component of an "international watercourse system."

Like the Helsinki Rules, the Seoul Rules have no formal standing, and should be considered only as an effort to create special principles which are no more than recommendatory. However, those Rules are valuable since they indicate the kinds of principles required to manage properly shared groundwater resources. Such principles

---

lay down a number of factors for equitable utilization. For the text of the Resolution *see The Salzburg Session of the Institute De Droit International,* 56 AM. J. INT'L L. 737 (1962).

[44] *Supra* note 5, Article 2(3), at 259.

[45] *Id.* at 268.

[46] *Id.*

[47] *Id.* at 244-245.

include international cooperation in the standardization and exchange of hydrologic data, exchange of information regarding projects which have the potential to affect the quantity (depletion) and quality (pollution) of shared groundwater resources, joint planning and integrated treatment of groundwater and surface water as well as the establishment of a coordination mechanism between the relevant institutions of the states involved.

Contribution of the International Law Commission

The work of the International Law Commission (ILC) on the Law of the Non-Navigational Uses of International Watercourses is of considerable importance in determining the direction of the development of international groundwater law. It may be recalled that the ILC was requested in 1970 by the General Assembly of the United Nations to prepare a set of draft articles dealing with the non-navigational uses of international watercourses. From the outset, ILC was confronted with the problem of defining "international watercourses" in a manner that was acceptable to the members of the UN General Assembly. Because of the divergence of views, it was decided not to define the term in the draft articles. Instead, the ILC adopted a provisional working hypothesis containing elaboration of the meaning of "international watercourse system." The note which contained the hypothesis read, in part, as follows:

> A watercourse system is formed of hydrographic components such as rivers, lakes, canals, glaciers and groundwater constituting by virtue of their physical relationship a unitary whole; thus, any use affecting waters in one part of the system may affect waters in another part.[48]

This definitional issue was, however, deferred with a view to expediting work on the topic before the ILC. In his Second Report, the Special Rapporteur Mr. Evansen, as he then was, accepted as a fact that international watercourses have a wide variety of "source components" and may, *inter alia*, include groundwater and other types of aquifers.[49] He went on to state: "The conservation and management of transboundary ground-water resources have much in common with the management and administration of international watercourses. Admittedly, groundwater resources will, to a large extent, be a relevant component, or part of an international watercourse and should as such fall under the applicable rules and principles laid down in a framework convention on the non-navigational uses of international watercourses." For excluding the independent groundwater resources from the framework convention being prepared by the ILC, Mr. Evansen observed, "[i]t must be admitted neither general principles of international law nor specific instruments of international law are sufficiently developed to meet adequately these problems and conflict areas in general. The principles and rules

---

[48] Stephen McCaffrey, Second Report on the Law of the Non-Navigational Uses of International Watercourses, U.N. Doc. A/CN.4/399 and Add. 1 and 2, *in* 2 YEARBOOK OF THE INTERNATIONAL LAW COMMISSION 1986, 87, at 89 (1988).

[49] Second Report on the Law of the Non-Navigational Uses of International Watercourse, dated April 24, U.N. Doc. A/CN/.4/381, 1984, at 16.

elaborated in a framework convention and in specific watercourse agreements may have a bearing or be analogously applied to independent ground-water resources."[50]

Although the scope of the term "international watercourse" was not defined, the ILC continued its work on the Law of Non-Navigational Uses of International Water Courses "with broad accord" that groundwaters (presumably of the type specified in the provisional hypothesis) were part of the topic.[51] In his Seventh Report,[52] considered by the ILC in the summer of 1991, Special Rapporteur Mr. McCaffrey noted: "Now that the Commission has adopted the bulk of the provisions of the draft, and is in the process of considering those that remain, the time has arrived for deciding upon the scope of the term 'international watercourse.'" Thus, the issue of whether or not to include groundwater within the concept of "international watercourse" was raised once again. Mr. McCaffrey argued very forcefully about such inclusion and presented two articles to the Commission with the concluding observation that with his Seventh Report, "the Special Rapporteur has completed the submission of the provisions he believes should be contained in the Commission's draft articles on the law of the non-navigational uses of international watercourses."[53] The Draft Articles of the convention proposed at that time defined the term "watercourse" as "a system of waters composed of hydrographic components, including rivers, lakes, groundwater and canals constituting by virtue of their physical relationship a unitary whole."

Thus, it should be concluded that the ILC recognized that groundwater constitutes a component of international watercourses and, therefore, is governed by international law. However, this recognition of the place of groundwater in the watercourse system is incomplete. It does not include confined groundwater as such groundwater has no connection or physical relationship to surface water, and as such does not constitute "a unitary whole" with such surface water.

The United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses, that was finally adopted by the United Nations General Assembly on May 21, 1997,[54] incorporates a similar definition of the term watercourse. Article 2(a) defines "watercourse" as "a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole, and normally flowing into a common terminus." As such, the definition moved away from the concept of "hydrographic components" to the clear cut components of surface and groundwater. It further clarified the relationship between surface water and groundwater. Not only should they constitute a unitary whole, but they should also normally flow "into a common

---

[50] *Id.*

[51] *See* Robert D. Hayton & Albert E. Utton, *supra* note 4, at 669.

[52] Stephen McCaffrey, Seventh Report on the Law of the Non-Navigational Uses of International Watercourses, U.N. Doc. A/CN.4/436, 15 March, 1991, at 5.

[53] *Id.* at 49.

[54] The Convention was adopted by a vote of 103 for, and 3 against (China, Burundi and Turkey) with 27 abstentions.

terminus." Those two criteria for the relationship between surface waters and groundwaters that are included in the definition left no doubt that confined groundwater is not covered by the provisions of the Convention.

It should not come as a surprise that the Convention excluded confined groundwater. Because of the conflicting interests of the different states, the work on the codification of the law of international watercourses has not been an easy one. The process took about twenty-seven years before an agreement could be reached. As such, the Convention should be seen as a result of compromises between the various interests. Despite the fact that confined groundwater was left out of the Convention, "...the inclusion of (connected) groundwater in the Convention was cited as a reason for the abstentions of two states from the vote on the Convention."[55]

However, after the ILC completed its consideration of "[t]he law of the non-navigational uses of international watercourses," it realized that there was a gap, and decided to address the issue of confined groundwater that was not included in the draft convention. This situation resembles the one in which the ILA found itself some time after it passed the Helsinki Rules. Just like the Helsinki Rules were complemented by the Seoul Rules, the ILC passed in 1994 the "Resolution on Confined Transboundary Groundwater."[56] The Resolution identified confined groundwater as "groundwater not related to international watercourses" and recognized that such groundwater is also a natural resource of vital importance for sustaining life, health and the integrity of ecosystems. The Resolution also recognizes the need for continuing efforts to elaborate rules pertaining to confined transboundary groundwater, and makes the following three recommendations:

1. That states be guided by the principles contained in the draft articles on the law of the non-navigational uses of international watercourses, where appropriate, in regulating transboundary groundwater.

2. That states consider entering into agreements with the other state or states in which the confined transboundary groundwater is located.

3. That in the event of any dispute involving transboundary confined groundwater that 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.

---

[55] Stephen McCaffrey, *The UN Convention on the Law of the Non-Navigational Uses of International Watercourses: Prospects and Pitfalls, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT 17, 18 (World Bank Technical Paper No. 414, 1998). The two countries that abstained because of the inclusion of groundwater were Pakistan and Rwanda.

[56] For the text of the Resolution *see* 2 YEARBOOK OF THE INTERNATIONAL LAW COMMISSION 1994 at 135 (1997), and ANNEX 4 of this Report.

As such, both the ILA Seoul Resolution and the ILC Resolution the have contributed to the development of the emerging rules of international groundwater law, and each of them carry the weight of the scholarly institution that issued them.

Writings of Scholars on Transboundary Groundwater

While writings of scholars are not extensive, almost all of the few works that do exist stress that the law is still at its infancy. Thus, their works, except in some instances, focus not in the expounding and explaining of existing principles but rather in recommending and proposing the direction which the development of such rules ought to follow.

On the question of whether the idea of shared groundwater resources has common acceptance, Mr. Barberis states that "[a] detailed examination of international practice will show that groundwater is deemed to form part of one and the same cycle as surface waters" and argues that when groundwater has interconnections with surface waters it "...stands in reciprocal relationship of dependence with the latter, and that all such waters form a natural cycle," thus leading to the conclusion that international aquifers are seen as constituting a "shared natural resource."[57] Mr. Barberis further states that "[i]n current international law there are to be found rules applicable to groundwater shared between States; and such rules apply to all shared aquifers, save where specific provisions are made for individual cases."[58] The rules of current international law that he identifies are (a) the obligation not to cause appreciable harm, (b) equitable and reasonable use, and (c) prior notification and duty to negotiate.[59]

Other scholars also favor the application of general rules and principles pertaining to shared surface water resources to groundwater. For example, Messrs. Caponera and Alheritiere, in their study of principles of international groundwater law, state that "the evolution of recent forms of international cooperation for the management of water resources of common interest to two or more States is of great significance ... "[60] They go on to add that "the same criterion of equitable utilization as has been accepted for surface water is also valid for groundwater. International law on this matter limits itself, in substance - in the absence of specific rules of conduct – to reference to general principles of responsibility and of equity in order to identify the law applicable in each particular case."[61]

Mr. Hayton also argues that "the potential for international strife attendant upon unregulated international groundwater use and abuse should not be underestimated. International law furnishes principles and rules which, if applied, will secure acceptable,

---

[57] *Supra* note 14, at 25 and 33.

[58] *Id.* at 37.

[59] *Id.* at 38-57.

[60] *Supra* note 23, at 46.

[61] *Id.* at 55.

peaceful outcomes." Regarding the obligation to consult, he writes that "[b]asin States have accepted a duty to consult, generally speaking, especially where the fact or threat of pollution is involved."[62]

Mr. Teclaff also seems to agree with the others (at least as far as groundwaters having interconnections with surface waters are concerned) when he comments that "the significant new doctrines which, starting from the premise of the areal unity of the river basin's waters, assume the right of basin States to an equitable share in the basin's waters, pertain to groundwater only in so far as it is connected with surface water."[63]

Again, here, it is important to note that there is a clear tendency on the part of scholars either to confine their view, implicitly or explicitly, to those groundwater resources which have connections to surface waters and, in the cases where they mention isolated aquifers, to suggest that the rules and principles applicable to shared surface waters have no, or only partial, relevance. For example, Mr. Teclaff comments that "not all groundwater is connected with surface streams or lakes ... The so-called fossil waters have been likened to minerals, and it has been suggested that rules analogous to mining law may apply to them."[64] Mr. Lagoni observed, writing on the law of oil and gas, that "the principles laid down in this article apply also to nonrenewable resources of mineral water, hot water or steam, but not to fresh water in general because it is normally a renewable resource."[65] This implies that even fresh water of a non-renewable type (i.e. fossil waters) should be subjected to the principles and rules applicable for liquid minerals. Mr. Barberis also appears to support the application of certain rules developed for liquid minerals to shared groundwater resources which do not have connections with surface waters. In this regard he states that "[w]here two States share an aquifer, an equitable solution would be that the volume that each may withdraw should be proportionate to that segment of the aquifer lying within its territory. This rule is usually applied in the working of mineral resources – gas or oil deposits – extending either side of an international frontier."[66]

In addition to the general principles mentioned above, studies made on the law of shared groundwater resources stress the need for specific rules and principles as well as institutional set ups to cater to the special nature and characteristics of groundwater. These rules are deemed necessary for the management of shared groundwater resources both from the quantitative and qualitative viewpoint. In this respect Mr. Hayton, for example, states that "there are some peculiar physical incidents in the appearance, movement and availability of groundwater that require special regulations and a particular administration, in coordination with the management of surface waters. Matters of

---

[62] *Supra* note 5, 238, at 269.

[63] *Supra* note 11.

[64] *Id.*

[65] *Supra* note 19, at 215.

[66] *Supra* note 14, at 51.

replenishment, extraction and water table measurement, losses, contamination, distribution, works design and inspection, withdrawal control, and relationship to the sea are among the behavioral and management considerations that continue to distinguish groundwater from surface and atmospheric water resources."[67]

The Bellagio Draft Treaty

In connection with the emerging international law on groundwater, mention must also be made of the Bellagio Draft Treaty which is the work of a group of multidisciplinary specialists in the field of transboundary groundwater, and is proposed by them to serve as a model international groundwater treaty. "It is based on the proposition that water rights should be determined by mutual agreement rather than be the subject of uncontrolled, unilateral taking, and that rational conservation and protection actions require joint resource management machinery."[68] "The overriding goal of the draft treaty is to achieve joint, optimum utilization of the available waters, facilitated by procedures for avoidance or resolution of differences over shared groundwaters in the face of the ever increasing pressures on this priceless resource."[69]

The Bellagio Draft Treaty consists of twenty articles and includes detailed provisions for specific cooperative arrangements required for the proper exploration and development of shared groundwater resources. It also contains detailed provisions pertaining to the establishment and maintenance of database, water quality protection, conservation areas, preparation of comprehensive management plans, dealing with health emergencies, implementing programs of planned depletion, transboundary transfer of waters and planning for drought. Issues relating to public participation, existing rights and obligations, accommodation of differences and resolution of disputes are also addressed in detail by the draft treaty.[70]

Implementation of such rules and principles will, of necessity, require institutional arrangements. Thus, Messrs. Caponera and Alheritiere argue that "...the need for adequate institutional frameworks for managing groundwater resources at the national level corresponds to the emerging duty to cooperate and establish appropriate joint machinery at the international level."[71] Utton also proposes that "the management should be placed in an international agency with authority which is broad enough to carry out the policies of the countries concerned and strong enough to enforce the policies designed for particular groundwater areas along and near the border."[72] Recognizing such need, the

---

[67] Robert D. Hayton, *The Ground Water Legal Regime as Instrument of Policy Objectives and Management Requirements, in* INTERNATIONAL GROUNDWATER LAW, *supra* note 16, 57, at 66.

[68] Robert D. Hayton & Albert E. Utton, *supra* note 4, at 664.

[69] *Id.* at 665.

[70] *Id.*

[71] *Supra*, note 23, at 54.

[72] *Supra* note 8, at 113.

Bellagio Draft Treaty also envisages a Commission (existing or newly established) which is endowed with a wide range of authority for implementation of the functions and responsibilities provided for therein.[73] Those functions and responsibilities include declaring transboundary groundwater conservation areas, drought alerts, drought and public health emergencies, and promulgating the corresponding plans and depletion plans. They also include preparing and proposing to the governments a budget, conducting a review of water quality and quantity control measures, creating and maintaining a comprehensive and unified database pertaining to transboundary groundwaters and including an inventory of all transboundary groundwater resources taking into account quantity, quality, aquifer geometry, recharge rates, interaction with surface waters and other pertinent data. The Commission is also entrusted with approving the terms and conditions for short term or long term transfers of waters between the parties.[74]

The Bellagio Draft Treaty includes detailed provisions for resolving differences and disputes.[75] The Commission itself would attempt to resolve differences within the Commission with respect to facts and circumstances. If after six months the Commission fails such differences, it would submit them to the Governments for resolution by consultation. If the Governments are unable to resolve such difference within twelve months, then any Government is entitled to ask for appointment of a commission of inquiry which will be charged with a full and impartial study for the purpose of verification of the facts of the situation. If the consultations do not achieve the agreed accommodation, then the Governments shall enter into formal direct negotiations for the purpose of resolving the disagreement. Failing direct negotiations, then the Governments shall refer the matter to mediation, conciliation, arbitration, the International Court of Justice, or any other means of peaceful settlement.[76]

---

[73] *Supra* note 4, at 684-687.

[74] The powers and functions of the Commission are referred to throughout the articles of the Draft Treaty, but Article III lays down the overall responsibilities of the Commission; *see id.* at 684. Feitelson and Haddad addressed the issue of crisis management and suggested three possible crisis. "The management of any aquifer faces its most severe test during crisis situations. Three types of crisis are possible: 1) *sudden crisis,* such as the spilling of toxic material in highly porous area, 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 crisis,* which could stem from the cumulative effects of certain trends or natural events, such droughts, or 3) *the overpumping* of water by one side, above the quantities previously agreed upon by both parties." *Supra* note 34, at 15.

[75] Article XV of the Draft Treaty deals with "Accommodation of Differences," *see* Robert D. Hayton & Albert E. Utton, *supra* note 4, at 714-718; whereas Article XVI deals with "Resolution of Disputes," *see id.*, 718-720.

[76] The UN Convention on the Law of the Non-Navigational Uses of International Watercourses lays down more detailed procedures for settlement of disputes. Article 33 of the Convention deals with mediation or conciliation, and detailed functions for a fact finding commission. The Article also deals with the possibility submission of the dispute to the International Court of Justice, and/or arbitration. The Annex to the Convention lays down detailed procedures for arbitration.

WORLD BANK POLICY AND PRACTICE WITH REGARDS TO TRANSBOUNDARY GROUNDWATER

According to Paragraph 1 of the Operational Policies (OP) 7.50 on "Projects on International Waterways," the term "international waterways" includes boundary rivers, lakes or canals, or any body of surface water that flows through two or more states. The paragraph states that the Operational Policy covers the following types of international waterways:

(a) any river, canal, lake, or similar body of water that forms a boundary between, or any river or body of surface water that flows through, two or more states, whether Bank members or not;

(b) any tributary or other body of surface water that is a component of any waterway described in (a) above; and

(c) any bay, gulf, strait, or channel bounded by two or more states or, if within one state, recognized as a necessary channel of communication between the open sea - and other states and any river flowing into such waters.

As such the Policy of the Bank, as enunciated in OP 7.50, does not include any type of groundwater. The complexity of the issue, the lack of sufficient scientific data, hydro-political considerations, and the absence of clear international standards are perhaps the reasons for excluding groundwater from the Bank Policy.

Although the World Bank has financed a number of groundwater projects in a number of countries including Yemen, Tunisia, Jordan, Mexico, Nepal and Bangladesh, the complexity of the issues of shared groundwater resources did not arise presumably because either the possibility of whether the concerned aquifers might be shared with neighboring States was not entertained, or simply because it was assumed the aquifers concerned were purely national. This should not be surprising, since it is only recently that concern for international issues and possible disputes that might arise in connection with shared groundwater have begun to develop.

However, despite the non-inclusion of groundwater in the World Bank Policy, the Bank has addressed on ad hoc basis the issue of shared groundwater when it arose. Case law is building and a policy of treating shared groundwater in par with shared surface water is gradually emerging.

The Sahara Regional Development Project in Algeria was the first project in which the policy on international waterways was extended to transboundary groundwater.[77] The Project involved the utilization of waters by Algeria from two

---

[77] Sahara Regional Development Project, Staff Appraisal Report No. 8952-AL, dated September 4, 1991; *see* also Loan Agreement between Democratic and Popular Republic of Algeria and International Bank for Reconstruction and Development, dated November 6, 1992 (Loan No. 3405-AL).

aquifers through drilling of wells and provision of related equipment and installations, and closure of deteriorating and non-operational wells. One of the aquifers, known as the "Continental Interclaire" (CI), is confined and holds fossil waters which are non-renewable. The aquifer which is known as the "Complex Terminal" (CT) is a rechargeable aquifer. While it has been established by geological studies that these aquifers extend from Algeria to Tunisia, the possibility of their extending further east to Libya and west to Morocco has been indicated by diagrams in some reports. An area of about 800,000 km^3 of these aquifers has been studied by UNESCO during 1968-1971, with UNDP funding as part of a strategy to explore water resources in the desert areas of the world. The studies were undertaken with the intention of assessing the water resources potential in these areas and to propose a policy for their exploitation by both countries involved. In 1983 UNDP reviewed and updated these studies.

As part of the policy of exploitation, three requirements were proposed in the studies as follows:

(a) the artisianism of the CI should be maintained until 2010;

(b) the pumping of the CT should not exceed 60 meters until 2010;

(c) extraction by each country should have the same impact on the other.

Both the Algerian and Tunisian sides appear to have endorsed, at least impliedly, the studies and recommendations therein in 1989 when the Algerian Minister of Agriculture visited Tunisia.

The Final Executive Summary for the Project issued on May 10, 1990, mentioned, for the first time, the possibility of "riparian issues" in its proposal that the World Bank should seek commitment from the Government of Algeria "to adhere to the recommendations of the UNESCO (ERESS) study for the use of the common groundwater resources and for the protection of the common international interests."

In August 1990, the Staff Appraisal Report (SAR) for the Project was completed. Again, the SAR raised the question of "riparian issues" but concluded that (a) since Operational Directive OD 7.50 (the predecessor of OP/BP 7.50) deals with projects on international waterways, aquifers are not covered, (b) the ERESS studies would ensure "...the best use of the common resources and protection of the common international interests", and (c) the "Commission Technique Tuniso/Algerienne pour l'Hydraulique et l'Environnement" (CTHE) should serve as the appropriate forum for the discussion of the issues.

However, at this point the issue of applying OD 7.50 to the Project started to come under serious consideration. It was suggested that Algeria should notify Tunisia about the Project, and that such notification should:

(a) indicate the Algerian Government's endorsement of the UNDP study and understanding of similar endorsement on the part of the Tunisian Government;

(b) emphasize the measures the Algerian Government plans to take to prevent pollution of the aquifers, and its hopes for similar measures on the part of the Tunisian Government;

(c) request comments on the Project from the Tunisian side; and

(d) give Tunisia a period of not less than one month to respond.

Since the extension of the aquifers to Libya and Morocco was not supported by actual geological studies and since ascertaining such extension would have been very difficult and costly, notifying these two countries of the proposed project was considered unwarranted. The possibility of the World Bank notifying Tunisia in the event of a request for such an action by Algeria was also considered.

However, this view was not unanimous within the Bank, and there was another opinion that suggested certain actions should be taken before extending the Bank Policy to shared aquifers. The suggested actions as regards this view were:

(a) review of positions taken by the Bank in the past relating to similar projects;

(b) a clearer exposition of "emerging" international law on the subject matter;

(c) a justification of the appropriateness for the Bank to review OD 7.50 to include groundwater in view of previous Bank reluctance to get involved "in this complex area;"

(d) more elaborate policy concerning the subject matter; and

(e) consideration of the need for a new policy to be approved by the Executive Directors of the Bank.

However, in the end the Bank decided to go ahead and have Algeria notify Tunisia, and to study at the same time the above issues.

On October 12, 1990, a telex was sent to Algeria explaining the Bank's desire to communicate to Tunisia the details of the Project, and ask for Tunisia's no objection to the project. The telex emphasized the Bank's understanding of:

(a) the existence of collaboration between the two Governments in the exploitation of the waters of the two aquifers through CTHE'; and

(b) the intention of the two Governments to exploit such waters in accordance with the recommendation of the ERESS studies.

Almost two weeks elapsed and no response was received from the Tunisian authorities to this telex. Accordingly, on October 24, 1990, the Bank sent to the Tunisian authorities a telex giving a brief summary of the Project and its impact on the shared aquifer, and informing them that the Project Evaluation Report prepared by the Bank would be sent to them, and that they should not hesitate to contact the Bank if they had any questions or desired additional information regarding the Project. The telex also emphasized the Bank's understanding of the existence of cooperation between the two countries regarding the aquifers and their intention to adhere to the ERESS recommendations.

Since no objection was received from Tunisia, the Bank decided to proceed with the processing of the Project, and the Project was presented to the Executive Directors of the Bank on September 24, 1991. It is worth adding that the legal documents included a covenant stating that "...the Borrower shall take all measures necessary to ensure that [the] use of the groundwater resources in [the Northern Sahara] Region shall be planned in accordance with the recommendation of the Study of Water Resources in the Sahara."[78]

Thus, the Policy of the Bank for Projects on International Waters which applies only to surface water was extended for the first time, on an ad hoc basis, to groundwater. Hence, a precedent was created in 1991.

Although OD 7.50 was converted in 1994 into Operational Policies and Bank Procedures (BPs), in line with the conversion of the other Operational Directives, the issue of adding groundwater to the Policy was considered but not included, perhaps because this was considered a mere conversion of the Directive, and not a revision of the Policy.[79]

The Bank faced a similar situation in a more recent project in Jordan, the Disi/Amman Water Conveyor Project. Under the proposed Project, Jordan would convey water from an aquifer in southern Jordan called Disi, to Amman through a 350 kilometer conveyor.[80] The Disi Aquifer is a non-renewable, thus depeletable, fossil aquifer which underlies both northern Saudi Arabia and southern Jordan. However, no joint management mechanism for the aquifer exists between the two countries. "There is a perceptible flow from the Saudi side into Jordan, with water from the aquifer eventually emerging at the surface near the Dead Sea. The reserves are large, but, because much of it

---

[78] Section 4.02 of the Loan Agreement between Democratic and Popular Republic of Algeria and International Bank for Reconstruction and Development, dated November 6, 1992 (Loan No. 3405-AL).

[79] However, it should be noted that paragraph 7 of OP 7.50, "Exceptions to Notification Requirement," added a clarification not mentioned in OD 7.50. This new addition reads "Any Project that relates to a tributary of an international waterway where the tributary runs exclusively in one state and the state is the lowest downstream riparian, unless there is concern that the Project could cause appreciable harm to other states."

[80] For a detailed discussion of the Project *see supra*, Chapter 6 of this Report.

is more than 250 meters below ground (the conventional economic pumping limit), it may not be cost effective to abstract more than a small proportion."[81] Abstractions in Saudi Arabia are large, in the range of 600 to 700 MCM/yr. mostly for irrigation, whereas abstractions in Jordan are small, about 80 MCM/yr. mainly for irrigation and water supply to Aqba. The proposed Project would abstract up to 100 MCM/yr. with the likelihood that the figure may climb to 150 MCM/yr. in future. The well field to be drilled would be about 35 kilometers from the borders with Saudi Arabia.

Because the amounts to be extracted under the project are small, the Project is not expected to cause harm to Saudi Arabia, being the upper riparian. However, increased abstractions by Saudi Arabia, or developing of new well fields close to the Jordanian borders, could result in significant impact on the Jordanian resources.

Although the Bank agreed that OP/BP 7.50 deals only with surface water, the precedent of the Sahara Regional Development Project in Algeria was considered, and it was decided that it should be followed. Accordingly, the Bank informed Jordan of the need to notify Saudi Arabia of the Project as Saudi Arabia can impact on the project. Jordan agreed and notified Saudi Arabia of the Project in February 1998. Since Saudi Arabia did not object to the Project, the Bank decided to proceed with the processing of the operation. It is interesting to note that in the Sahara Regional Development Project the Bank notified Tunisia of the proposed Project, whereas in this Project, Jordan carried out the notification itself. It is also noteworthy that in both projects the aquifers in question are confined and non-renewable.

Although the above two projects confirm the extension of the Bank Policy for projects on international waterways to confined aquifers, another recent Project addressed the issue of aquifers connected to international watercourses. The Southern Region (GAP) Urban Sanitation and Planning Project in Turkey includes a component dealing with the rehabilitation of the existing water distribution networks in a number of towns in that Region. The water supply source in this Region is from groundwater wells and springs. The issues that arose were (a) whether the wells and springs are connected to any international watercourses, and (b) if so, how should the Bank handle the situation. After technical studies were conducted, the Bank concluded that there is no connection between the groundwater wells and springs, and any international waterways. In addition to this finding, the Project team argued that even if surface water was involved, the proposed improvements would be exempt from the notification requirement of OP 7.50 under paragraph 7(a). That paragraph exempts "...any on-going schemes, projects involving additions or alterations that require rehabilitation, construction or other changes that in the judgment of the Bank (a) will not adversely change the quality or quantity of the water flows to the other riparians, and (b) will not be adversely affected by the other riparians' possible water use."

---

[81] GREG SHAPLAND, *supra* note 16, at 148.

Although the issues raised were finally dealt with under the exemptions under Paragraph 7(a), the Project did raise, for the first time, the issues of Bank-financed projects dealing with groundwater that is connected to surface water, and whether OP/BP 7.50 extend to such projects.

CONCLUSION

The foregoing indicates clearly that international groundwater law is still in the infancy stage and a number of its rules are still emerging. Even the question of whether groundwater resources, when they are transboundary, should be treated as shared (or of international interest) is not yet a fully settled question. This seems to be the result of the absence of scientific data and knowledge of the hydrologic cycle, and the complex hydro-political issues involved. Nonetheless, when the trends in treaty practice, in the pronouncements and recommendations of intergovernmental bodies, the proposals of non-governmental international entities and the works of scholars are weighed together, it seems reasonable to conclude that the trend of treating transboundary groundwater resources as shared has reached an irreversible stage, and that certain principles and rules are definitely emerging as applicable to international groundwater.

The most important among such emerging principles are the principles of not causing appreciable harm (in terms of depriving other States, quantitatively or qualitatively, of the right to use the waters) and the principle of equitable utilization of the water. These principles have been, initially, developed and refined from the general principles of international law such as good neighborliness and equity to apply to shared surface water resources. In the same manner the principles of exchange of information, consultation and negotiation in good faith are also applicable.

In terms of principles of modern groundwater management, the requirements of integrated management, as well as the conjunctive use of both surface and groundwater resources, particularly when any interconnections exist between surface and groundwater resources, can be observed as strong trends. The same applies to the principles of safe yield (for isolated but rechargeable aquifers) and planned depletion or mining (for totally confined aquifers which are virtually not rechargeable).

The current thinking seems to clearly favor the application of general principles developed for shared surface water resources to shared groundwater resources, whether connected to surface water or confined. It also appears to consider the application of rules and principles developed for liquid minerals or, at least, the modification of existing shared surface water principles with the view of appropriately applying them to cases of confined groundwater (fossil waters). Whichever is the case, joint cooperation in the development and exploitation of fossil waters is seen as an essential applicable principle, because the amount of equitable share of a State in isolated aquifers cannot be determined without the cooperation of the other States, and unilateral development and exploitation of such aquifers by one State alone (even in quantities which it thinks is its equitable share), may permanently deprive the other States of their equitable share or the possibility of being able to exploit their equitable share in the future.

Additionally, current thinking recognizes the need for the development of specific principles to cater to the special nature and characteristics of groundwater in its shared context. The management principles developed for wholly national groundwaters are deemed to have significance for the development of such rules. Examples are rules concerning use and extraction limitations, drilling permit requirements, construction standards, zones of conservation or prohibition, abatement and control of pollution and reporting and registering requirements. The designation or establishment of some sort of joint international organization is particularly considered indispensable for the purpose of directly carrying out functions and responsibilities, or else to see to it that the concerned national organizations do carry out appropriately such functions and responsibilities.

Based on the emerging trends in the law, and the scientific evidence which supports the conclusion that groundwater resources should be treated as shared resources when they are of interest to two or more states, it is suggested that the World Bank should consider adopting a policy in conformity with said trends and scientific facts. The Algeria-Tunisia Project, and the Jordanian-Saudi Arabia Project discussed above underscore the risk of the Bank getting involved in a possible dispute between aquifer States, and hence the need for adoption of a clear policy.

The adoption in May 1997 by the United Nations of the Convention on the Law of the Non-Navigational Uses of International Watercourses, with its restricted definition of the term "watercourse" that leaves out confined groundwater, underscores the emerging trend towards addressing the issue of shared connected groundwater. Moreover, the adoption of the Seoul Rules in 1986, the Bellagio Draft Treaty in 1988, and the ILC Resolution in 1994 highlights the relevance and importance of groundwater, and have made significant contribution to the development of international groundwater law. Indeed, the Bank's own "case law" points in the direction of addressing issues of transboundary groundwater. In addition, considerations of sound and scientific management of groundwater to ensure implementation of financially successful projects should also be considered as adequate reasons for adopting such a policy. The adoption of a separate policy on, or expansion of the existing Policy to include, international groundwater has an additional merit in that the Bank will not be seen as supporting the drainage basin system approaches to which some States are rather sensitive.

The following are recommended as a basis for the Bank Policy on transboundary groundwater:

First, the Bank policy must go beyond the UN Convention and cover confined groundwater[82] when they are intersected by international boundaries, as well as groundwaters which are a component of an international watercourse system.

---

[82] The authors recognize, and agree with McCaffrey, supra note 64, Chapter 9, that the term "confined" groundwater may be used differently by lawyers and hydrologists.

Second, a clear definition of what is meant by the term "international groundwater" should be adopted. The term should perhaps include the four situations elaborated by Mr. Barberis.[83]

Third, before projects are proposed, Bank staff should ensure that the beneficiary State has all technical, scientific and other data on the formation, contours, flow, chargeability, quantity, quality and other pertinent aspects of the groundwater resource proposed to be exploited. Such information should be furnished to the other state or states involved in the use of such groundwater as part of the notification requirement under the World Bank's OP/BP 7.50.

Fourth, the Bank should categorize shared groundwater resources, from the quantitative point of view, into two main categories, i.e. depletable and non-depletable. It should, of course, be noted that any groundwater will be depleted if extractions exceed recharge. However, provided adequate measures are taken, rechargeable groundwaters, whether confined or having interconnection with surface waters, could be categorized as non-depletable. On the other hand, fossil groundwaters, whose aquifers are not rechargeable, should be considered as depletable, since their exploitation will finally end up in their exhaustion.

Fifth, in the case of non-depletable groundwaters, it is proposed that the Bank essentially should apply procedures similar to those in OP/BP/GP 7.50. However, the Bank should, as necessary, encourage conjunctive use and integrated management with surface waters as well as the safe yield principle. The latter is of particular importance in arid and semi-arid areas.

Sixth, in the case of depletable groundwaters, since by definition, unilateral exploitation of confined aquifers would eventually result in appreciable adverse effects to other concerned States who would be deprived of the use of their equitable share of water, there is a compelling logic for the Bank to insist on joint cooperative management arrangements between the concerned States. Such joint cooperative management arrangements should be encouraged in the case of rechargeable aquifers.

Seventh, in the financing of projects using or polluting groundwaters, the Bank should require strict anti-pollution measures, since once polluted, groundwater may take quite a long time to recover or may even be irreversibly polluted.

In expanding its Policy to cover groundwater, the Bank will essentially be following the emerging trend in international groundwater law, and codifying its existing case law.

---

[83] *Supra* note 14.

BIBLIOGRAPHY (Selected)

BARBERIS, JULIO A., INTERNATIONAL GROUNDWATER RESOURCES LAW 36 (FAO Legislative Study No. 40, 1986).

Bearak, Barry, *Arsenic in Drinking Water*, FRONTLINE, January 1, 1999.

Caponera, Dante A. and Alheritiere, Dominique, *Principles of International Groundwater Law, in* LUDWIK A. TECLAFF & ALBERT E. UTTON EDS., INTERNATIONAL GROUNDWATER LAW 25 (1981).

CLARKE, ROBIN ET AL., GROUNDWATER: A THREATENED RESOURCE 7 (UNEP Environment Library No. 15, 1996).

ELMUSA, SHARIF S., WATER CONFLICT - ECONOMICS, POLITICS, LAW AND PALESTINIAN-ISRAELI WATER RESOURCES (1997).

FEITELSON, ERAN & HADDAD, MARWAN, IDENTIFICATION OF JOINT MANAGEMENT STRUCTURES FOR SHARED AQUIFERS – A COOPERATIVE PALESTINIAN ISRAELI EFFORT (World Bank Technical Paper No. 415, 1998).

FOSTER, STEPHEN ET AL., GROUNDWATER IN URBAN DEVELOPMENT 9 (World Bank Technical Paper No. 390, 1998).

Hayton, Robert D. & Utton, Albert E., *Transboundary Groundwaters: The Bellagio Draft Treaty*, 29 Nat. Resources J. 677 (1989).

INTERNATIONAL LAW ASSOCIATION, REPORT OF THE FIFTY-SECOND CONFERENCE HELD AT HELSINKI, AUGUST 14TH TO AUGUST 20TH, 1966, 484, 485 (1967).

INTERNATIONAL LAW ASSOCIATION, REPORT OF THE SIXTY-SECOND CONFERENCE HELD AT SEOUL, AUGUST 24TH TO AUGUST 30TH, 1986 (1987).

Lagoni, Rainer, *Oil and Gas Deposits Across National Frontiers*, 73 AM. J. INT'L L. 215 (1979).

McCaffrey, Stephen, Second Report on the Law of the Non-Navigational Uses of International Watercourses, U.N. Doc. A/CN.4/399 and Add. 1 and 2, *in* 2 YEARBOOK OF THE INTERNATIONAL LAW COMMISSION 1986, 87 (1988).

McCaffrey, Stephen, Seventh Report on the Law of the Non-Navigational Uses of International Watercourses, U.N. Doc. A/CN.4/436, March 15, 1991.

McCaffrey, Stephen, *The UN Convention on the Law of the Non-Navigational Uses of International Watercourses: Prospects and Pitfalls, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES –

ENHANCING COOPERATION AND MANAGING CONFLICT 17 (World Bank Technical Paper No. 414, 1998).

SALMAN, SALMAN M. A. & LAURENCE BOISSON DE CHAZOURNES, LAURENCE EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT (World Bank Technical Paper No. 414, 1998).

SHAPLAND, GREG, RIVERS OF DISCORD – INTERNATIONAL WATER DISPUTES IN THE MIDDLE EAST (1997).

TECLAFF, LUDWIK A., WATER LAW IN HISTORICAL PERSPECTIVES 199 (1985).

Utton, Albert E., *The Development of International Groundwater Law, in* LUDWIK A. TECLAFF & ALBERT E. UTTON EDS., INTERNATIONAL GROUNDWATER LAW 1 (1981).

Utton, Albert E., *The Development of International Groundwater Law*, 22 Nat. Resources J. 93 (1982).

U.N. D.E.S.A. & I.S.E.T., GROUNDWATER AND SOCIETY: RESOURCES, TENSIONS AND OPPORTUNITIES – THEMES IN GROUNDWATER MANAGEMENT FOR THE 21ST CENTURY 1 (1999).

U.N. D.T.C.D., *Conventions Statutes Realating to the Chad Basin, in* U.N. DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT, TREATIES CONCERNING THE UTILIZATION OF INTERNATIONAL WATER COURSES FOR OTHER PURPOSES THEN NAVIGATION – AFRICA (Natural Resources/Water Series No. 13, 1984).

U.N. D.T.C.D., *Groundwater Regulation: The International Dimension, in* U.N. DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT, INTERNATIONAL RIVERS AND LAKES 3 (Newsletter of June 1985).

CHAPTER 12

International Environmental Law: Principles Relevant to Transboundary Groundwater

David Freestone*

INTRODUCTION

International environmental law and the related field of, what UNEP has termed "international law in the field of sustainable development"[1] are relative newcomers to the international law family, but vibrant new additions which have forced lawyers to look again, or to look in a different way, at many basic concepts of international law. It is only in the last quarter of a century that we have seen the emergence of these two important new themes in international law, which are now beginning to crystallize into defined systems. The rapid growth of the subject can be seen in the very number of international instruments regulating the environment and natural resources management - which in 1993 Professor Brown Weiss put at more than 900[2]- but which has continued vigorously since that date.[3]

Both concepts have indeed posed challenges to international law, or, put more positively, have provided platforms for innovation and development. These vary from the development of new law-making processes and concepts, and the progressive development of jurisdictional principles to the adaptation of traditional institutions and concepts to the new needs of the twenty-first century. Most significantly, however, it can be argued that international environmental law and sustainable development provide a new perspective - a new lens - through which to view existing international law rights and obligations.

---

* Legal Adviser, Environment and International Law, Legal Vice Presidency, The World Bank.

[1] Judge Weeramantry has talked of sustainable development as a legal principle in its own right; *see* Gabcikovo-Nagymaros (Hungary v. Slovakia), 1997 I.C.J. 88 (September 25) (separate opinion of Vice-President Weeramantry).

[2] Edith Brown Weiss, *International Environmental Law: Contemporary Issues and the Emergence of a New World Order*, 81 GEO. L. J. 675 (1993).

[3] For example the 1993 FAO Compliance Agreement, 33 I.L.M. 968 (1994), and the 1995 UN Straddling Stocks Agreement, 34 I.L.M. 1542 (1995), were directly mandated by UNCED. But others, such as the 1994 UN Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 33 I.L.M. 1328 (1994), the 1998 Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention), 38 I.L.M. 1 (1999), and the negotiations for a Convention on Persistent Organic Pollutants (POPs), <http://irptc.unep.ch/pops/>, have grown directly out of the Rio Process.

It is perhaps worth reflecting on why this rapid development has taken place. We are only beginning to understand and be aware of the way that life on the planet depends on the proper functioning of its physical and biological systems. As the UN General Assembly recognized in 1982 in the "World Charter for Nature," terrestrial and marine ecosystems are quite literally "life support systems."[4] Indeed, the very continuation of human life on the planet depends on the continued existence of physical conditions within a relatively narrow range of parameters. These conditions, which do not exist on most other planets in our solar system, include not only the existence of water and the maintenance of ecosystems which produce an abundant supply of vegetable matter and other foodstuffs, but also the continued existence of the ozone layer and the climatic system. Our own activities are putting a number of these systems under stress. Rapid advances in science and technology may have given us the internal combustion engine, air conditioning and space travel as well as unparalleled advances in medicine, but these and other advances have not been without cost. The hole in the ozone layer, land degradation, water pollution and probably (or perhaps possibly) global climate change are the prices that we have paid, and may still have to pay.

These new threats to natural life support systems force us into a different view of the nature of the demands that mankind can legitimately make upon the planet and have changed our perceptions of the nature of sovereignty as much as they have changed our views of the vulnerability of our planet. As Professor Handl has argued,[5] it is no longer easy to accept the traditional notion of national sovereignty that states may do whatever they please within their own territory[6] when we know that certain types of activities - such as the release of ozone depleting chemicals, the burning of fossil fuels, deforestation, damage to watersheds and the reckless exploitation of groundwater resources - may well cause damage to environmental systems at transnational, regional or global level. Therefore, international environmental law is increasingly accepting in the development of both, treaty and custom, that a rigid traditional view of state territory and state sovereignty under which activities under state control are unchallengeable by other states can no longer be compatible with serious attempts to address environmental problems.[7]

The impact is especially acute in the way in which these new concepts relate to the international law of natural resources, particularly the issue of permanent sovereignty

---

[4] This term was popularized by its use in *The World Charter for Nature*, G.A. Res. 37/7, U.N. GAOR, 37th Sess., Supp. No. 51, at 17, U.N. Doc. A/37/51 (1982); *see* also 22 I.L.M. 455 (1983).

[5] Gunther Handl, *Environmental Security and Global Change: the Challenge to International Law*, 1 YB. INT'L ENVTL. L. 3, at 32 (1990).

[6] Or of course in areas beyond national jurisdiction, but this has been accepted at least since the 1972 UN Conference on the Human Environment. *See* Principle 21 of the Stockholm Declaration, *infra* note 11, now Principle 2 of the Rio Declaration, *infra* note 10.

[7] As Professor Handl has said, "sovereignty signals no longer a simple *status negativus*, a legal basis for exclusion, but has become the legal basis for inclusion of a commitment to co-operate for the good of the international community at large," *see* Handl, *supra* note 5, at 32.

over natural resources, such as forests, water (both surface and groundwater) and other natural systems, and the use of common property resources, such as fisheries or resources of common concern, such as the ozone layer, global climate and biological diversity.[8]

There is broad consensus among experts that "international groundwater law" is still in its infancy.[9] No subject specific legal framework pertaining specifically to transboundary aquifers exists at either a regional or a global level. It should be clear from the discussion in the previous Chapters not only that the sustainable use of water will be a major pre-occupation in the next century but also that "invisible" groundwater resources may well hold the only key to addressing many of the water problems currently faced and to be faced. It is paradoxical that although surface waters represent what Professor McCaffrey calls the tip of the iceberg of global water resources, there is a developed international regime for international watercourses, but only an embryonic regime for groundwater. The analogy to the visible tip of an invisible iceberg is highly compelling. There is clearly a pressing need for specific instruments developing a legal regime specifically designed for the management of transboundary groundwater resources. To be adequate, such a regime has to address two issues in particular: the protection of this extensive resource base from pollution, and its protection from excessive and, thus depleting, abstraction. The purpose of this Chapter is to outline how existing principles of international environmental law could serve those two objectives. It will attempt to demonstrate the role these principles have to play in the protection of natural resources, and to identify a number which could be relevant to the sound management of transboundary groundwater resources.

RELEVANT PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW

Principle 2 of the 1992 Rio Declaration[10] provides a particularly vivid illustration of the dichotomy between the requirements of the doctrine of permanent sovereignty over natural resources, and sustainable development. It reads as follows:

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and development policies, *and* the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction. [emphasis added]

I will seek to argue that the second leg of this principle has actually become much more wide ranging than was, perhaps, initially envisaged in 1972 by the drafters of what

---

[8] Resources classified by economists as "global public goods."

[9] *See* McCaffrey, Chapter 9, and Salman & Krishna, Chapter 10 of this Report.

[10] Rio Declaration on Environment and Development, U.N. Doc.A/CONF.151/26; *see* also 31 I.L.M. 874 (1992), and ANNEX 6 of this Report.

was then Principle 21 of the Stockholm Declaration.[11] The requirements of the second leg - not to cause extra territorial harm - are not simply passive or responsive obligations to respond when damage is shown, but have become positive and pro-active obligations.[12] The reason for this has a lot to do with our understanding of the nature of, as well as, the interdependence and vulnerability of ecosystems. There is an increasing appreciation of the inter-linkages between climate, land use, desertification and biodiversity loss,[13] as well as a better understanding of the impacts of human activities, often in relation to practices which were thought innocuous when they were first started. A few examples, as well as the legal responses to these are set out below:

- discharge of ballast water;[14]
- transnational emissions and atmospheric emissions;[15]
- discharges to water, whether watercourses or the sea, from diffuse sources, such as agriculture;[16]
- deliberate introduction of exotic species (such as the Nile perch introduced into Lake Victoria).[17]

Sustainable development involves controls on the use of natural resources at both a national and international level. In fact, many of the elements of international law in the field of sustainable development have emerged or are emerging as legal principles and can be found in the 1992 Rio Declaration on Environment and Development.[18] From an

---

[11] Stockholm Declaration of the United Nations Conference on the Human Environment, 11 I.L.M. 1416 (1972).

[12] And to follow Professor Handl and others in arguing that this has resulted in a major change in the nature of sovereignty over natural resources.

[13] *See* ROBERT T. WATSON ET AL., PROTECTING OUR PLANET – SECURING OUR FUTURE, LINKAGES AMONG GLOBAL ENVIRONMENTAL ISSUES AND HUMAN NEEDS, UNEP/NASA/THE WORLD BANK (1998).

[14] A vivid example can be found in the Black Sea where the accumulated biomass of a jellyfish-like species (*mnemiopsis leidyi*), introduced through tanker ballast water, is ten times the worlds annual global fish catch.

[15] UNECE 1979 Geneva Convention on Long-Range Transboundary Air Pollution, 18 I.L.M. 1442 (1979) and protocols; 1992 UN Framework Convention on Climate Change (UNFCCC), 31 I.L.M. 849 (1992).

[16] 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses, 36 I.L.M. 700 (1997); *see* also 1995 Washington Programme of Action on Land Based Sources of Pollution.

[17] Introduced as a game fish, it has virtually eliminated the endemic bottom feeding species which help keep eutrophication at bay. Together with the impact of human waste and agricultural runoff, the nutrient load has become extremely high, resulting in the virtually uncontrollable growth of water hyacinths. *See* Rafik Hirji & David Grey, *Managing International Waters in Africa: Process and Progress, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT 77, 85-86 (World Bank Technical Paper No. 414, 1998).

[18] For the text, *see* ANNEX 5 of this Report.

international law point of view, one of the most revolutionary aspects of the package deal of Rio both in the Declaration and in the treaties which emerged from the process[19] is that it makes a State's management of its own domestic environment and resources a matter of international concern.[20]

> See, for example, the little quoted Principle 8 of the 1992 Rio Declaration:[21]
>
> To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

But the Declaration also imposes requirements on States (note the use of term of obligation - "shall" - in the following principles) to enact effective environmental legislation (Principle 11) and undertake environmental impact assessment (Principle 17).

These considerations are one element of what many commentators have called the paradigm shift which sustainable development entails.[22] Two examples will have to suffice of the sorts of paradigm shifts that can be found in the law regarding equitable utilization of common property resource.

The first highlighted by Professor McCaffrey relates to international watercourses and also (by implication) to groundwater resources. The 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses[23] contains a blanket and unqualified obligation on watercourse states, individually and where appropriate, jointly to "protect and preserve the ecosystems of international waterways." (Article 20). Compared with the controversy over the balance between equitable and reasonable use (Articles 5 and 6) and the obligation not to cause significant harm (Articles 7), it appears that Article 20 on protection and preservation of ecosystems was relatively uncontroversial and yet it imposes on States a sweeping and unqualified obligation.[24] This obligation is not qualified for example by the need to protect ecosystems only if failure to do so may adversely effect another state. It applied to all ecosystems of international watercourses. Since the ecosystems of watercourses include contiguous land

---

[19] David Freestone, *The Road from Rio: International Environmental Law after the Earth Summit*, 6 J. ENVTL. L. 193 (1994).

[20] The idea that sustainable development involves some limits on the use of natural resources can be found in a number of international conventions, such as the UNFCCC (Article 3), *supra* note 15, the Convention on Biological Diversity (CBD), 32 I.L.M. 818 (1992), the Convention to Combat Desertification, *supra* note 3, and the 1995 UN Straddling Stocks Agreement, *supra* note 3.

[21] *See supra* note 10.

[22] For a discussion of the term "paradigm shift" and an analysis of the number of times it has been used in this connection, *see* PETER SAND, TRANSNATIONAL ENVIRONMENTAL LAW, at iii (1999).

[23] *See supra* note 16.

[24] Stephen McCaffrey, *The UN Convention on the Law of the Non-Navigational Uses of International Watercourses: Prospects and Pitfalls, in* SALMAN M. A. SALMAN AND LAURENCE BOISSON DE CHAZOURNES EDS., *supra* note 17, at 17, 24.

areas, it imposes a very high standard of care on the littoral state to maintain land use in a way that does not affect the ecosystem. This would include for example restrictions on deforestation, use of pesticides and protection of associated groundwater resources. Although this is a treaty law obligation binding only upon parties to the Convention, in the *Gabcikovo-Nagymaros (Hungary v. Slovakia)* case, the International Court of Justice seems to suggest that this is already passing into customary international law.[25]

It can also be argued that sustainable development provides an additional perspective to the legal regime of international watercourses and of transboundary groundwater resources. This suggests that the whole question of equitable use, which has traditionally been seen entirely within a bilateral context, must also be seen through a wider lens, so as to involve broader community concerns. This *erga omnes* aspect of the obligations of littoral states would be premised on the argument that major international watercourses, and of course groundwater reserves and resources, have a significance to the wider international community which is greater than, and may be different from, the interests of two or more littoral states. This issue is also touched upon in the *Gabcikovo-Nagymaros* case.[26]

Another example can be found in the 1995 Straddling Fish Stocks and Highly Migratory Fish Stocks Agreement.[27] It will be recalled that the convening of an international conference on straddling stocks was specifically mandated by Agenda 21.[28] Agenda 21 had also called for an approach to marine resources management which was both holistic and precautionary.[29] Both these concepts are reflected in the 1995 Straddling Stocks Agreement which endorses for the first time an ecosystem approach to fisheries management, mandates precaution in assessing stocks and even provides a precautionary methodology for stock management in its Annex II.

The objectives of the Agreement are not defined in terms of the maximization of food for human consumption (as was the case in the 1958 Geneva Convention on Fisheries and Conservation of the Living Resources of the High Seas), but for the first time in an international agreement of this type, conservation is defined in terms of ecosystem protection, and protection of biological diversity. It declares an aspiration to

---

[25] *Supra* note 1.

[26] *Id.*

[27] *Supra* note 3.

[28] This was then implemented by U.N.G.A. Res. 47/192 on the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks. For a general discussion of the issues involved *see* Barbara Kwiatkowska, *The High Seas Fisheries Regime: At a Point of No Return?*, 8 INT'L J. OF MARITIME AND COASTAL L. 327 (1993), and David Freestone, *The Effective Conservation and Management of High Seas Living Resources: Towards a New Regime?*, 5 THE CANTERBURY LAW REVIEW (NZ) 341 (1994).

[29] For the documents adopted at UNCED *see* U.N. Doc. A/CONF.151/26 (Volumes I-V), August 12, 1992, or STANLEY P. JOHNSON, THE EARTH SUMMIT: THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT (UNCED) (1992); *see* Chapter 17 on "Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas and coastal areas and the protection, rational use and development of their resources."

improve upon previous fisheries management treaties by recognizing the independent need to protect the marine environment through the protection of its biodiversity, maintenance of the integrity of marine ecosystems and the minimization of the risk of long term or irreversible effects of fishing operations.[30] This statement can be seen as evidence that the 1995 Agreement is the first global fisheries agreement to recognize at a primary level the environmental significance of fishing activities: not simply as an issue to have regard to in, for example the calculation of Total Allowable Catch (TAC), but as an independent issue in its own right. This provides the justification for the even more far reaching (and long overdue) restrictions on the traditional right of freedom of fishing on the high seas introduced by the Convention.[31]

The key modality for obtaining this outcome is the precautionary approach. Precaution occupies a central place in any realistic strategy for the achievement of sustainable development, and particularly sustainable use of the planet's natural resources. The origins and development of the precautionary principle or approach have been extensively discussed elsewhere.[32] Again the Rio Declaration provides much of the text. A definition of the precautionary principle is set out in Principle 15:[33]

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty

---

[30] In preambular recital number seven is found the first and most significant statement of the environmental importance of international fisheries issues. *See* generally David Freestone & Zen Makuch, *The New International Environmental Law of Fisheries: The 1995 UN Straddling Stocks Agreement,* 7 YB. INT'L ENVTL. L. 3 (1996).

[31] *See* further David Freestone & Zen Makuch, *id.* It is also instructive to re-examine the very far-sighted language of the 1982 Law of the Sea Convention in its provisions on fisheries to *see* the way in which the essential elements of a precautionary approach can also be found within its provisions, *id.*, at 18-19.

[32] *See*, for exapmle, L. Gündling, *The Status in International Law of the Principle of Precautionary Action, in* DAVID FREESTONE & TON IJLSTRA EDS., THE NORTH SEA: PERSPECTIVES ON REGIONAL ENVIRONMENTAL CO-OPERATION 23 (1990); James Cameron & Julie Abouchar, *The Precautionary Principle: a Fundamental Principle of Law and Policy for the Protection of the Global Environment*, 14 B. C. INT'L & COMP. L. REV. 1 (1991); David Freestone, *The Precautionary Principle, in* ROBIN CHURCHILL & DAVID FREESTONE EDS., INTERNATIONAL LAW AND GLOBAL CLIMATE CHANGE 21 (1991); Ellen Hey, *The Precautionary Approach: Implications of the Revision of the Oslo and Paris Conventions*, 15 MARINE POLICY (1991). *See* also TIMOTHY O'RIORDON & JAMES CAMERON EDS., INTERPRETING THE PRECAUTIONARY PRINCIPLE (1994), and DAVID FREESTONE & ELLEN HEY EDS., THE PRECAUTIONARY PRINCIPLE AND INTERNATIONAL LAW: THE CHALLENGE OF IMPLEMENTATION (1996). Most recently *see* David Freestone, *International Fisheries Law Since Rio - the Continued Rise of the Precautionary Principle, in* ALAN E. BOYLE & DAVID FREESTONE EDS., INTERNATIONAL LAW AND SUSTAINABLE DEVELOPMENT 135 (1999).

[33] On the distinction between the precautionary approach and the principle *see* further Ellen Hey, *The Precautionary Principle in Environmental Law and Policy: Institutionalising Caution*, 4 GEO. INT'L ENVL. L. REV. 303 (1992), who argues that an approach must be interpreted in the light of the principle. This view is also taken by Professor Alexandre Kiss, *Will the Necessity to Protect the Global Environment Transform the Law of International Relations?, in* 1992 JOSEPHINE ONOH MEMORIAL LECTURE, UNIVERSITY OF HULL 13 (1993).

shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

I have suggested before that the precautionary principle is not an entirely new concept.[34] Acceptance of the precautionary principle entails acceptance of the fact that restrictions must be placed on activities which are likely to have significant negative impacts on the environment, even if science is unable to predict accurately what these impacts will be. It does not, as many fear, provide an absolutist prohibition on such activities - it mandates "measures" (maybe even cost effective measures) - the appropriateness of which will and must vary from case to case. Again the Straddling Fish Stocks Agreement provides an innovative methodology - the establishment of reference points regarding fish stock biomass which, when they are approached, trigger further management conservation measures. The significance is that it should initiate a decision-making process in which the onus of proof is on those who wish to continue exploitation to show that the resource can sustain such exploitation, rather than as usual in the past where the burden is presumed to be on those in favor of conservation to show that the resource cannot sustain continued exploitation.[35]

The distinctive feature then of the precautionary principle is not that it dictates specific regulatory measures: many different types of measures can be used to implement it. The distinctive characteristic is the way in which, and the time at which, the measures are to be adopted. "It is a challenge to our way of viewing the world as much as to our views about the role of science or the burden of proof."[36] Like the concept of sustainable development itself (of which it is an intrinsic element), precaution can also provide a new lens with which to view existing legal rights and obligations.

Seen in this light, the precautionary approach or methodology encompasses a number of other procedures:

1. The requirement to enact environmental legislation (Rio Principle 11) is itself essentially precautionary in that it requires that established procedures and institutions be in place in order to deal with issues as they arise, rather than in an *ad hoc* response mode. It also aims to ensure that environmental concerns are an established and legitimate aspect of governance.

2. Provision of prior and timely notification of relevant information regarding transboundary impacts (contained in Rio Principle 19). We can see this concept emerging in treaty law and in practice. Again note that in Part III of the 1997

---

[34] David Freestone, *The Precautionary Principle, in* ROBIN CHURCHILL & DAVID FREESTONE EDS., *supra* note 32.

[35] A similar approach has been proposed in relation to Marine Biodiversity by the Jakarta Mandate Experts Group established under the Convention on Biological Diversity; *see* Report of the First Meeting of Experts on Marine and Coastal Biological Diversity, UNEP/CBD/JM/Expert/1/5, UNEP/CBD/SBSTTA/3/Inf.1 (visited June 24, 1999) <http://www.biodiv.org/jm/JM1_5.html>.

[36] DAVID FREESTONE & ELLEN HEY EDS., *supra* note 32.

Convention on the Law of the Non-Navigational Uses of International Watercourses are included prior notification requirements for proposed activities which might have adverse impacts. Similarly the World Bank Operational Policy for Projects on International Waterways (OP 7.50) prescribe specific procedures on notification.[37] The requirement of simple notification has actually been developed further for certain particularly hazardous activities into the requirement of Prior Informed Consent (PIC) in the context of the 1989 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal.[38] For international trade in chemical and pesticides, the Principle has now developed into the 1998 Prior Informed Consent Convention.[39] Note also that for certain shared mineral reserves the principle of no unconsented unilateral exploitation is now firmly established in treaty and custom.[40]

3. Environmental Assessment (Principle 17) does not apply simply to those activities with transboundary impacts such as those governed by the ECE 1991 Espoo Convention on Environmental Impact Assessment in a Transboundary Context,[41] the 1974 Nordic Convention[42] which permits rights of action by individuals in the courts of the other signatories. Principle 17 builds on the developments pioneered by UNEP (see 1987 UNEP Nairobi Guidelines) and operationalized by the World Bank, which since 1989 has required all investment projects to be screened for environmental purposes.[43]

---

[37] *See* World Bank OP 7.50, The World Bank, *The Operational Manual* (visited June 24, 1999) <http://wbln0011.worldbank.org/Institutional/Manuals/OpManual.nsf>; also reproduced in SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT, ANNEX 2A, at 193 (World Bank Technical Paper No. 414, 1998).

[38] 28 I.L.M. 649, 657 (1989).

[39] 1998 Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 31 I.L.M. 1 (1999). The PIC regime for exports of hazardous chemicals from industrialized countries was pioneered by UNEP, FAO and various NGOs (including those representing industry) after the failure of previous attempts to regulate the trade more formally. In the absence of a treaty regime there was by definition no compliance regime, but informal information feedback systems allowed the PIC system to "learn by doing" in a way which Victor argues a formal (and, he argues, inflexible) treaty regime could not have accommodated. The PIC treaty, building on this informal regime, has been negotiated - by all accounts the negotiating process was, perhaps as a result, relatively swift and uncomplicated. *See* DAVID G. VICTOR ET AL. EDS., THE IMPLEMENTATION AND EFFECTIVENESS OF INTERNATIONAL ENVIRONMENTAL COMMITMENTS: THEORY AND PRACTICE (1998).

[40] William Onorato, *Apportionment of an International Common Petroleum Deposit*, 26 INT'L & COMP. L.Q. 324 (1977); Rainer Lagoni, *Oil and Gas Deposits Across National Frontiers*, AM. J. INT'L L. 217, 219 (1979).

[41] 30 I.L.M. 800 (1991).

[42] Convention on the Protection of the Environment between Denmark, Finland, Norway and Sweden, 13 I.L.M. 591 (1974).

[43] Since October 1989 all investment projects proposed for World Bank consideration must be screened for their potential environmental impacts. This requirement was originally contained in a Operational Manual Statement, but was issued as an Operational Directive (OP 4.01 on Environmental Assessment) in

4. Participation and access to information (Principle 10). Again we look to the UN Economic Commission for Europe (ECE) for a recent "state of the art" convention, the 1998 Aarhus Convention on Access to Environmental Information[44] which is open for signature by non-ECE states and which also requires states to implement these principles within international organizations to which they belong.

How then are these principles applicable to transboundary groundwater resources? This chapter has sought to argue that these are generic legal principles which through the evolution of international environmental law and the law of sustainable development provide an overarching framework for the sustainable exploitation of any natural resources, particularly those with a transboundary element. The fact that there is as yet no specific developed global legal regime for groundwater law should not blind us to the fact that many of the basic principles are already known, and may be argued to be in place already under emerging customary international environmental law, and international law regulating natural resources.

Such meager regional treaty law as there is, points in this direction also. The highly innovative and prescient 1968 African Convention on the Conservation of Nature and Natural Resources[45] provides in its Article V(1) that:

> The Contracting States shall establish policies for the conservation, utilization and development of underground and surface water, and shall endeavour to guarantee for their populations a sufficient and continuous supply of suitable water, taking appropriate measures with due regard to:
>
> (i) the study of water cycles and the investigation of each catchment area,
>
> (ii) the co-ordination and planning of water resources development projects,
>
> (iii) the administration and control of all water utilization, and
>
> (iv) prevention and control of water pollution.

In Article V(2) it provides that:

October 1991. In December 1998 it was re-issued as Operational Policy 4.01. *See* generally Charles Di Leva, *International Environmental Law and Development*, 10 GEO. INT'L ENVIRONMENTAL L. REV. 501 (1998); The World Bank, *The Operational Manual* (visited June 24, 1999) <http://wbln0011.worldbank.org/Institutional/Manuals/OpManual.nsf>.

[44] For the full text of the Convention *see* The Secretariat for the Arhus Conference, June 1998, *Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters* (visited June 24, 1999) <http://www.mem.dk/aarhus-conference/issues/public-participation/ppartikler.htm>. See also 38 I.L.M. 517 (1999).

[45] Algiers, 1968. Reproduced in Harald Hohmann Ed., 3 Basic Documents in International Environmental Law 1530 (1992).

> Where surface or underground water resources are shared by two or more of the Contracting States, the latter shall act in consultation, and if the need arises, set up inter-State Commissions to study and resolve problems arising from the joint use of these resources, and for the joint development and conservation thereof.

The 1992 UN ECE Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes,[46] concluded in the March of 1992, draws strongly on the same principles which in June of that year were encapsulated in the Rio Declaration, as well as on ECE's own work on surface and groundwater management.[47] The overarching general provisions set out in Article 2 provide a direct link between the law of watercourses and the principles of international environmental law. The Parties agree to take all appropriate measures: "to prevent, control and reduce any transboundary impact.";[48] "...to prevent, control and reduce pollution of waters causing or likely to cause transboundary impact; to ensure that transboundary waters are used with the aim of ecologically sound and rational water management, conservation of water resources and environmental protection; ...to ensure conservation and where necessary restoration of ecosystems."[49] It is also agreed that measures taken for prevention, control and reduction of water pollution shall be taken where possible at source and shall not result in the transfer of pollution to other parts of the environment.[50] Perhaps even more significant however is the explicit inclusion of the more innovative principles to guide the above measures. These include the precautionary principle,[51] the polluter pays and an inter-generational equity/sustainable development principle.[52]

---

[46] Reproduced *in* SALMAN M. A. SALMAN & LAURENCE BOISSION DE CHAZOURNES EDS., ANNEX 3, at 203, *supra* note 17.

[47] *See* Preambular paragraph 6 to the Convention which refers to a number of instruments concluded by UNECE including the ECE Principles Regarding Co-operation in the Field of Transboundary Waters, and the ECE Charter on Groundwater Management; *see* Branko Bosnjakovic, *UN/ECE Strategies for Protecting the Environment with Respect to International Watercourses: The Helsinki and Espoo Conventions*, *in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., *supra* note 17.

[48] *Id.*, Article 2(1).

[49] *Id.*, Article 2(2)

[50] *Id.*, Article 2(3) and (4).

[51] "....by virtue of which action to avoid the potential transboundary impact of the release of hazardous substances shall not be postponed on the ground that scientific research has not fully proved a causal link between those substances on the one hand, and the potential transboundary impact, on the other hand;" *id.* Article 2(5)(a).

[52] "Water resources shall be managed so that the needs of the present generation are met without compromising the ability of future generations to meet their own needs." This text is based on the definition of sustainable development in the Report of the Brundtland Commission.

CONCLUSION

The concept of sustainable development as encapsulated in the 1992 Rio Declaration and the emerging rules of international environmental law does suggest certain conclusions as to the way in which the exploitation of groundwater resources should proceed. These are both substantive and procedural. Water, although a renewable resource, is an increasingly scarce one. With the enactment of a Convention on Desertification, the issue of water uses has also been flagged as an issue of international concern.[53] Exploitation of scarce, transboundary groundwater resources can no longer be seen as an issue exclusively within the jurisdiction of the State under the territory of which these resources extend. For the vast continental groundwater resources discussed elsewhere in this Chapter there can be argued to be obligations owed *erga omnes*[54] - they are resources of international concern. The perspective of sustainable development demands that their exploitation be conducted within a paradigm of sustainability. This paradigm requires not simply sustainability in terms of the volumes extracted, but also in the institutional or legal arrangements under which such extraction takes place.

From a procedural point of view, the precautionary modalities are set out in the Rio Declaration. Environmental impact assessment must be conducted for potential impacts on the resource and its dependent ecosystems. There should be prior and timely notification of all relevant information regarding transboundary impacts to those states likely to be affected, and to address the *erga omnes* aspects. Access to this information should be provided to the broader community. Exploitation of groundwater should therefore only take place within an agreed and ordered regulatory framework.

---

[53] As Mr. Boyle has pointed out in relation to the atmosphere, the importance of this designation was that it is signaled as an area "in whose protection all states have a legal interest and which all states have a duty to preserve from serious harm." *See* Alan E. Boyle, *International Law and the Protection of the Global Atmosphere: Concepts, Categories and Principles, in* ROBIN CHURCHILL & DAVID FREESTONE EDS., *supra* note 32, at 19.

[54] *See* further MAURIZIO RAGAZZI, OBLIGATIONS ERGA OMNES IN INTERNATIONAL LAW (1998).

BIBLIOGRAPHY (Selected)

Boyle, Alan, E., *International Law and the Protection of the Global Atmosphere: Concepts, Categories and Principles, in* ROBIN CHURCHILL & DAVID FREESTONE EDS. 19 (1998).

Cameron, James & Abouchar, Julie, *The Precautionary Principle: a Fundamental Principle of Law and Policy for the Protection of the Global Environment*, 14 B. C. INT'L & COMP. L. REV. 1 (1991).

Di Leva, Charles, *International Environmental Law and Development*, 10 GEO. INT'L ENVIRONMENTAL L. REV. 501 (1998).

Freestone, David, *International Fisheries Law Since Rio - the Continued Rise of the Precautionary Principle, in* ALAN E. BOYLE & DAVID FREESTONE EDS., INTERNATIONAL LAW AND SUSTAINABLE DEVELOPMENT 135 (1999).

Freestone, David, *The Effective Conservation and Management of High Seas Living Resources: Towards a New Regime?*, 5 THE CANTERBURY LAW REVIEW (NZ) 341 (1994).

Freestone, David, *The Precautionary Principle, in* ROBIN CHURCHILL & DAVID FREESTONE EDS., INTERNATIONAL LAW AND GLOBAL CLIMATE CHANGE 21 (1991).

Freestone, David, *The Road from Rio: International Environmental Law after the Earth Summit*, 6 J. ENVTL. L. 193 (1994).

FREESTONE, DAVID & HEY, ELLEN, EDS., THE PRECAUTIONARY PRINCIPLE AND INTERNATIONAL LAW: THE CHALLENGE OF IMPLEMENTATION (1996).

Freestone, David & Makuch, Zen, *The New International Environmental Law of Fisheries: The 1995 UN Straddling Stocks Agreement,* 7 YB. INT'L ENVTL. L. 3 (1996).

Gündling, L., *The Status in International Law of the Principle of Precautionary Action, in* DAVID FREESTONE & TON IJLSTRA EDS., THE NORTH SEA: PERSPECTIVES ON REGIONAL ENVIRONMENTAL CO-OPERATION 23 (1990).

Handl, Gunther, *Environmental Security and Global Change: the Challenge to International Law*, 1 YB. INT'L ENVTL. L. 3 (1990).

Hey, Ellen, *The Precautionary Principle in Environmental Law and Policy: Institutionalising Caution*, 4 GEO. INT'L ENVL. L. REV. 303 (1992).

Hey, Ellen, *The Precautionary Approach: Implications of the Revision of the Oslo and Paris Conventions*, 15 MARINE POLICY (1991).

JOHNSON, STANLEY P., THE EARTH SUMMIT: THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT (UNCED) (1992).

Kiss, Alexandre, *Will the Necessity to Protect the Global Environment Transform the Law of International Relations?, in* 1992 JOSEPHINE ONOH MEMORIAL LECTURE, UNIVERSITY OF HULL 13 (1993).

Lagoni, Rainer, *Oil and Gas Deposits Across National Frontiers*, AM. J. INT'L L. 217, 219 (1979).

McCaffrey, Stephen, *The UN Convention on the Law of the Non-Navigational Uses of International Watercourses: Prospects and Pitfalls, in* SALMAN M. A. SALMAN AND LAURENCE BOISSON DE CHAZOURNES EDS. 17 (World Bank Technical Paper No. 414, 1998).

Onorato, William, *Apportionment of an International Common Petroleum Deposit*, 26 INT'L & COMP. L.Q. 324 (1977).

O'RIORDON, TIMOTHY & CAMERON, JAMES, EDS., INTERPRETING THE PRECAUTIONARY PRINCIPLE (1994).

Rafik Hirji & David Grey, *Managing International Waters in Africa: Process and Progress, in* SALMAN M. A. SALMAN & LAURENCE BOISSON DE CHAZOURNES EDS., INTERNATIONAL WATERCOURSES – ENHANCING COOPERATION AND MANAGING CONFLICT 77 (World Bank Technical Paper No. 414, 1998).

RAGAZZI, MAURIZZIO, OBLIGATIONS ERGA OMNES IN INTERNATIONAL LAW (1998).

SAND, PETER, TRANSNATIONAL ENVIRONMENTAL LAW (1999).

VICTOR, DAVID G. ET AL., EDS., THE IMPLEMENTATION AND EFFECTIVENESS OF INTERNATIONAL ENVIRONMENTAL COMMITMENTS: THEORY AND PRACTICE (1998).

WATSON, ROBERT T. ET AL., UNEP/NASA/THE WORLD BANK, PROTECTING OUR PLANET – SECURING OUR FUTURE, LINKAGES AMONG GLOBAL ENVIRONMENTAL ISSUES AND HUMAN NEEDS (1998).

Weiss, Edith Brown, *International Environmental Law: Contemporary Issues and the Emergence of a New World Order*, 81 GEO. L. J. 675 (1993).

ANNEXES

ANNEX 1

THE HASHEMITE KINGDOM OF JORDAN

Ministry of Water and Irrigation

POLICY PAPER NO. 3

Groundwater Management Policy

February 1998
Amman, Jordan

FOREWORD

A water strategy for Jordan was prepared by the Minister of Water and Irrigation and was debated by the staff of the Ministry, the Jordan Valley Authority (JVA) and the Water Authority (WAJ). It was adopted by a joint session of the Board of Directors of both the JVA and WAJ.

The Strategy was then debated and approved by the Ministerial Development Council of the Government, and was forwarded to the Council of Ministers who debated the same and approved it on 29 April 1997. Under this Strategy, a series of policies are to be formulated by the Ministry and its two authorities and adopted by the competent bodies of Government.

The first such policy addressed the Water Utility. It was prepared by the Minister and his staff. The Board of Directors of WAJ debated and approved it. The document was then forwarded to the Prime Minister for consideration by the Ministerial Development Council. It was reviewed and debated by the Council and was approved on 23 July 1997, and the Council of Ministers approved it on 26 July 1997.

The second policy addressed the Irrigation Water Policy It was formulated by the Minister and completed on 10 December 1997, was reviewed and discussed by his staff on 13 December, debated and approved by the Board Directors of the JVA, and was subsequently forwarded to the Prime Minister for consideration by the Ministerial Development Council. The Council debated and amended the document on 7 January 1998, and on 11 February 1998. It then forwarded it to the Council of Ministers who debated and approved it on 14 February 1998.

The third Policy Paper is the subject of this volume. It addresses the topic of groundwater management, and the Government's policy towards it. It was debated and amended by the Ministerial Development Council on 7 January and on 11 February 1998. The Council had it forwarded to the Council of Ministers who approved it on 17 February 1998.

The Water Policy papers address most of the issues related to the respective topic, and spell out the Government policy towards it. Such policies cover a span of five years or more. It is understood that, while the goal of the Strategy are long term goals, those of the policy are not as permanent, and would change with changing times, circumstances and relevant factors.

It is hoped that the various water policies would serve the purposes for which they were formulated for a period of no less than five years. They, nonetheless, respond to an urgent need at this time, and serve to assist in the clarity of vision and the transparency of government intentions regarding the various composites of the water sector.

Dr. Munther J. Haddadin

Minister of Water and Irrigation

GROUNDWATER MANAGEMENT POLICY

Background

Groundwater in the Hashemite Kingdom of Jordan occurs in a renewable and nonrenewable form in 12 distinct basins. The exploitation of groundwater in ancient times was done through the exploitation of springs where groundwater emerge to the ground surface, and through the artificial means of tapping the aquifers by drilling shafts. Archaeological remains in the Jordan Rift Valley indicate the sinking of such shafts at different angles. They date back to the Nabatean era (300 B.C – 106 A.C) and the Roman era thereafter. Jordanians continued to harness the benefits of the use of spring water for different purposes. In the Ottoman era (1516 – 1916), the use of water was regulated and water rights were kept by the district administration in an official register. Legislation for water acquisition and use in the Hashemite Kingdom started in 1938, and due consideration was taken of the prior water rights recognized by the previous Ottoman administration.

Modern technology to access groundwater aquifers was introduced to the Kingdom in the late fifties; legislation to regulate the exploitation of groundwater resources and to have it supervised by Government was soon introduced. The country had its population doubled as it hosted the first wave of Palestinian refugees in 1948. It united with the West Bank in 1951 in one Hashemite Kingdom. Free movement of people, goods, and services was normal and added more to the population. The increase in population occurred in and around urban areas, which intensified the demand for urban water. Springs that had been the source of urban water could no more cope with the increased demand. Streams that emerged from them dried up with adverse environmental consequences. Tube wells were drilled to pump more water from the aquifers for urban supply purposes.

Demand also increased for food. Permits were also issued to interested developers to drill wells for agricultural development. The drilling and abstraction of groundwater were monitored and controlled until the outbreak of the 1967 war and its aftermath. Government control weakened, and many wells were drilled without permits. The relaxation of Government controls thereafter continued primarily because of the institutional instability and the shifting institutional responsibilities.

Today, each of the 12 water basins has wells sunk in it and pumps installed in them capable of abstracting more water than the safe yield of each. The average annual abstraction from all basins exceeds the renewable average of recharge and currently stands at 159% of that average. The over pumping ration ranges between 146% in minor aquifers to 235% in major ones. This situation could not be tolerated, and decisions were taken to treat the situation.

The desire to propagate agricultural development prompted Government to lease out lands in the southeast in 1984, and contracted with agricultural production companies to undertake such activities in those remote and arid areas. Fossil fresh water is being used for the purpose. The aquifers thus exploited have been identified as a primary source for urban water supply to Amman, and a major project has been designed to convey water to Amman

at an average capacity of 100 MCM per year. Action has been taken to reduce agricultural usage from these aquifers.

The Water Strategy for Jordan, and the water supply – demand table indicate that a gradual reduction of pumping from the groundwater aquifers has to be effected so that the abstraction rate will be close to the annual recharge by the year 2005.

Current Institutional Set-Up

Government administration of the groundwater affairs formally started in the late fifties with the creation of a specialized agency, the Central Water Authority, CTA. This was amalgamated in 1965 into a newly founded organization, the Natural Resources Authority, NRA. In 1977, the newly created Jordan Valley Authority, JVA, was authorized by law to carry out groundwater investigation and development in the Jordan Rift Valley. In 1983, the Water Authority law was enacted, and WAJ assumed the responsibility of groundwater administration, management and development. The concerned directorate of NRA and that of the JVA were transferred to WAJ in 1984. Both WAJ and JVA came under the umbrella of a newly founded Ministry, the Ministry of Water and Irrigation, MWI in 1988.

Currently, MWI/WAJ is in charge of groundwater administration and management in addition to its responsibilities in providing municipal water supplies to all population centers in Jordan, and the collection and treatment of their wastewater. MWI/WAJ receives application for drilling licenses and abstraction permits, and issues such licenses and permits in accordance with the effective groundwater legislation. WMI/WAJ also supervises the drilling, the abstraction, and makes arrangements for the lease of land and use of groundwater for agricultural purposes in remote arid areas. Recently, MWI has stepped up the activities of groundwater resources studies on a national scale.

Conditions of Groundwater Aquifers

There are eleven renewable groundwater reservoirs in the country. Their sustainable yields vary from one reservoir to another, and their combined sustainable yield is 275 million cubic meters per year.

The majority of the reservoirs are being utilized at rates exceeding their sustainable yields. The important ones are of particular concern because they are the most over utilized aquifers. The combined abstraction rate of all renewable reservoirs approaches 437 MCM per year, a rate equal to 159% of their sustainable yield. The over pumping ratio varies from 146% in minor aquifers to 235% in major ones.

The over pumping from one aquifer in the 1960's and 1970's caused its loss due to high salinity ratios. It is feared that this unpleasant experience will be repeated in some others aquifers if they are not rescued through proper management.

There are extensive non-renewable reservoirs in the sandstone formation underlying almost the entire area of the country. The water quality of these reservoirs varies and is known to be fresh in the Disi-Mudawwara area.

Qualities elsewhere have been sparsely investigated and preliminary findings indicate brackish water qualities. More work is needed to investigate these reservoirs.

The use of fresh fossil waters form the non-renewable reservoir in Disi-Mudawwara started in the early eighties for municipal and industrial purposes in the city of Aqaba. This was followed by the use of the same aquifer (Disi) for agricultural purposes. Future use of this aquifer is earmarked municipal purposes for the city of Amman, and pumping for agricultural purposes is being reduced.

The Policy

Objective

The objective of this policy is to outline in more detail the statements contained in the document entitled: "Jordan's Water Strategy." The policy statements set out the Government's policy and intentions concerning groundwater management aiming at development of the resource, its protection, management and measures needed to bring the annual abstractions from the various renewable aquifers to the sustainable rate of each.

On Resource Exploration

1. Plans and implementation measures for the exploration of groundwater resources shall be prepared and updated. Theoretical investigation and field operations in the form of drilling, sampling and logging shall be conducted continually.

2. Assessment and re-assessment of the sustainable yields of groundwater reservoirs shall be made in light of the accumulation of data and information.

3. Monitoring of each reservoir shall be conducted through a network of observation wells. Such crucial data as the groundwater table, the draw down as a result of development, the physical, chemical and biological characteristics and their changes will be collected.

4. Implementation of groundwater exploration will be conducted by MWI/WAJ personnel as a priority. The service can be out-sourced when deemed necessary or required by any partnership with others in this activity.

5. Equipment, hardware and computer software needed for groundwater investigation and exploration shall be maintained by MWI/WAJ. Drilling services can be out-sourced when needed and so will be the maintenance of software packages.

6. Advance methods and tools for investigation, including landsat imagery, shall be employed, and co-operation with other countries in this field will be promoted.

7. A comprehensive program to assess the potential of brackish groundwater shall be conducted. Brackish groundwater will be used to augment water supply for domestic uses through desalination in due time and specified localities. They also may be used for agricultural purposes where appropriate.

8. Compilation of oil and gas drilling data as well as geophysical data shall be made to gain better understanding of the potential of the deep aquifers.

On Monitoring

9. A network of observation wells shall be installed in each of the groundwater reservoirs or parts thereof for the purpose of monitoring the conditions and performance of the reservoirs in response to development and abstraction.

10. A groundwater reservoir can be divided into sub-units for the purposes of monitoring and control of abstraction.

11. Advanced technology shall be employed in the monitoring processes including the installation of water meters, remote control devices, telemetry, automation and field central controls.

12. Data collected in the monitoring process shall be formatted for storage in and retrieval from computer fields. Hard copies and computer back up copies shall be maintained at all times.

13. Analysis and interpretation of data shall be made by a specialized group of professionals and their aides, and results published in special reports by MWI/WAJ.

14. Logistics for the field teams shall be secured, and their working conditions improved to the best affordable levels.

15. MWI/WAJ shall evaluate, update and redesign the groundwater-monitoring plan to cover all aquifers with emphasis on the overexploited and polluted aquifers.

16. A Special monitoring network of industries and olive presses will be adopted and installed for those with potential pollution to groundwater.

On Resource Protection, Sustainability and Quality Control

17. Recharge areas of aquifers shall be protected to the maximum extent possible. Conflicts arising out of urbanization shall be addressed, and mitigation measures specified for the urban planners to have them included in the urban planning process.

18. Recharge areas shall be protected against pollution caused by whatever means including solid and liquid waste disposal, mining, land fills, brine disposal, agricultural inputs and the like.

19. Drilling of wells and abstraction of groundwater from them shall be prohibited without a drilling license and an abstraction permit issued by WAJ.

20. Withdrawal from wells shall not exceed the abstraction permit rate under penalty of substantial fines and/ or revoking the abstraction permit and the closure of the well. Over-abstraction from aquifers shall be reduced to sustainable levels in accordance with a time-phased plan.

21. The laboratories of the Water Authority of Jordan shall be equipped with the latest technologies and equipment to match the requirements of good quality controls and assurance. Monitoring of groundwater qualities shall be made, hazards identified and mitigation measures specified and implemented.

22. Withdrawal from non-renewable fossil aquifers shall be made carefully and after elaborate studies and investigations. A lifetime will be assigned for each of these aquifers and an abstraction rate specified accordingly.

23. The MWI will co-operate with planning and environmental authorities to have polluting industries and solid waste dumps located outside the protection zones of aquifers.

24. The MWI shall co-operate with the Ministry of Agriculture and its arm of extension service to regulate the type and application rate of fertilizers, pesticides, and sludge used within the area of aquifer recharge.

25. MWI/WAJ in liaison with other authorities will seek to restrict storage of chemicals, waste materials and sewage treatment works within the inner circle protection zone.

On Resource Development

26. Development of groundwater reservoirs shall be commenced only after careful studies are made of the potential of each, and observation wells installed in carefully chosen locations to monitor the reservoir during exploitation. Wellfields shall be distributed with a proper distance between wells to minimize sudden draw down of water levels.

27. Development of deep groundwater aquifers shall be carefully made. Abstraction from them shall be gradual with periodic assessment of quality and quantity.

28. Potentials of reservoirs shall be based on the natural rate of recharge. These can be augmented through means of artificial recharge induced through proper designs.

29. Natural rainwater and treated effluent of wastewater are considered primary sources for artificial recharge. Monitoring of recharge facilities and their maintenance shall be made periodically.

30. Development of groundwater reservoirs shall not be allowed without a license issued by MWI/WAJ. Private developers and public entities shall all be required to apply for any development they intend to undertake.

31. Inflow into and outflow from each groundwater reservoir shall be determined as accurately as possible before any permit is issued for the development of that reservoir.

32. Artificial underground storage, especially in the alluvial fans of the Jordan Valley, shall be investigated.

33. Groundwater mathematical models shall be developed or updated for all regional aquifers of the basins to predict their yield under various pumping scenarios.

34. New nonrenewable groundwater resources shall be allocated to municipal and industrial uses as a first priority.

35. MWI/WAJ shall encourage the use of groundwater conjunctively with surface water in places where such joint management has the potential for increasing the benefits of water use.

36. MWI/WAJ shall encourage the use of marginal groundwater quality for agricultural uses especially when such use may relieve pumping from fresh groundwater aquifers.

On Priority of Allocation

37. Priority of allocation of groundwater shall be given to municipal and industrial uses, to educational institutes and to tourism. These purposes are deemed to have the higher returns in economic and social terms.

38. Priority shall also be given to the sustainability of existing irrigated agriculture where high capital investment had been made. In particular, trees irrigated from groundwater shall continue to receive an amount sufficient for their sustainability with the use of advanced irrigation methods.

39. Expropriation of use rights arising from legal use of groundwater, or of water rights established on springs rising from groundwater reservoirs shall not be made without clear higher priority need, and against fair compensation.

40. Priority shall be given to the use in irrigated agriculture of the reservoirs whose water quality does not qualify them for use in municipal and industrial purposes.

41. Priority for use in agriculture shall also be given to the cases where supplementary irrigation from the groundwater reservoir is possible.

42. A contingency plan shall be made and updated for the purpose of allocating the water from privately operated wells for use in the municipal networks.

On Regulation and Control

43. Campaigns shall be waged against illegal drilling of tube wells, and wells thus drilled shall be stopped, rigs confiscated and legal action taken against violators.

44. Comprehensive groundwater basin management plan for each aquifer shall be developed as part of the National Water Master Plan.

45. Water meters installed on groundwater wells shall be read on quarterly basis to make sure that abstraction form the wells do not exceed their allocation, specified in the permits.

46. Prohibition of well licensing for agricultural purposes will be sustained. Only high priority purpose shall be entertained for licensing.

47. Fees and charges will be used as an instrument to control groundwater over-pumping.

On Legislation and Institutional Arrangements

48. Legislation and institutional arrangements for the development and management of groundwater resources shall be reviewed form time to time. Shortcomings shall be addressed and institutional arrangements shall be updated, adjusted or restructured.

49. Effective laws shall be reviewed from time to time with the intention of updating their provisions to match the requirements of changing times. By-laws issued under the applicable laws shall also be updated to serve the purpose of performance efficiency. Institutional set-up shall be reviewed in parallel, updated, adjusted or restructured to improve performance.

50. Close co-operation will be maintained with the other organization whose activities may directly impact the performance in the water sector.

On Research, Development and Technology Transfer

51. A study and research activity shall be entrusted with a specialized unit within MWI. The unit will be entrusted with technology transfer responsibilities.

52. Due emphasis will be made on the efforts targeting human resources development.

53. Training centers will be reinforced and upgraded. Cooperation with outside centers and agencies will be promoted.

54. International and regional cooperation shall be pursued in the fields of research, development and technology transfer in groundwater exploration, management, quality control, and economics shall be promoted. Exchange of information and experience shall be maintained with regional and international parties.

On Shared Groundwater Resources

55. Legal research shall be made on the sharing of groundwater aquifers and their protection.

56. Efforts shall be made and sustained to establish Jordan's rights in shared groundwater resources through international agreements.

57. Regional data exchange on shared groundwater resources shall be encouraged.

58. Cooperation with neighboring countries for the optimal and sustainable use and management of the shared groundwater resources shall be sought.

59. Special attention will be paid to the monitoring, assessment and development of shared groundwater resources.

On Public Awareness

60. Workshops and seminars for well owners will be organized to promote groundwater conservation and raise efficiency of groundwater use.

61. Training programs for Ministry staff shall be conducted to build capacity for public awareness campaigns related to groundwater use and protection.

62. MWI/WAJ in cooperation with other concerned agencies shall maintain a program to educate farmers on the importance of groundwater protection and shall promote technology transfer related to groundwater use in irrigation.

63. Cooperation with other concerned agencies shall be maintained to encourage the reuse of groundwater in beneficial purposes.

On Private Sector Participation

64. The role of the private sector in the development of fresh groundwater resources shall be reduced where reduction of abstraction is sought The private sector shall be encouraged to co-operate in the rehabilitation of aquifers where needed.

65. The private sector shall be encouraged to develop aquifers of marginal water quality for use in irrigation. It shall also be encouraged to develop fossil and renewable aquifers in remote areas for agricultural uses with the intention of promoting technology transfer and the creation of job opportunities.

66. Desalination of brackish groundwater by the private sector shall be promoted. Care shall be given to the environmental impacts of such activities, particularly the safe disposal of brines.

ANNEX 2

International Law Association

THE SEOUL RULES ON INTERNATIONAL GROUNDWATERS*

(Adopted by the International Law Association at the Sixty-second Conference Held at Seoul in 1986)

Article 1

THE WATERS OF INTERNATIONAL AQUIFERS*

The waters of an aquifer that is intersected by the boundary between two or more States are international groundwaters and such an aquifer with its waters forms an international basin or part thereof. Those States are basin States within the meaning of the Helsinki Rules whether or not the aquifer and its waters form with surface waters part of a hydraulic system flowing into a common terminus.

*The term 'aquifer' as here employed comprehends all underground water bearing strata capable of yielding water on a practicable basis, whether these are in other instruments or contexts called by another name such as "groundwater reservoir," "groundwater catchment area," etc., including the waters in fissured or fractured rock formations and the structures containing deep, so-called "fossil waters."

Article 2

HYDRAULIC INTERDEPENDENCE

1. An aquifer that contributes water to, or receives water from, surface waters of an international basin constitutes part of that international basin for the purpose of the Helsinki Rules.

2. An aquifer intersected by the boundary between two or more States that does not contribute water to, or receive water from, surface waters of an international drainage basin constitutes an international drainage basin for the purpose of the Helsinki Rules.

3. Basin States, in exercising their rights and performing their duties under international law, shall take into account any interdependence of the groundwater and

---

* INTERNATIONAL LAW ASSOCIATION, REPORT OF THE SIXTY-SECOND CONFERENCE HELD AT SEOUL, AUGUST 24TH TO AUGUST 30TH, 1986 (1987)

other waters, including any interconnections between aquifers, and any leaching into aquifers caused by activities and areas under their jurisdiction.

Article 3

PROTECTION OF GROUNDWATER

1. Basin States shall prevent or abate the pollution of international groundwaters in accordance with international law applicable to existing, new, increased and highly dangerous pollution. Special consideration shall be given to the long-term effects of the pollution of groundwater.

2. Basin States shall consult and exchange relevant available information and data at the request of any one of them

(a) for the purpose of preserving the groundwaters of the basin from degradation and protecting from impairment the geologic structure of the aquifers, including recharge areas;

(b) for the purpose of considering joint or parallel quality standards and environmental protection measures applicable to international groundwaters and their aquifers.

3. Basin States shall co-operate, at the request of any one of them, for the purpose of collecting and analyzing additional needed information and data pertinent to the international groundwaters or their aquifers.

Article 4

GROUNDWATER MANAGEMENT AND SURFACE WATERS

Basin States should consider the integrated management, including conjunctive use with surface waters, of their international groundwaters at the request of any one of them.

ANNEX 3

THE BELLAGIO DRAFT TREATY*

AGREEMENT

CONCERNING THE USE OF TRANSBOUNDARY GROUNDWATERS

The High Contracting Parties, _____ and _____,

Motivated by the spirit of cordiality and cooperation which characterizes the relations between them;

Desirous of expanding the scope of their concerted actions with respect to the problems confronting their Peoples along their common frontier;

Recognizing the critical importance of their transboundary water resources and the need to enhance the rational use and conservation of the said resources on a long-term basis;

Noting especially the present unsatisfactory state of protection and control of their transboundary groundwater as well as the prospects of crisis conditions in some areas because of increasing demands upon, and the decreasing quality of, those groundwaters;

Seeking to provide for the utilization, protection and control of those groundwaters on an equitable basis and, to that end, for the creation and maintenance of an adequate data base;

Recognizing that the optimum and efficient use of their transboundary water resources is essential to the interests of both Parties;

Resolving to protect the quality of the transboundary groundwaters for present and future generations;

Wishing to resolve amicably any difference that may arise in connection with the use, protection or control of the said transboundary groundwaters and, for that purpose, to utilize a joint agency; and

---

* Robert D. Hayton & Albert E. Utton, *Transboundary Groundwaters: The Bellagio Draft Treaty*, 29 NAT. RESOURCES J. 677 (1989).

Concluding that the best means to achieve the rational management of their transboundary water resources and the protection of the underground environment is to adopt, in principle, an integrated approach including, where appropriate, the conjunctive use of surface water and groundwater in their border region,

Have agreed as follows:

ARTICLE I

DEFINITIONS

As used in this agreement:

1. "Aquifer" means a subsurface waterbearing geologic formation from which significant quantities of water may be extracted.

2. "Border region" means the area within approximately _____ kilometers from each side of the mutual boundary as set forth on the annexed map.

3. "The Commission" means the agency designated in Article III, para. 1, of this Agreement.

4. "Conjunctive Use" means the integrated development and management of surface and groundwater as a total water supply system.

5. "Contaminant" means any substance, species or energy which detrimentally affects directly, indirectly, cumulatively or in combination with other substances, human health or safety or agricultural or industrial products or processes, or flora, fauna or an ecosystem.

6. "Contamination" means any detrimental chemical, physical, biological, or temperature change in the content or characteristics of a body of water.

7. "Depletion" means the withdrawals of water from an aquifer at a rate faster than it is recharged, otherwise known as "mining" the water.

8. "Drought" means a condition of abnormal water scarcity in a specific area resulting from natural conditions.

9. "Drought Alert" means the declared condition provided for in Article XII.

10. "Drought Emergency" means the declared emergency provided for in Article XII.

11. "Drought Management Plan" means the plan provided for pursuant to Article XII.

12. "Environmental sensitivity" means vulnerability or susceptibility to changes detrimentally affecting the quality of life of one or more biological or physical systems.

13. "Government(s)" means the governments of the Parties to this Agreement.

14. "Groundwater" means the water in aquifers.

15. "Impairment" means any physical change in an aquifer or its recharge area which significantly reduces or restricts the potential for use of the waters of the aquifer.

16. "Interrelated surface water" means those surface waters in the territory of either Party, the quantity or quality of which is affected by the outflows from, or the inflows to, transboundary groundwater.

17. "Pollution" means the introduction of any contaminant by man, directly or indirectly, into groundwaters or surface waters.

18. "Public Health Emergency" means the declared emergency provided for in Article IX.

19. "Recharge" means the addition of water to an aquifer by infiltration of precipitation through the soil or of water from surface streams, lakes, or reservoirs, by discharges of water to the land surface, or by injection of water into the aquifer through wells.

20. "Transboundary aquifer" means an aquifer intersected by a common boundary.

21. "Transboundary Groundwater Conservation Area" means an area declared by the Commission pursuant to Article VII.

22. "Transboundary groundwaters" means waters in transboundary aquifers.

ARTICLE II

GENERAL PURPOSES

1. The Parties recognize their common interest and responsibility in ensuring the reasonable and equitable development and management of groundwaters in the border region for the well being of their Peoples.

2. Accordingly, the Parties have entered into this Agreement in order to attain the optimum utilization and conservation of transboundary groundwaters and to protect the underground environment. It is also the purpose of the Parties to develop and maintain reliable data and information concerning transboundary aquifers and their waters in order to use and protect these waters in a rational and informed manner.

ARTICLE III

THE COMMISSION RESPONSIBLE UNDER THIS AGREEMENT

1. The _____Commission is designated as the Parties' agency to carry out the functions and responsibilities provided for by this Agreement.

2. The Commission shall be authorized a technical staff, which, in collaboration with the technical staffs of the Governments, shall assist the Commission in the accomplishment of its functions and responsibilities.

3. The Commission is authorized to declare Transboundary Groundwater Conservation Areas, Drought Alerts, Drought Emergencies and Public Health Emergencies, and to promulgate the corresponding plans and Depletion Plans, in accordance with the provisions of this Agreement.

4. The Commission shall have jurisdiction over such additional matters concerning the border region as are from time to time referred to it by the Governments jointly.

5. The Commission shall prepare and propose to the Governments a budget, conforming insofar as practicable to the budget cycles and procedures of the Governments, covering the projected expenses and capital costs of the Commission's joint operations, plant and staff. The total amount of each budget shall be divided between the Governments in the proportions agreed upon by the Commission and approved by the Governments.

6. The budget for the separate operating costs of each national Section shall be the responsibility of the respective Government.

7. The Governments may jointly refer a specific matter relating to transboundary groundwater to the Commission for investigation or action. Individually Governments may request the Commission's advice relating to transboundary groundwaters on matters originating within the requesting Government's portion of the border region.

8. The Commission shall cause each such referral and request to be taken up and investigated, studied or acted upon, as appropriate. The Commission shall render a report to the Governments on every referral and request taken up.

ARTICLE IV

ENFORCEMENT AND OVERSIGHT RESPONSIBILITIES

1. The enforcement of water quality and quantity measures and related land use controls within the territory of each Party shall be the responsibility of that Party or of its political subdivisions, as appropriate.

2. The Commission shall biennially conduct a review of the water quality and quantity control measures taken within each Party's territory affecting the border region and shall issue a Report containing its assessment of the adequacy and effectiveness of programs

for the protection and improvement of the transboundary aquifers and their waters and withdrawal and land use controls, including with respect to any Transboundary Groundwater Conservation Areas, Depletion Plans, Drought Emergency Plans and Health Emergencies. To that end, each Government shall furnish the Commission with the relevant data, information, and studies for use by the Commission in preparing its Report, in accordance with the reporting formats provided by the Commission.

3. In addition to facilitating, as needed, the Commission's oversight responsibilities under paragraph 2, each Government shall make a biennial Report to the Commission specifying the water quality and conservation measures taken; quantities withdrawn, transferred and exchanged, and any problems encountered in carrying out the provisions of this Agreement or in implementation of any of the conservation, depletion and drought management plans and health emergency measures adopted.

ARTICLE V

ESTABLISHMENT AND MAINTENANCE OF THE DATABASE

1. The Commission is charged with the creation and maintenance of a comprehensive and unified database pertaining to transboundary groundwaters, in the languages of the Parties. The database shall include an inventory of all transboundary groundwater resources taking into account quantity, quality, aquifer geometry, recharge rates, interaction with surface waters, and other pertinent data and shall identify all transboundary aquifers.

2. The Commission shall carry out studies directly, or through research programs conducted by or with other bodies, public or private:

a. to identify inadequacies in available data and to propose remedial action;

b. to examine present and potential future uses of said groundwaters, taking into account demographic projections and socioeconomic development plans;

c. to assess the impact of present and potential development on transboundary groundwaters and related resources;

d. to study possible alternative sources of surface water and groundwater for use in the border region, taking into account the quantity and quality of the waters and the potential for the conjunctive use of the available waters; and

e. to examine the potential for, and the consequences of, drought, floods, and contamination in the border region.

3. The Parties undertake to facilitate the acquisition of information and data by the Commission on a timely basis in accordance with the Commission's requirements.

4. The Commission shall compile, analyze, and disseminate the data, information and studies and provide the results to the Governments.

ARTICLE VI

WATER QUALITY PROTECTION

1. The Parties undertake cooperatively to protect and to improve, insofar as practicable, the quality of transboundary aquifers and their waters in conjunction with their programs for surface water quality control, and to avoid appreciable harm in or to the territories of the Parties.

2. The Governments shall promptly inform the Commission of any actual or planned, significantly polluting discharge into transboundary groundwaters or recharge areas, or of other activity with the potential for significant leaching into transboundary groundwaters.

3. The Commission shall without delay consider the gravity of any situation indicating significant groundwater contamination, or the threat thereof, in any part of the border region in accordance with the provisions of Article VII.

ARTICLE VII

TRANSBOUNDARY GROUNDWATER CONSERVATION AREAS

1. The Commission shall determine the desirability of declaring any area within the border region containing transboundary groundwaters to be a Transboundary Groundwater Conservation Area.

2. In the event that the Commission determines that a Transboundary Groundwater Conservation Area is desirable, such determination shall be reported to the Governments with a draft of the proposed declaration and justification therefore, including the delineation of the area and its aquifer(s).

3. If no Government files an objection with the Commission within one hundred eighty (180) days, the Commission shall issue the formal declaration. Any objection(s) filed shall specify, with an explanation, the objectionable Section(s) of the proposed declaration or justification or both.

4. Unless an objection requires termination of consideration, the Commission shall within ninety (90) days of receipt of objections, report to the Governments a revised proposed declaration, to be effective within ninety (90) days, unless a Government files a subsequent objection with the Commission. If no subsequent objection is filed within the said ninety (90) day period, the formal declaration shall be issued by the Commission. If a subsequent objection is filed within ninety (90) day period, the Commission shall refer the matter, together with the entire record, to the Governments for resolution by consultation.

5. In making its determination, the Commission shall consider whether:

a. groundwater withdrawals exceed or are likely to exceed recharge so as to endanger yield or water quality or are likely to diminish the quantity or quality of interrelated surface water;

b. recharge has been or may become impaired;

c. the use of the included aquifer(s) as an important source of drinking water has been, or may become impaired;

d. the aquifer(s) have been or may become contaminated; and

e. recurring or persistent drought conditions necessitate management of all or some water supplies in the particular area.

6. In making its determination, the Commission shall take into account the impact of the implementation of the declaration under consideration on the sources and uses of water previously allocated by agreements between the Parties or under the Drought Management Plan.

7. The Commission shall periodically review the appropriateness of continuing or modifying Transboundary Groundwater Conservation Areas.

ARTICLE VIII

COMPREHENSIVE MANAGEMENT PLANS

1. For each declared Transboundary Groundwater Conservation Area, the Commission shall prepare a Comprehensive Management Plan for the rational development use, protection and control of the waters in the Transboundary Groundwater Conservation Area.

2. A Comprehensive Management Plan may:

a. prescribe measures to prevent, eliminate or mitigate degradation of transboundary groundwater quality, and for that purpose may:

(1) classify transboundary groundwaters according to use and coordinate the formulation of water quality standards;

(2) identify toxic and hazardous contaminants in the Area and require a continuing record of such substances from origin to disposal;

(3) establish criteria for the safe storage of wastes and maintain an inventory of dumpsites, abandoned as well as active, that have caused or may cause transboundary aquifer pollution;

(4) propose a scheme for monitoring water quality conditions including the placement and operation of test wells and for remedial actions where required, including pretreatment and effluent discharge limitations and charges; and

(5) provide for the establishment where required of protective zones in which land use must be regulated;

b. allocate the uses of groundwaters and interrelated surface waters taking into account any other allocation(s) previously made applicable within the Transboundary Groundwater Conservation Area;

c. prescribe measures including pumping limitations, criteria for well placement and number of new wells, retirement of existing wells, imposition of extraction fees, planned depletion regimes or reservations of groundwaters for future use;

d. arrange, where conditions are favorable, programs of transboundary aquifer recharge;

e. articulate programs of conjunctive use where appropriate;

f. prescribe the integration and coordination of water quality and quantity control programs;

g. include other measures and actions as may be deemed appropriate by the Commission.

3. In making any allocations of water uses within a Comprehensive Management Plan, the Commission shall consider all relevant factors such as:

a. hydrogeology and meteorology;

b. existing and planned uses;

c. environmental sensitivity;

d. quality control requirements;

e. socioeconomic implications (including dependency);

f. water conservation practices (including efficiency of water use);

g. artificial recharge potential; and

h. comparative costs and implications of alternative sources of supply.

The weight to be given to each factor is to be determined by its importance in comparison with that of the other relevant factors.

4. The Commission shall submit proposed Comprehensive Management Plans to the Governments.

a. If no Government files an objection with the Commission within one hundred eighty (180) days, the Commission shall adopt the Plan and monitor its implementation.

b. A Government's objections shall specify with an explanation the objectionable portions of the proposed Comprehensive Management Plan.

c. Within ninety (90) days of receipt of objections, the Commission shall submit to the Governments a revised proposed Comprehensive Management Plan to be effective within ninety (90) days unless a subsequent objection is filed. If no subsequent objection is filed within the ninety (90) day period, the proposed Comprehensive Management Plan shall be adopted and the Commission shall monitor its implementation. If subsequent objections are filed within the ninety (90) day period, the Commission shall refer the matter, together with the entire record, to the Governments for resolution by consultation.

5. The Commission is authorized to approve advances and exchanges of water consistent with the objectives of the applicable Comprehensive Management Plan.

6. The Commission shall monitor and evaluate the measures taken under the Comprehensive Management Plan and shall propose, as appropriate, modifications thereto.

ARTICLE IX

PUBLIC HEALTH EMERGENCIES

1. Upon a determination by the Commission or any Government that there is an imminent or actual public health hazard involving the contamination of transboundary groundwaters, the Commission shall notify the respective Governments, and may declare a Public Health Emergency for a stated period.

2. In the event that the Public Health Emergency is not mitigated or abated within the initial stated period, the Commission may extend the emergency for such additional period as may be deemed necessary under the circumstances.

3. On the basis of the declaration, the Commission shall have the authority to investigate the area of imminent or actual contamination and to prescribe measures to prevent, eliminate or mitigate the public health hazard.

4. The Governments shall provide the indicated information, data, studies and reports concerning public health emergencies as set forth in Paragraphs 2 and 3 of Article IV.

ARTICLE X

PLANNED DEPLETION

1. The Commission, after evaluation of all relevant considerations, may prepare and, with the consent of the Governments, may approve a plan for the depletion of an aquifer over a calculated period. The plan may apportion the uses and specify the rates and means of extraction of the transboundary groundwaters, and may authorize advances, exchanges and transboundary transfers of water consistent with the objectives of the Depletion Plan.

2. The Governments shall provide the indicated information, data, studies and reports concerning depletion as set forth in Paragraphs 2 and 3 of Article IV.

ARTICLE XI

TRANSBOUNDARY TRANSFERS

Nothing in this Agreement shall be so construed as to preclude either short-term or long-term transfers of waters between the Parties under terms and conditions approved by the Commission.

ARTICLE XII

PLANNING FOR DROUGHT

1. The Commission shall, within two (2) years of the coming into force of this Agreement, complete the preparation of a Drought Management Plan applicable to the border region for activation in the region, or in parts thereof, in the event of drought. The completed Plan shall be submitted to the Governments for standby approval.

2. The Drought Management Plan shall:

a. specify the hydrometeorological preconditions for the declaration of a Drought Alert and, thereunder, the conservation measures to be observed by all water users within the border region;

b. specify the hydrometeorological preconditions for the declaration of a Drought Emergency and, thereunder, the specific measures to be observed by all water users within the border region;

c. provide for the monitoring of the hydrometeorological conditions generally in the border region, and compliance with prescribed conservation or other specific measures under any Drought Alert or Drought Emergency; and

d. provide for periodic reports to the Governments during any Drought Alert or Drought Emergency, to include any proposed modifications to the Drought Emergency

Plan and any modifications made to the prescribed measures under any Drought Alert or Drought Emergency.

3. The Drought Management Plan may:

a. Designate and reserve certain transboundary aquifers or specific well sites for use in times of drought;

b. provide, for the duration of any declared Drought Emergency:

(1) the conjunctive management of groundwater and surface water supplies within or made available to the border region or part(s) thereof governed by the declaration;

(2) increases and reductions in the normal allowable withdrawals and at variance with allocations made under a Comprehensive Management Plan for a Transboundary Groundwater Conservation Area or by prior agreements between the parties, maintaining to the extent practicable the established withdrawal ratios between the Parties and an equitable balance of all emergency obligations;

(3) authorization to use designated and reserved groundwaters within the border region;

c. include other structural and nonstructural measures deemed likely to be needed under various drought conditions.

4. The conservation and other specific measures provided in the Plan for Drought Alert declarations or Drought Emergency declarations may be modified or suspended by the Commission to meet the specific requirements of the situation at the time of such declarations and during the time such declarations remain in force.

5. The authority to determine the existence of the preconditions specified in the approved Drought Management Plan and to declare drought alerts and drought emergencies thereunder, in any portion of the border region, is vested in the Commission.

6. The Commission is authorized to modify or terminate a declaration of Drought Alert or Drought Emergency when the hydrometeorological conditions so warrant.

7. Declarations of Drought Alert and Drought Emergency, and modifications to or termination of the same, shall be immediately communicated to the Governments and published so as to come to the attention of all water users in the border region.

8. The Governments shall provide the indicated information, data, studies and reports concerning drought as set forth in Paragraphs 2 and 3 of Article IV.

ARTICLE XIII

INQUIRY IN THE PUBLIC INTEREST

1. The Commission shall by general notice invite written statements and information from all persons professing interest in the groundwater-related conditions and activities in the portion of the border region for which a Transboundary Groundwater Conservation Area declaration, a Comprehensive Management Plan, a Depletion Plan, a transboundary transfer, or a Drought Alert or emergency declaration is under consideration.

2. All submissions received pursuant to Paragraph 1 shall be taken into account by the Commission.

3. Whenever the Commission deems that public interest warrants, it shall schedule and conduct hearings open to the public in appropriate places and facilitates in the border region, and shall make and publish a record of such hearings.

4. Any person professing an interest may also petition the Commission at any time requesting the Commission to schedule a hearing or to invite written statements and information concerning groundwater conditions in the border region, or urging the Commission to take a particular action under this Agreement.

5. When deemed useful by the Commission, technical meetings, workshops and briefings relating to transboundary groundwater matters may be held under the auspices of the Commission or in cooperation with authorities and organizations concerned with the welfare of the border region.

ARTICLE XIV

EXISTING RIGHTS AND OBLIGATIONS

The rights and obligations of the Parties as set forth in prior agreements between the Parties shall not be permanently altered by this Agreement or any measures taken hereunder.

ARTICLE XV

ACCOMMODATION OF DIFFERENCES

1. The Commission shall expend its best efforts to resolve differences within the Commission with respect to the facts and circumstances of a situation within the purview of this Agreement. Failure to resolve such differences within six (6) months at the technical level of the Commission shall result in the submission of the differences, together with the entire record, to the Governments for resolution by consultation.

2. If after good faith consultations during a period of twelve (12) months the Governments are unable to reach an accommodation of a difference or differences between them concerning the facts and circumstances of a situation within the purview of

this Agreement, or with respect to which the Commission has been unable to reach agreement,

a. any Government is entitled to invoke this Article to the effect that a commission of inquiry be appointed and charged with a full and impartial study for the purpose of verification of the facts of the situation;

b. the Governments shall appoint and instruct the commissioner(s), and defray the expenses of such commissions equally, unless otherwise agreed; and

c. in the event the Governments fail to agree upon the implementation of this Paragraph within six (6) months from the date of its formal invocation, the _____, at the request of any Government shall, after consultation with each Government, appoint the commissioner(s), instruct the same, and apportion the expenses of the commission, as may be required to render the commission operational.

3. A commission of inquiry appointed under this Article shall render a report to the Governments within the terms of its instructions and on the basis of independent and detailed examination of the data and information made available to it by the Governments and the Commission, and may request such additional data and information as the commission of inquiry deems significant for its deliberations and findings.

4. On the basis of the report of a commission of inquiry, the Parties undertake promptly to enter into consultations for the purpose of reaching an agreed accommodation of the difference(s).

5. The Commission shall expend its best efforts to resolve differences within the Commission with respect to the interpretation of this Agreement, of any declaration, plan or prescribe measure, or of any other relevant document, referral, request or decision. Failure to resolve such differences within six (6) months by the Commission shall result in the submission of such difference(s), together with the record of deliberations, to the Governments for resolution by consultation.

6. Should the Governments, after six (6) months of consultations fail to agree upon a questioned interpretation submitted to them by the Commission, pursuant to Paragraph 5, or that has otherwise arisen, including with respect to the validity or interpretation of any binding decision by the Commission, the provisions of Article XVI of this Agreement shall apply.

ARTICLE XVI

RESOLUTION OF DISPUTES

1. If the consultations called for under Article XV do not achieve an agreed accommodation, the Governments shall promptly enter into formal, direct negotiations for the purpose of resolving the disagreement.

2. Should the Governments not achieve agreement after six (6) months of direct negotiations, the Parties shall refer the matter to mediation, conciliation, arbitration, the International Court of Justice or any other means of peaceful settlement, absent a previously agreed, applicable means of dispute settlement binding upon the Parties.

3. In resolving differences and questions affecting the implementation of this Agreement and decisions taken thereunder, the Parties undertake to avoid delay and to facilitate the process of resolution as between themselves and, as appropriate, before any mediator, conciliator, tribunal or other settlement forum, taking into account the importance of timely resolution with respect to critical transboundary groundwater situations.

ARTICLE XVII

AMENDMENT

This Agreement may be amended by agreement of the Parties.

ARTICLE XVIII

ENTRY INTO FORCE

This Agreement shall enter into force on the date of the exchange of instruments of ratification [signature by the duly authorized representatives of the Parties].

ARTICLE XIX

AUTHENTIC TEXTS

This Agreement has been concluded in two originals, one in the _____language and one in the _____language, both being equally authentic.

ARTICLE XX

RESERVATIONS AND EXCEPTIONS

Any reservations or exceptions made by one Party upon signature or ratification shall be effective to modify this Agreement only after express acceptance by the other Parties.

IN WITNESS WHEREOF, the undersigned Plenipotentiaries, being duly authorized, have signed this Agreement.

DONE AT _____, this _____day of _____, one thousand nine hundred and _____.

_____ _____

ANNEX 4

International Law Commission

RESOLUTION

ON CONFINED TRANSBOUNDARY GROUNDWATER*

The International Law Commission,

Having completed its consideration of the topic "The law of the non-navigational uses of international watercourses",

Having considered in that context groundwater which is related to an international watercourse,

Recognizing that confined groundwater, that is groundwater not related to an international watercourse, is also a natural resource of vital importance for sustaining life, health and the integrity of ecosystems,

Recognizing also the need for continuing efforts to elaborate rules pertaining to confined transboundary groundwater,

Considering its view that the principles contained in its draft articles on the law of the non-navigational uses of international watercourses may be applied to transboundary confined groundwater,

1. *Commends* States to be guided by the principles contained in the draft articles on the law of the non-navigational uses of international watercourses, where appropriate, in regulating transboundary groundwater;

2. *Recommends* States to consider entering into agreements with the other State or States in which the confined transboundary groundwater is located;

3. *Recommends also* that, in the event of any dispute involving transboundary confined groundwater, 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.

---

* 2 YEARBOOK OF THE INTERNATIONAL LAW COMMISSION 1994 at 135 (1997).

ANNEX 5

Convention on the Law of the Non-Navigational Uses of International Watercourses

The Parties to the present Convention,

Conscious of the importance of international watercourses and the non-navigational uses thereof in many regions of the world,

Having in mind Article 13, paragraph 1 (a), of the Charter of the United Nations, which provides that the General Assembly shall initiate studies and make recommendations for the purpose of encouraging the progressive development of international law and its codification,

Considering that successful codification and progressive development of rules of international law regarding non-navigational uses of international watercourses would assist in promoting and implementing the purposes and principles set forth in Articles 1 and 2 of the Charter of the United Nations,

Taking into account the problems affecting many international watercourses resulting from, among other things, increasing demands and pollution,

Expressing the conviction that a framework convention will ensure the utilization, development, conservation, management and protection of international watercourses and the promotion of the optimal and sustainable utilization thereof for present and future generations,

Affirming the importance of international cooperation and good-neighborliness in this field,

Aware of the special situation and needs of developing countries,

Recalling the principles and recommendations adopted by the United Nations Conference on Environment and Development of 1992 in the Rio Declaration and Agenda 21,

Recalling also the existing bilateral and multilateral agreements regarding the non-navigational uses of international watercourses,

Mindful of the valuable contribution of international organizations, both governmental and non-governmental, to the codification and progressive development of international law in this field,

Appreciative of the work carried out by the International Law Commission on the law of the non-navigational uses of international watercourses,

Bearing in mind United Nations General Assembly resolution 49/52 of December 9, 1994,

Have agreed as follows:

PART I. INTRODUCTION

Article 1

Scope of the present Convention

1. The present Convention applies to uses of international watercourses and of their waters for purposes other than navigation and to measures of protection, preservation and management related to the uses of those watercourses and their waters.

2. The uses of international watercourses for navigation is not within the scope of the present Convention except insofar as other uses affect navigation or are affected by navigation.

Article 2

Use of terms

For the purposes of the present Convention:

(a) "Watercourse" means a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus;

(b) "International watercourse" means a watercourse, parts of which are situated in different States;

(c) "Watercourse State" means a State Party to the present Convention in whose territory part of an international watercourse is situated, or a Party that is a regional economic integration organization, in the territory of one or more of whose Member States part of an international watercourse is situated;

(d) "Regional economic integration organization" means an organization constituted by sovereign States of a given region, to which its member States have transferred competence in respect of matters governed by this Convention and which has

been duly authorized in accordance with its internal procedures, to sign, ratify, accept, approve or accede to it.

Article 3

Watercourse agreements

1. In the absence of an agreement to the contrary, nothing in the present Convention shall affect the rights or obligations of a watercourse State arising from agreements in force for it on the date on which it became a party to the present Convention.

2. Notwithstanding the provisions of paragraph 1, parties to agreements referred to in paragraph 1 may, where necessary, consider harmonizing such agreements with the basic principles of the present Convention.

3. Watercourse States may enter into one or more agreements, hereinafter referred to as "watercourse agreements", which apply and adjust the provisions of the present Convention to the characteristics and uses of a particular international watercourse or part thereof.

4. Where a watercourse agreement is concluded between two or more watercourse States, it shall define the waters to which it applies. Such an agreement may be entered into with respect to an entire international watercourse or any part thereof or a particular project, programme or use except insofar as the agreement adversely affects, to a significant extent, the use by one or more other watercourse States of the waters of the watercourse, without their express consent.

5. Where a watercourse State considers that adjustment and application of the provisions of the present Convention is required because of the characteristics and uses of a particular international watercourse, watercourse States shall consult with a view to negotiating in good faith for the purpose of concluding a watercourse agreement or agreements.

6. Where some but not all watercourse States to a particular international watercourse are parties to an agreement, nothing in such agreement shall affect the rights or obligations under the present Convention of watercourse States that are not parties to such an agreement.

Article 4

Parties to watercourse agreements

1. Every watercourse State is entitled to participate in the negotiation of and to become a party to any watercourse agreement that applies to the entire international watercourse, as well as to participate in any relevant consultations.

2. A watercourse State whose use of an international watercourse may be affected to a significant extent by the implementation of a proposed watercourse agreement that applies only to a part of the watercourse or to a particular project, programme or use is entitled to participate in consultations on such an agreement and, where appropriate, in the negotiation thereof in good faith with a view to becoming a party thereto, to the extent that its use is thereby affected.

PART II. GENERAL PRINCIPLES

Article 5

Equitable and reasonable utilization and participation

1. Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse States with a view to attaining optimal and sustainable utilization thereof and benefits therefrom, taking into account the interests of the watercourse States concerned, consistent with adequate protection of the watercourse.

2. 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 Convention.

Article 6

Factors relevant to equitable and reasonable utilization

1. Utilization of an international watercourse in an equitable and reasonable manner within the meaning of article 5 requires taking into account all relevant factors and circumstances, including:

(a) Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character;

(b) The social and economic needs of the watercourse States concerned;

(c) The population dependent on the watercourse in each watercourse State;

(d) The effects of the use or uses of the watercourses in one watercourse State on other watercourse States;

(e) Existing and potential uses of the watercourse;

(f) Conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;

(g) The availability of alternatives, of comparable value, to a particular planned or existing use.

2. In the application of article 5 or paragraph 1 of this article, watercourse States concerned shall, when the need arises, enter into consultations in a spirit of cooperation.

3. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable use, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

Article 7

Obligations not to cause significant harm

1. Watercourse States shall, in utilizing an international watercourse in their territories, take all appropriate measures to prevent the causing of significant harm to other watercourse States.

2. Where significant harm nevertheless is caused to another watercourse State, the States whose use causes such harm shall, in the absence of agreement to such 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 such harm and, where appropriate, to discuss the question of compensation.

Article 8

General obligation to cooperate

1. Watercourse States shall cooperate on the basis of sovereign equality, territorial integrity, mutual benefit and good faith in order to attain optimal utilization and adequate protection of an international watercourse.

2. In determining the manner of such cooperation, watercourse States may consider the establishment of joint mechanisms or commissions, as deemed necessary by them, to facilitate cooperation on relevant measures and procedures in the light of experience gained through cooperation in existing joint mechanisms and commissions in various regions.

Article 9

Regular exchange of data and information

1. Pursuant to article 8, watercourse States shall on a regular basis exchange readily available data and information on the condition of the watercourse, in particular that of a hydrological, meteorological, hydrogeological and ecological nature and related to the water quality as well as related forecasts.

2. If a watercourse State is requested by another watercourse State to provide data or information that is not readily available, it shall employ its best efforts to comply with the request but may condition its compliance upon payment by the requesting State of the reasonable costs of collecting and, where appropriate, processing such data or information.

3. Watercourse States shall employ their best efforts to collect and, where appropriate, to process data and information in a manner which facilitates its utilization by the other watercourse States to which it is communicated.

Article 10

Relationship between different kinds of uses

1. In the absence of agreement or custom to the contrary, no use of an international watercourse enjoys inherent priority over other uses.

2. In the event of a conflict between uses of an international watercourse, it shall be resolved with reference to articles 5 to 7, with special regard being given to the requirements of vital human needs.

PART III. PLANNED MEASURES

Article 11

Information concerning planned measures

Watercourse States shall exchange information and consult each other and, if necessary, negotiate on the possible effects of planned measures on the condition of an international watercourse.

Article 12

Notification concerning planned measures with possible adverse effects

Before a watercourse State implements or permits the implementation of planned measures which may have a significant adverse effect upon other watercourse States, it shall provide those States with timely notification thereof. Such notification shall be accompanied by available technical data and information, including the results of any environmental impact assessment, in order to enable the notified States to evaluate the possible effects of the planned measures.

Article 13

Period for reply to notification

Unless otherwise agreed:

(a) A watercourse State providing a notification under article 12 shall allow the notified States a period of six months within which to study and evaluate the possible effects of the planned measures and to communicate the findings to it;

(b) This period shall, at the request of a notified State for which the evaluation of the planned measures poses special difficulty, be extended for a period of six months.

Article 14

Obligations of the notifying State during the period for reply

During the period referred to in article 13, the notifying State:

(a) Shall cooperate with the notified States by providing them, on request, with any additional data and information that is available and necessary for an accurate evaluation; and

(b) Shall not implement or permit the implementation of the planned measures without the consent of the notified States.

Article 15

Reply to notification

The notified States shall communicate their findings to the notifying State as early as possible within the period applicable pursuant to article 13. If a notified State finds that implementation of the planned measures would be inconsistent with the provisions of articles 5 or 7, it shall attach to its finding a documented explanation setting forth the reasons for the finding.

Article 16

Absence of reply to notification

1. If, within the period applicable pursuant to article 13, the notifying State receives no communication under article 15, it may, subject to its obligations under articles 5 and 7, proceed with the implementation of the planned measures, in accordance with the notification and any other data and information provided to the notified States.

2. Any claim to compensation by a notified State which has failed to reply within the period applicable pursuant to article 13 may be offset by the costs incurred by the notifying State for action undertaken after the expiration of the time for a reply which would not have been undertaken if the notified State had objected within that period.

Article 17

Consultations and negotiations concerning planned measures

1. If a communication is made under article 15 that implementation of the planned measures would be inconsistent with the provisions of articles 5 or 7, the notifying State and the State making the communication shall enter into consultations and, if necessary, negotiations with a view to arriving at an equitable resolution of the situation.

2. The consultations and negotiations shall be conducted on the basis that each State must in good faith pay reasonable regard to the rights and legitimate interests of the other State.

3. During the course of the consultations and negotiations, the notifying State shall, if so requested by the notified State at the time it makes the communication, refrain from implementing or permitting the implementation of the planned measures for a period of six months unless otherwise agreed.

Article 18

Procedures in the absence of notification

1. If a watercourse State has reasonable grounds to believe that another watercourse State is planning measures that may have a significant adverse effect upon it, the former State may request the latter to apply the provisions of article 12. The request shall be accompanied by a documented explanation setting forth its grounds.

2. In the event that the State planning the measures nevertheless finds that it is not under an obligation to provide a notification under article 12, it shall so inform the other State, providing a documented explanation setting forth the reasons for such finding. If this finding does not satisfy the other State, the two States shall, at the request of that other State, promptly enter into consultations and negotiations in the manner indicated in paragraphs 1 and 2 of article 17.

3. During the course of the consultations and negotiations, the State planning the measures shall, if so requested by the other State at the time it requests the initiation of consultations and negotiations, refrain from implementing or permitting the implementation of those measures for a period of six months unless otherwise agreed.

Article 19

Urgent implementation of planned measures

1. In the event that the implementation of planned measures is of the utmost urgency in order to protect public health, public safety or other equally important interests, the State planning the measures may, subject to articles 5 and 7, immediately proceed to implementation, notwithstanding the provisions of article 14 and paragraph 3 of article 17.

2. In such case, a formal declaration of the urgency of the measures shall be communicated without delay to the other watercourse States referred to in article 12 together with the relevant data and information.

3. The State planning the measures shall, at the request of any of the States referred to in paragraph 2, promptly enter into consultations and negotiations with it in the manner indicated in paragraphs 1 and 2 of article 17.

PART IV. PROTECTION, PRESERVATION AND MANAGEMENT

Article 20

Protection and preservation of ecosystems

Watercourse States shall, individually and, where appropriate, jointly, protect and preserve the ecosystems of international watercourses.

Article 21

Prevention, reduction and control of pollution

1. For the purpose of this article, "pollution of an international watercourse" means any detrimental alteration in the composition or quality of the waters of an international watercourse which results directly or indirectly from human conduct.

2. Watercourse States shall, individually and, where appropriate, jointly, prevent, reduce and control the pollution of an international watercourse that may cause significant harm to other watercourse States or to their environment, including harm to human health or safety, to the use of the waters for any beneficial purpose or to the living resources of the watercourse. Watercourse States shall take steps to harmonize their policies in this connection.

3. Watercourse States shall, at the request of any of them, consult with a view to arriving at mutually agreeable measures and methods to prevent, reduce and control pollution of an international watercourse, such as:

(a) Setting joint water quality objectives and criteria;

(b) Establishing techniques and practices to address pollution from point and non-point sources;

(c) Establishing lists of substances the introduction of which into the waters of an international watercourse is to be prohibited, limited, investigated or monitored.

Article 22

Introduction of alien or new species

Watercourse States shall take all measures necessary to prevent the introduction of species, alien or new, into an international watercourse which may have effects detrimental to the ecosystem of the watercourse resulting in significant harm to other watercourse States.

Article 23

Protection and preservation of the marine environment

Watercourse States shall, individually and, where appropriate, in cooperation with other States, take all measures with respect to an international watercourse that are necessary to protect and preserve the marine environment, including estuaries, taking into account generally accepted international rules and standards.

Article 24

Management

1. Watercourse States shall, at the request of any of them, enter into consultations concerning the management of an international watercourse, which may include the establishment of a joint management mechanism.

2. For the purposes of this article, "management" refers, in particular, to:

(a) Planning the sustainable development of an international watercourse and providing for the implementation of any plans adopted; and

(b) Otherwise promoting the rational and optimal utilization, protection and control of the watercourse.

Article 25

Regulation

1. Watercourse States shall cooperate, where appropriate, to respond to needs or opportunities for regulation of the flow of the waters of an international watercourse.

2. Unless otherwise agreed, watercourse States shall participate on an equitable basis in the construction and maintenance or defrayal of the costs of such regulation works as they may have agreed to undertake.

3. For the purposes of this article, "regulation" means the use of hydraulic works or any other continuing measure to alter, vary or otherwise control the flow of the waters of an international watercourse.

Article 26

Installations

1. Watercourse States shall, within their respective territories, employ their best efforts to maintain and protect installations, facilities and other works related to an international watercourse.

2. Watercourse States shall, at the request of any of them which has reasonable grounds to believe that it may suffer significant adverse effects, enter into consultations with regard to:

(a) The safe operation and maintenance of installations, facilities or other works related to an international watercourse; and

(b) The protection of installations, facilities or other works from willful or negligent acts or the forces of nature.

PART V. HARMFUL CONDITIONS AND EMERGENCY SITUATIONS

Article 27

Prevention and mitigation of harmful conditions

Watercourse States shall, individually and, where appropriate, jointly, take all appropriate measures to prevent or mitigate conditions related to an international watercourse that may be harmful to other watercourse States, whether resulting from natural causes or human conduct, such as flood or ice conditions, water-borne diseases, siltation, erosion, salt-water intrusion, drought or desertification.

Article 28

Emergency situations

1. For the purpose of this article, "emergency" means a situation that causes, or poses an imminent threat of causing, serious harm to watercourse States or other States and that results suddenly from natural causes, such as floods, the breaking up of ice, landslides or earthquakes, or from human conduct, such as industrial accidents.

2. A watercourse State shall, without delay and by the most expeditious means available, notify other potentially affected States and competent international organizations of any emergency originating within its territory.

3. A watercourse State within whose territory an emergency originates shall, in cooperation with potentially affected States and, where appropriate, competent international organizations, immediately take all practicable measures necessitated by the circumstances to prevent, mitigate and eliminate harmful effects of the emergency.

4. When necessary, watercourse States shall jointly develop contingency plans for responding to emergencies, in cooperation, where appropriate, with other potentially affected States and competent international organizations.

PART VI. MISCELLANEOUS PROVISIONS

Article 29

International watercourses and installations in time of armed conflict

International watercourses and related installations, facilities and other works shall enjoy the protection accorded by the principles and rules of international law applicable in international and non-international armed conflict and shall not be used in violation of those principles and rules.

Article 30

Indirect procedures

In cases where there are serious obstacles to direct contacts between watercourse States, the States concerned shall fulfil their obligations of cooperation provided for in the present Convention, including exchange of data and information, notification, communication, consultations and negotiations, through any indirect procedure accepted by them.

Article 31

Data and information vital to national defence or security

Nothing in the present Convention obliges a watercourse State to provide data or information vital to its national defence or security. Nevertheless, that State shall cooperate in good faith with the other watercourse States with a view to providing as much information as possible under the circumstances.

Article 32

Non-discrimination

Unless the watercourse States concerned have agreed otherwise for the protection of the interests of persons, natural or juridical, who have suffered or are under a serious threat of suffering significant transboundary harm as a result of activities related to an international watercourse, a watercourse State shall not discriminate on the basis of nationality or residence or place where the injury occurred, in granting to such persons, in accordance with its legal system, access to judicial or other procedures, or a right to claim compensation or other relief in respect of significant harm caused by such activities carried on in its territory.

Article 33

Settlement of disputes

1. In the event of a dispute between two or more Parties concerning the interpretation or application of the present Convention, the Parties concerned shall, in the absence of an applicable agreement between them, seek a settlement of the dispute by peaceful means in accordance with the following provisions.

2. If the parties concerned cannot reach agreement by negotiation requested by one of them, they may jointly seek the good offices of, or request mediation or conciliation by, a third party, or make use, as appropriate, of any joint watercourse institutions that may have been established by them or agree to submit the dispute to arbitration or to the International Court of Justice.

3. Subject to the operation of paragraph 10, if after six months from the time of the request for negotiations referred to in paragraph 2, the Parties concerned have not been able to settle their dispute through negotiation or any other means referred to in paragraph 2, the dispute shall be submitted, at the request of any of the parties to the dispute, to impartial fact-finding in accordance with paragraphs 4 to 9, unless the Parties otherwise agree.

4. A Fact-finding Commission shall be established, composed of one member nominated by each Party concerned and in addition a member not having the nationality of any of the Parties concerned chosen by the nominated members who shall serve as Chairman.

5. If the members nominated by the Parties are unable to agree on a Chairman within three months of the request for the establishment of the Commission, any Party concerned may request the Secretary-General of the United Nations to appoint the Chairman who shall not have the nationality of any of the parties to the dispute or of any riparian State of the watercourse concerned. If one of the Parties fails to nominate a member within three

months of the initial request pursuant to paragraph 3, any other Party concerned may request the Secretary-General of the United Nations to appoint a person who shall not have the nationality of any of the parties to the dispute or of any riparian State of the watercourse concerned. The person so appointed shall constitute a single-member Commission.

6. The Commission shall determine its own procedure.

7. The Parties concerned have the obligation to provide the Commission with such information as it may require and, on request, to permit the Commission to have access to their respective territory and to inspect any facilities, plant, equipment, construction or natural feature relevant for the purpose of its inquiry.

8. The Commission shall adopt its report by a majority vote, unless it is a single-member Commission, and shall submit that report to the Parties concerned setting forth its findings and the reasons therefor and such recommendations as it deems appropriate for an equitable solution of the dispute, which the Parties concerned shall consider in good faith.

9. The expenses of the Commission shall be borne equally by the Parties concerned.

10. When ratifying, accepting, approving or acceding to the present Convention, or at any time thereafter, a Party which is not a regional economic integration organization may declare in a written instrument submitted to the Depository that, in respect of any dispute not resolved in accordance with paragraph 2, it recognizes as compulsory *ipso facto* and without special agreement in relation to any Party accepting the same obligation:

(a) Submission of the dispute to the International Court of Justice; and/or

(b) Arbitration by an arbitral tribunal established and operating, unless the parties to the dispute otherwise agreed, in accordance with the procedure laid down in the annex to the present Convention.

A Party which is a regional economic integration organization may make a declaration with like effect in relation to arbitration in accordance the subparagraph (b).

PART VII. FINAL CLAUSES

Article 34

Signature

The present Convention shall be open for signature by all States and by regional economic integration organizations from 21 May 1997 until 20 May 2000 at United Nations Headquarters in New York.

Article 35

Ratification, acceptance, approval or accession

1. The present Convention is subject to ratification, acceptance, approval or accession by States and by regional economic integration organizations. The instruments of ratification, acceptance, approval or accession shall be deposited with the Secretary-General of the United Nations.

2. Any regional economic integration organization which becomes a Party to this Convention without any of its member States being a Party shall be bound by all the obligations under the Convention. In the case of such organizations, one or more of whose member States is a Party to this Convention, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under the Convention. In such cases, the organization and the member States shall not be entitled to exercise rights under the Convention concurrently.

3. In their instruments of ratification, acceptance, approval or accession, the regional economic integration organizations shall declare the extent of their competence with respect to the matters governed by the Convention. These organizations shall also inform the Secretary-General of the United Nations of any substantial modification in the extent of their competence.

Article 36

Entry into force

1. The present Convention shall enter into force on the ninetieth day following the date of deposit of the thirty-fifth instrument of ratification, acceptance, approval or accession with the Secretary-General of the United Nations.

2. For each State or regional economic integration organization that ratifies, accepts or approves the Convention or accedes thereto after the deposit of the thirty-fifth instrument of ratification, acceptance, approval or accession, the Convention shall enter into force on the ninetieth day after the deposit by such State or regional economic integration organization of its instrument of ratification, acceptance, approval or accession.

3. For the purposes of paragraphs 1 and 2, any instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by States.

Article 37

Authentic texts

The original of the present Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

IN WITNESS WHEREOF the undersigned plenipotentiaries, being duly authorized thereto, have signed this Convention.

DONE at New York, this 21st day of May one thousand nine hundred and ninety-seven.

ANNEX

ARBITRATION

Article 1

Unless the parties to the dispute otherwise agree, the arbitration pursuant to article 33 of the Convention shall take place in accordance with articles 2 to 14 of the present annex.

Article 2

The claimant party shall notify the respondent party that it is referring a dispute to arbitration pursuant to Article 33 of the Convention. The notification shall state the subject matter of arbitration and include, in particular, the articles of the Convention, the interpretation or application of which are at issue. If the parties do not agree on the subject matter of the dispute, the arbitral tribunal shall determine the subject matter.

Article 3

1. In disputes between two parties, the arbitral tribunal shall consist of three members. Each of the parties to the dispute shall appoint an arbitrator and the two arbitrators so appointed shall designate by common agreement the third arbitrator, who shall be the Chairman of the tribunal. The latter shall not be a national of one of the parties to the dispute or of any riparian State of the watercourse concerned, nor have his or her usual place of residence in the territory of one of these parties or such riparian State, nor have dealt with the case in any other capacity.

2. In disputes between more than two parties, parties in the same interest shall appoint one arbitrator jointly by agreement.

3. Any vacancy shall be filled in the manner prescribed for the initial appointment.

Article 4

1. If the Chairman of the arbitral tribunal has not been designated within two months of the appointment of the second arbitrator, the President of the International Court of Justice shall, at the request of a party, designate the Chairman within a further two-month period.

2. If one of the parties to the dispute does not appoint an arbitrator within two months of the receipt of the request, the other party may inform the President of the International Court of Justice, who shall make the designation within a further two-month period.

Article 5

The arbitral tribunal shall render its decisions in accordance with the provisions of this Convention and international law.

Article 6

Unless the parties to the dispute otherwise agree, the arbitral tribunal shall determine its own rules of procedure.

Article 7

The arbitral tribunal may, at the request of one of the Parties, recommend essential interim measures of protection.

Article 8

1. The parties to the dispute shall facilitate the work of the arbitral tribunal and, in particular, using all means at their disposal, shall:

(a) Provide it with all relevant documents, information and facilities; and

(b) Enable it, when necessary, to call witnesses or experts and receive their evidence.

2. The parties and the arbitrators are under an obligation to protect the confidentiality of any information they receive in confidence during the proceedings of the arbitral tribunal.

Article 9

Unless the arbitral tribunal determines otherwise because of the particular circumstances of the case, the costs of the tribunal shall be borne by the parties to the dispute in equal shares. The tribunal shall keep a record of all its costs, and shall furnish a final statement thereof to the parties.

Article 10

Any Party that has an interest of a legal nature in the subject matter of the dispute which may be affected by the decisions in the case, may intervene in the proceedings with the consent of the tribunal.

Article 11

The tribunal may hear and determine counterclaims arising directly out of the subject matter of the dispute.

Article 12

Decisions both on procedure and substance of the arbitral tribunal shall be taken by a majority vote of its members.

Article 13

If one of the parties to the dispute does not appear before the arbitral tribunal or fails to defend its case, the other party may request the tribunal to continue the proceedings and to make its award. Absence of a party or a failure of a party to defend its case shall not constitute a bar to the proceedings. Before rendering its final decision, the arbitral tribunal must satisfy itself that the claim is well founded in fact and law.

Article 14

1. The tribunal shall render its final decision within five months of the date on which it is fully constituted unless it finds it necessary to extend the time limit for a period which should not exceed five more months.

2. The final decision of the arbitral tribunal shall be confined to the subject matter of the dispute and shall state the reasons on which it is based. It shall contain the names of the members who have participated and the date of the final decision. Any member of the tribunal may attach a separate or dissenting opinion to the final decision.

3. The award shall be binding on the parties to the dispute. It shall be without appeal unless the parties to the dispute have agreed in advance to an appellate procedure.

4. Any controversy which may arise between the parties to the dispute as regards the interpretation or manner of implementation of the final decision may be submitted by either party for decision to the arbitral tribunal which rendered it.

ANNEX 6

THE RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT*

Preamble

The United Nations Conference on Environment and Development

Having met at Rio de Janeiro from 3 to 14 June 1992,

Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, and seeking to build upon it,

With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people,

Working towards international agreements which respect the interests of all protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

Principle 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

State have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

---

* U.N. Doc. A/CONF.151/26; 31 I.L.M. 874 (1992)

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the filed of environment and development should also address the interests and needs of all countries.

Principle 7

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patters of production and consumption and promote appropriate demographic policies.

Principle 9

States should cooperate to strength endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries ma be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Principle 12

States should cooperate to support a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be base don an international consensus.

Principle 13

States should develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and ore determined manner to develop further international law regarding

liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18

States shall immediately notify other States of any natural disasters of other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19

State shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22

Indigenous people and their communities, and other local communities, have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

Principle 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfillment of the principles embodies in this Declaration and in the further development of international law in the field of sustainable development.

Distributors of World Bank Group Publications

Prices and credit terms vary from country to country. Consult your local distributor before placing an order.

ARGENTINA
World Publications SA
Av. Cordoba 1877
1120 Ciudad de Buenos Aires
Tel: (54 11) 4815-8156
Fax: (54 11) 4815-8156
E-mail: wpbooks@infovia.com.ar

AUSTRALIA, FIJI, PAPUA NEW GUINEA, SOLOMON ISLANDS, VANUATU, AND SAMOA
D.A. Information Services
648 Whitehorse Road
Mitcham 3132, Victoria
Tel: (61) 3 9210 7777
Fax: (61) 3 9210 7788
E-mail: service@dadirect.com.au
URL: http://www.dadirect.com.au

AUSTRIA
Gerold and Co.
Weihburggasse 26
A-1011 Wien
Tel: (43 1) 512-47-31-0
Fax: (43 1) 512-47-31-29
URL: http://www.gerold.co/at.online

BANGLADESH
Micro Industries Development Assistance Society (MIDAS)
House 5, Road 16
Dhanmondi R/Area
Dhaka 1209
Tel: (880 2) 326427
Fax: (880 2) 811188

BELGIUM
Jean De Lannoy
Av. du Roi 202
1060 Brussels
Tel: (32 2) 538-5169
Fax: (32 2) 538-0841

BRAZIL
Publicacões Tecnicas Internacionais Ltda.
Rua Peixoto Gomide, 209
01409 Sao Paulo, SP.
Tel: (55 11) 259-6644
Fax: (55 11) 258-6990
E-mail: postmaster@pti.uol.br
URL: http://www.uol.br

CANADA
Renouf Publishing Co. Ltd.
5369 Canotek Road
Ottawa, Ontario K1J 9J3
Tel: (613) 745-2665
Fax: (613) 745-7660
E-mail: order.dept@renoufbooks.com
URL: http:// www.renoufbooks.com

CHINA
China Financial & Economic Publishing House
8, Da Fo Si Dong Jie
Beijing
Tel: (86 10) 6401-7365
Fax: (86 10) 6401-7365

China Book Import Centre
P.O. Box 2825
Beijing

Chinese Corporation for Promotion of Humanities
52, You Fang Hu Tong,
Xuan Nei Da Jie
Beijing
Tel: (86 10) 660 72 494
Fax: (86 10) 660 72 494

COLOMBIA
Infoenlace Ltda.
Carrera 6 No. 51-21
Apartado Aereo 34270
Santafé de Bogotá, D.C.
Tel: (57 1) 285-2798
Fax: (57 1) 285-2798

COTE D'IVOIRE
Center d'Edition et de Diffusion Africaines (CEDA)
04 B.P. 541
Abidjan 04
Tel: (225) 24 6510; 24 6511
Fax: (225) 25 0567

CYPRUS
Center for Applied Research
Cyprus College
6, Diogenes Street, Engomi
P.O. Box 2006
Nicosia
Tel: (357 2) 59-0730
Fax: (357 2) 66-2051

CZECH REPUBLIC
USIS, NIS Prodejna
Havelkova 22
130 00 Prague 3
Tel: (420 2) 2423 1486
Fax: (420 2) 2423 1114
URL: http://www.nis.cz/

DENMARK
SamfundsLitteratur
Rosenoerns Allé 11
DK-1970 Frederiksberg C
Tel: (45 35) 351942
Fax: (45 35) 357822
URL: *http://www.sl.cbs.dk*

ECUADOR
Libri Mundi
Libreria Internacional
P.O. Box 17-01-3029
Juan Leon Mera 851
Quito
Tel: (593 2) 521-606; (593 2) 544-185
Fax: (593 2) 504-209
E-mail: librimu1@librimundi.com.ec
E-mail: librimu2@librimundi.com.ec

CODEU
Ruiz de Castilla 763, Edif. Expocolor
Primer piso, Of. #2
Quito
Tel/Fax: (593 2) 507-383; 253-091
E-mail: codeu@impsat.net.ec

EGYPT, ARAB REPUBLIC OF
Al Ahram Distribution Agency
Al Galaa Street
Cairo
Tel: (20 2) 578-6083
Fax: (20 2) 578-6833

The Middle East Observer
41, Sherif Street
Cairo
Tel: (20 2) 393-9732
Fax: (20 2) 393-9732

FINLAND
Akateeminen Kirjakauppa
P.O. Box 128
FIN-00101 Helsinki
Tel: (358 0) 121 4418
Fax: (358 0) 121-4435
E-mail: akatilaus@stockmann.fi
URL: http://www.akateeminen.com

FRANCE
Editions Eska; DBJ
48, rue Gay Lussac
75005 Paris
Tel: (33-1) 55-42-73-08
Fax: (33-1) 43-29-91-67

GERMANY
UNO-Verlag
Poppelsdorfer Allee 55
53115 Bonn
Tel: (49 228) 949020
Fax: (49 228) 217492
URL: http://www.uno-verlag.de
E-mail: unoverlag@aol.com

GHANA
Epp Books Services
P.O. Box 44
TUC
Accra
Tel: 223 21 778843
Fax: 223 21 779099

GREECE
Papasotiriou S.A.
35, Stournara Str.
106 82 Athens
Tel: (30 1) 364-1826
Fax: (30 1) 364-8254

HAITI
Culture Diffusion
5, Rue Capois
C.P. 257
Port-au-Prince
Tel: (509) 23 9260
Fax: (509) 23 4858

HONG KONG, CHINA; MACAO
Asia 2000 Ltd.
Sales & Circulation Department
302 Seabird House
22-28 Wyndham Street, Central
Hong Kong, China
Tel: (852) 2530-1409
Fax: (852) 2526-1107
E-mail: sales@asia2000.com.hk
URL: http://www.asia2000.com.hk

HUNGARY
Euro Info Service
Margitszgeti Europa Haz
H-1138 Budapest
Tel: (36 1) 350 80 24, 350 80 25
Fax: (36 1) 350 90 32
E-mail: euroinfo@mail.matav.hu

INDIA
Allied Publishers Ltd.
751 Mount Road
Madras - 600 002
Tel: (91 44) 852-3938
Fax: (91 44) 852-0649

INDONESIA
Pt. Indira Limited
Jalan Borobudur 20
P.O. Box 181
Jakarta 10320
Tel: (62 21) 390-4290
Fax: (62 21) 390-4289

IRAN
Ketab Sara Co. Publishers
Khaled Eslamboli Ave., 6th Street
Delafrooz Alley No. 8
P.O. Box 15745-733
Tehran 15117
Tel: (98 21) 8717819; 8716104
Fax: (98 21) 8712479
E-mail: ketab-sara@neda.net.ir

Kowkab Publishers
P.O. Box 19575-511
Tehran
Tel: (98 21) 258-3723
Fax: (98 21) 258-3723

IRELAND
Government Supplies Agency
Oifig an tSoláthair
4-5 Harcourt Road
Dublin 2
Tel: (353 1) 661-3111
Fax: (353 1) 475-2670

ISRAEL
Yozmot Literature Ltd.
P.O. Box 56055
3 Yohanan Hasandlar Street
Tel Aviv 61560
Tel: (972 3) 5285-397
Fax: (972 3) 5285-397

R.O.Y. International
PO Box 13056
Tel Aviv 61130
Tel: (972 3) 649 9469
Fax: (972 3) 648 6039
E-mail: royil@netvision.net.il
URL: http://www.royint.co.il

Palestinian Authority/Middle East
Index Information Services
P.O.B. 19502 Jerusalem
Tel: (972 2) 6271219
Fax: (972 2) 6271634

ITALY, LIBERIA
Licosa Commissionaria Sansoni SPA
Via Duca Di Calabria, 1/1
Casella Postale 552
50125 Firenze
Tel: (39 55) 645-415
Fax: (39 55) 641-257
E-mail: licosa@ftbcc.it
URL: http://www.ftbcc.it/licosa

JAMAICA
Ian Randle Publishers Ltd.
206 Old Hope Road, Kingston 6
Tel: 876-927-2085
Fax: 876-977-0243
E-mail: irpl@colis.com

JAPAN
Eastern Book Service
3-13 Hongo 3-chome, Bunkyo-ku
Tokyo 113
Tel: (81 3) 3818-0861
Fax: (81 3) 3818-0864
E-mail: orders@svt-ebs.co.jp
URL: http://www.bekkoame.or.jp/~svt-ebs

KENYA
Africa Book Service (E.A.) Ltd.
Quaran House, Mfangano Street
P.O. Box 45245
Nairobi
Tel: (254 2) 223 641
Fax: (254 2) 330 272

Legacy Books
Loita House
Mezzanine 1
P.O. Box 68077
Nairobi
Tel: (254) 2-330853, 221426
Fax: (254) 2-330854, 561654
E-mail: Legacy@form-net.com

KOREA, REPUBLIC OF
Dayang Books Trading Co.
International Division
783-20, Pangba Bon-Dong,
Socho-ku
Seoul
Tel: (82 2) 536-9555
Fax: (82 2) 536-0025
E-mail: seamap@chollian.net

Eulyoo Publishing Co., Ltd.
46-1, Susong-Dong
Jongro-Gu
Seoul
Tel: (82 2) 734-3515
Fax: (82 2) 732-9154

LEBANON
Librairie du Liban
P.O. Box 11-9232
Beirut
Tel: (961 9) 217 944
Fax: (961 9) 217 434
E-mail: hsayegh@librairie-du-liban.com.lb
URL: http://www.librairie-du-liban.com.lb

MALAYSIA
University of Malaya Cooperative Bookshop, Limited
P.O. Box 1127
Jalan Pantai Baru
59700 Kuala Lumpur
Tel: (60 3) 756-5000
Fax: (60 3) 755-4424
E-mail: umkoop@tm.net.my

MEXICO
INFOTEC
Av. San Fernando No. 37
Col. Toriello Guerra
14050 Mexico, D.F.
Tel: (52 5) 624-2800
Fax: (52 5) 624-2822
E-mail: infotec@rtn.net.mx
URL: http://rtn.net.mx

Mundi-Prensa Mexico S.A. de C.V.
c/Rio Panuco, 141-Colonia Cuauhtemoc
06500 Mexico, D.F.
Tel: (52 5) 533-5658
Fax: (52 5) 514-6799

NEPAL
Everest Media International Services (P.) Ltd.
GPO Box 5443
Kathmandu
Tel: (977 1) 416 026
Fax: (977 1) 224 431

NETHERLANDS
De Lindeboom/Internationale Publicaties b.v.-
P.O. Box 202, 7480 AE Haaksbergen
Tel: (31 53) 574-0004
Fax: (31 53) 572-9296
E-mail: lindeboo@worldonline.nl
URL: http://www.worldonline.nl/~lindeboo

NEW ZEALAND
EBSCO NZ Ltd.
Private Mail Bag 99914
New Market
Auckland
Tel: (64 9) 524-8119
Fax: (64 9) 524-8067

Oasis Official
P.O. Box 3627
Wellington
Tel: (64 4) 499 1551
Fax: (64 4) 499 1972
E-mail: oasis@actrix.gen.nz
URL: http://www.oasisbooks.co.nz/

NIGERIA
University Press Limited
Three Crowns Building Jericho
Private Mail Bag 5095
Ibadan
Tel: (234 22) 41-1356
Fax: (234 22) 41-2056

PAKISTAN
Mirza Book Agency
65, Shahrah-e-Quaid-e-Azam
Lahore 54000
Tel: (92 42) 735 3601
Fax: (92 42) 576 3714

Oxford University Press
5 Bangalore Town
Sharae Faisal
PO Box 13033
Karachi-75350
Tel: (92 21) 446307
Fax: (92 21) 4547640
E-mail: ouppak@TheOffice.net

Pak Book Corporation
Aziz Chambers 21, Queen's Road
Lahore
Tel: (92 42) 636 3222; 636 0885
Fax: (92 42) 636 2328
E-mail: pbc@brain.net.pk

PERU
Editorial Desarrollo SA
Apartado 3824, Ica 242 OF. 106
Lima 1
Tel: (51 14) 285380
Fax: (51 14) 286628

PHILIPPINES
International Booksource Center Inc.
1127-A Antipolo St, Barangay, Venezuela
Makati City
Tel: (63 2) 896 6501; 6505; 6507
Fax: (63 2) 896 1741

POLAND
International Publishing Service
Ul. Piekna 31/37
00-677 Warzawa
Tel: (48 2) 628-6089
Fax: (48 2) 621-7255
E-mail: books%ips@ikp.atm.com.pl
URL: http://www.ipscg.waw.pl/ips/export

PORTUGAL
Livraria Portugal
Apartado 2681, Rua Do Carm o 70-74
1200 Lisbon
Tel: (1) 347-4982
Fax: (1) 347-0264

ROMANIA
Compani De Librarii Bucuresti S.A.
Str. Lipscani no. 26, sector 3
Bucharest
Tel: (40 1) 313 9645
Fax: (40 1) 312 4000

RUSSIAN FEDERATION
Isdatelstvo <Ves Mir>
9a, Kolpachniy Pereulok
Moscow 101831
Tel: (7 095) 917 87 49
Fax: (7 095) 917 92 59
ozimarin@glasnet.ru

SINGAPORE; TAIWAN, CHINA MYANMAR; BRUNEI
Hemisphere Publication Services
41 Kallang Pudding Road #04-03
Golden Wheel Building
Singapore 349316
Tel: (65) 741-5166
Fax: (65) 742-9356
E-mail: ashgate@asianconnect.com

SLOVENIA
Gospodarski vestnik Publishing Group
Dunajska cesta 5
1000 Ljubljana
Tel: (386 61) 133 83 47; 132 12 30
Fax: (386 61) 133 80 30
E-mail: repansekj@gvestnik.si

SOUTH AFRICA, BOTSWANA
For single titles:
Oxford University Press Southern Africa
Vasco Boulevard, Goodwood
P.O. Box 12119, N1 City 7463
Cape Town
Tel: (27 21) 595 4400
Fax: (27 21) 595 4430
E-mail: oxford@oup.co.za

For subscription orders:
International Subscription Service
P.O. Box 41095
Craighall
Johannesburg 2024
Tel: (27 11) 880-1448
Fax: (27 11) 880-6248
E-mail: iss@is.co.za

SPAIN
Mundi-Prensa Libros, S.A.
Castello 37
28001 Madrid
Tel: (34 91) 4 363700
Fax: (34 91) 5 753998
E-mail: libreria@mundiprensa.es
URL: http://www.mundiprensa.com/

Mundi-Prensa Barcelona
Consell de Cent, 391
08009 Barcelona
Tel: (34 3) 488-3492
Fax: (34 3) 487-7659
E-mail: barcelona@mundiprensa.es

SRI LANKA, THE MALDIVES
Lake House Bookshop
100, Sir Chittampalam Gardiner Mawatha
Colombo 2
Tel: (94 1) 32105
Fax: (94 1) 432104
E-mail: LHL@sri.lanka.net

SWEDEN
Wennergren-Williams AB
P. O. Box 1305
S-171 25 Solna
Tel: (46 8) 705-97-50
Fax: (46 8) 27-00-71
E-mail: mail@wwi.se

SWITZERLAND
Librairie Payot Service Institutionnel
C(tm)tes-de-Montbenon 30
1002 Lausanne
Tel: (41 21) 341-3229
Fax: (41 21) 341-3235

ADECO Van Diermen
EditionsTechniques
Ch. de Lacuez 41
CH1807 Blonay
Tel: (41 21) 943 2673
Fax: (41 21) 943 3605

THAILAND
Central Books Distribution
306 Silom Road
Bangkok 10500
Tel: (66 2) 2336930-9
Fax: (66 2) 237-8321

TRINIDAD & TOBAGO AND THE CARRIBBEAN
Systematics Studies Ltd.
St. Augustine Shopping Center
Eastern Main Road, St. Augustine
Trinidad & Tobago, West Indies
Tel: (868) 645-8466
Fax: (868) 645-8467
E-mail: tobe@trinidad.net

UGANDA
Gustro Ltd.
PO Box 9997, Madhvani Building
Plot 16/4 Jinja Rd.
Kampala
Tel: (256 41) 251 467
Fax: (256 41) 251 468
E-mail: gus@swiftuganda.com

UNITED KINGDOM
Microinfo Ltd.
P.O. Box 3, *Omega Park, Alton,*
Hampshire GU34 2PG
England
Tel: (44 1420) 86848
Fax: (44 1420) 89889
E-mail: wbank@microinfo.co.uk
URL: http://www.microinfo.co.uk

The Stationery Office
51 Nine Elms Lane
London SW8 5DR
Tel: (44 171) 873-8400
Fax: (44 171) 873-8242
URL: http://www.the-stationery-office.co.uk/

VENEZUELA
Tecni-Ciencia Libros, S.A.
Centro Cuidad Comercial Tamanco
Nivel C2, Caracas
Tel: (58 2) 959 5547; 5035; 0016
Fax: (58 2) 959 5636

ZAMBIA
University Bookshop, University of Zambia
Great East Road Campus
P.O. Box 32379
Lusaka
Tel: (260 1) 252 576
Fax: (260 1) 253 952

ZIMBABWE
Academic and Baobab Books (Pvt.) Ltd.
4 Conald Road, Graniteside
P.O. Box 567
Harare
Tel: 263 4 755035
Fax: 263 4 781913

Recent World Bank Technical Papers *(continued)*

No. 409 Heggie and Vickers, *Commercial Management and Financing of Roads*

No. 410 Sayeg, *Successful Conversion to Unleaded Gasoline in Thailand*

No. 411 Calvo, *Options for Managing and Financing Rural Transport Infrastructure*

No. 413 Langford, Forster, and Malcolm, *Toward a Financially Sustainable Irrigation System: Lessons from the State of Victoria, Australia, 1984–1994*

No. 414 Salman and Boisson de Chazournes, *International Watercourses: Enhancing Cooperation and Managing Conflict, Proceedings of a World Bank Seminar*

No. 415 Feitelson and Haddad, *Identification of Joint Management Structures for Shared Aquifers: A Cooperative Palestinian-Israeli Effort*

No. 416 Miller and Reidinger, eds., *Comprehensive River Basin Development: The Tennessee Valley Authority*

No. 417 Rutkowski, *Welfare and the Labor Market in Poland: Social Policy during Economic Transition*

No. 418 Okidegbe and Associates, *Agriculture Sector Programs: Sourcebook*

No. 420 Francis and others, *Hard Lessons: Primary Schools, Community, and Social Capital in Nigeria*

No. 421 Gert Jan Bom, Robert Foster, Ebel Dijkstra, and Marja Tummers, *Evaporative Air-Conditioning: Applications for Environmentally Friendly Cooling*

No. 422 Peter Quaak, Harrie Knoef, and Huber Stassen, *Energy from Biomass: A Review of Combustion and Gasification Technologies*

No. 423 Energy Sector Unit, Europe and Central Asia Region, World Bank, *Non-Payment in the Electricity Sector in Eastern Europe and the Former Soviet Union*

No. 424 Jaffee, ed., *Southern African Agribusiness: Gaining through Regional Collaboration*

No. 425 Mohan, ed., *Bibliography of Publications: Africa Region, 1993–98*

No. 426 Rushbrook and Pugh, *Solid Waste Landfills in Middle- and Lower-Income Countries: A Technical Guide to Planning, Design, and Operation*

No. 427 Mariño and Kemper, *Institutional Frameworks in Successful Water Markets: Brazil, Spain, and Colorado, USA*

No. 428 C. Mark Blackden and Chitra Bhanu, *Gender, Growth, and Poverty Reduction: Special Program of Assistance for Africa, 1998 Status Report on Poverty in Sub-Saharan Africa*

No. 429 Gary McMahon, José Luis Evia, Alberto Pascó-Font, and José Miguel Sánchez, *An Environmental Study of Artisanal, Small, and Medium Mining in Bolivia, Chile, and Peru*

No. 430 Maria Dakolias, *Court Performance around the World: A Comparative Perspective*

No. 431 Severin Kodderitzsch, *Reforms in Albanian Agriculture: Assessing a Sector in Transition*

No. 432 Luiz Gabriel Azevedo, Musa Asad, and Larry D. Simpson, *Management of Water Resources: Bulk Water Pricing in Brazil*

No. 433 Malcolm Rowat and José Astigarraga, *Latin American Insolvency Systems: A Comparative Assessment*

No. 434 Csaba Csaki and John Nash, editors, *Regional and International Trade Policy: Lessons for the EU Accession in the Rural Sector—World Bank/FAO Workshop, June 20–23, 1998*

No. 436 Roy Prosterman and Tim Hanstad, ed., *Legal Impediments to Effective Rural Land Relations in Eastern Europe and Central Asia: A Comparative Perspective*

No. 437 Csaba Csaki, Michel Dabatisse, and Oskar Honisch, *Food and Agriculture in the Czech Republic: From a "Velvet" Transition to the Challenges of EU Accession*

No. 443 Luc Lecuit, John Elder, Christian Hurtado, François Rantrua, Kamal Siblini, and Maurizia Tovo, *DeMISti-fying MIS: Guidelines for Management Information Systems in Social Funds*

No. 444 Robert F. Townsend, *Agricultural Incentives in Sub-Saharan Africa: Policy Challenges*

No. 445 Ian Hill, *Forest Management in Nepal: Economics of Ecology*

No. 446 Gordon Hughes and Magda Lovei, *Economic Reform and Environmental Performance in Transition Economies*

No. 447 R. Maria Saleth and Ariel Dinar, *Evaluating Water Institutions and Water Sector Performance*

No. 449 Keith Oblitas and J. Raymond Peter in association with Gautam Pingle, Halla M. Qaddumi, and Jayantha Perera, *Transferring Irrigation Management to Farmers in Andhra Pradesh, India*

No. 450 Andrés Rigo Sureda and Waleed Haider Malik, *Judicial Challenges in the New Millennium: Proceedings of the Second Summit of the Ibero-American Supreme Courts*

No. 452 Lev Freinkman, Daniel Treisman, and Stephen Titov, *Subnational Budgeting in Russia: Preempting a Potential Crisis*

THE WORLD BANK

1818 H Street, N.W.
Washington, D.C. 20433 USA

Telephone: 202-477-1234

Facsimile: 202-477-6391

Telex: MCI 64145 WORLDBANK
MCI 248423 WORLDBANK

Internet: www.worldbank.org

E-mail: books@worldbank.org

ISBN 0-8213-4613-X