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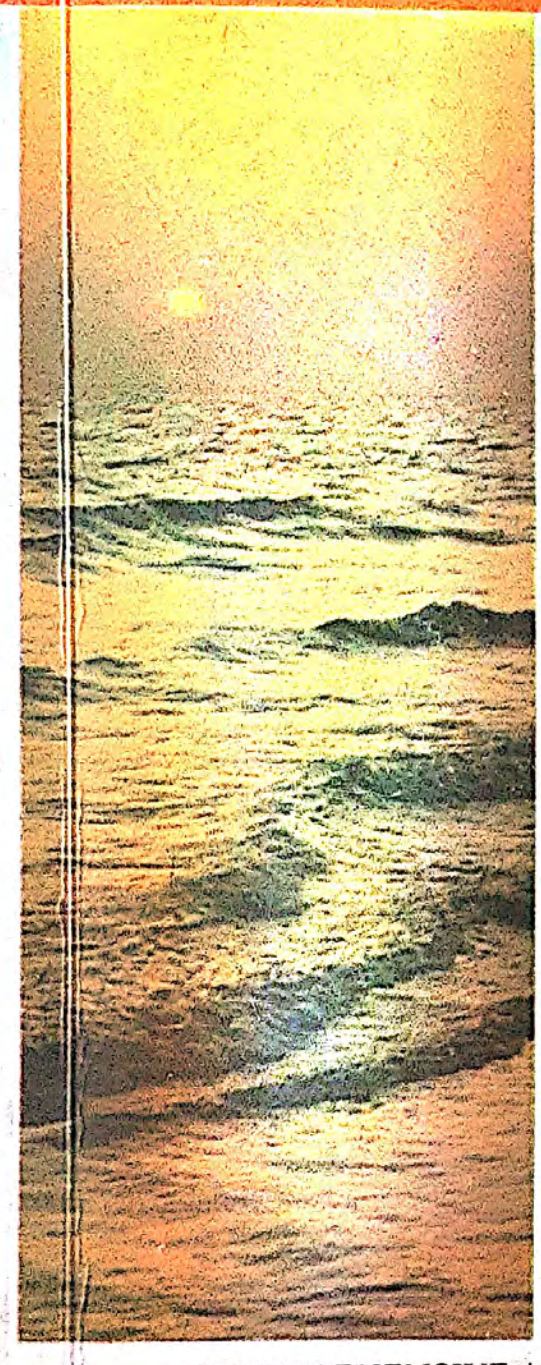

WATER RESOURCES MANAGEMENT SERIES

CORE AND PERIPHERY

A COMPREHENSIVE APPROACH TO MIDDLE EASTERN WATER

ASIT K. BISWAS
JOHN KOLARS
MASAHIRO MURAKAMI
JOHN WATERBURY
AARON WOLF

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WATER RESOURCES MANAGEMENT SERIES: 5

Core and Periphery: A Comprehensive Approach to Middle Eastern Water

By

ASIT K. BISWAS (Chairman)
JOHN KOLARS
MASAHIRO MURAKAMI
JOHN WATERBURY
AARON WOLF
Members, Middle East Water Commission

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This book is dedicated to

Akira Iriyama and Takashi Shirasu

President and Chief Programme Officer
Sasakawa Peace Foundation
without whose support and encouragement
this book could never have been written

Foreword

In the summer of 1991, Professor Asit K. Biswas, the then President of the International Water Resources Association and Senior Scientific Advisor to the Executive Director of the United Nations Environment Programme, visited the Sasakawa Peace Foundation in Tokyo, to discuss possible areas of collaboration with Dr Takashi Shirasu, the Chief Programme Officer of our Foundation. One of the main items of their discussion was a new initiative to promote regional cooperation in the Middle East in the area of water resources by fostering a dialogue between the key players of the countries and major international institutions concerned. It was felt that a new negotiating mechanism could be effectively used, under the aegis of a non-governmental organization, through which many of the most contentious problems associated with the current regional water use and management problems of the Middle East could be resolved. It would be a parallel track event to the continuing bilateral and multilateral talks between the countries concerned, where by that time actual progress on the difficult issues concerned was very limited and painfully slow.

The discussion between Dr Biswas and Dr Shirasu led to the eventual agreement to organize a Middle East Water Forum to review and discuss the principal water issues of the area in Cairo, Egypt, 7–9 February 1993. It was believed that if the Forum was carefully planned and properly organized, it could significantly facilitate the bilateral and multilateral negotiations between the countries concerned by identifying various feasible alternative scenarios for resolving the long-smouldering historical problems which the countries of the region had to face due to serious shortages of water availability, combined with steadily increasing demands. It was also felt that a free

and informal dialogue between the main inter-country negotiators of the water issue, without the presence of the media and the general public, could also be considered as an important confidence-building measure, which could accelerate, or even reinforce, formal diplomatic initiatives in this area.

The Sasakawa Peace Foundation thus joined hands with the United Nations Environment Programme (UNEP) and the United Nations University (UNU) to support the International Water Resources Association (IWRA) to convene the Middle East Water Forum. In retrospect, we were very fortunate that Professor Biswas personally took charge of convening the Forum. He has been directly involved with the various Middle East water issues for more than three decades, and during this period he has advised most of the governments of the region and all the international organizations on such issues officially at very high levels. Furthermore, his expertise on water management has been well-acknowledged internationally, and his objectivity and impartiality in water issues of the region are unquestionable. He is thus equally acceptable to all the parties concerned.

The participation to the Forum was by invitation only. Twenty-seven participants to the Forum were carefully chosen, and it is indeed remarkable that all the experts invited by Professor Biswas in their personal capacities, promptly agreed to take part. Seventeen of the participants were directly involved in bilateral and multilateral Peace Talks.

By all accounts, the Forum was an outstanding success. It turned out to be a remarkable exercise in international relations and preventive diplomacy. The book that was subsequently published by Oxford University Press containing all the specially commissioned papers for the Forum, *International Waters of the Middle East: From Euphrates-Tigris to Nile*, is now considered to be the most definitive text available on the subject.

Following the Forum and during one of his very regular visits to Japan, Professor Biswas and Dr Shirasu discussed how best to follow up the most remarkable results that were produced by the Forum. It was agreed that a Middle East Water Commission should be established, with a fixed set of objectives and a limited lifespan of three years. The Foundation agreed to support the Commission, and Professor Biswas agreed to chair it personally.

After a great deal of discussion and deliberation, it was decided that

no member of the Commission should be from any of the countries of the region, but rather well-known experts on the water problems of the region, who are equally acceptable to all the countries concerned. It was felt that if any one member of the Commission came from one of the countries of the region, other countries would have to be represented as well. This would not only transform the Commission into a 'mini United Nations', but also a large membership would make its functioning somewhat inefficient. Equally, past experiences indicated that the commissions with large memberships have seldom produced worthwhile and innovative results, since their reports are invariably full of compromises that are acceptable to each and every one of their many members.

In addition to Professor Biswas, other members of the Commission were Professor John Kolars (University of Michigan), Dr Masahiro Murakami (Nippon Koei, Japan), Professor John Waterbury (Princeton University) and Professor Aaron Wolf (University of Alabama).

The Commission first met in 28-30 September, 1993 in Santa Fe, USA, during which a detailed work programme was prepared. In the summer of 1994, all the Commission members spent a month at Princeton University to prepare a preliminary draft. In late 1994, during the World Water Congress in Cairo, the Commission outlined its preliminary findings and views. The Cairo Congress was attended by more than 600 water specialists from around sixty-three countries, including a large number of participants from the Middle East. A lively interchange took place between the Commission members and a packed audience. In August 1995, the Commission was specially invited to outline its findings at the Stockholm Water Symposium, the premier international water event each year. The final meeting of the Commission took place in Ankara, Turkey, 1–2 February 1996.

During the entire working life of the Commission, it kept regular contacts with all the governments of the region, as well as with other interested governments and international organizations who were actively promoting peace in the region. Among the latter were Canada, Japan, United States, UNDP, and the World Bank. Professor Biswas not only directed the substantive work of the Commission, but also during his 'normal' course of work as an advisor to seventeen governments and all the major international organizations at the senior-most levels, he used his extensive network and personal contacts to keep up a continual dialogue with all the major players of the

Middle East water issues. Furthermore, all the other Commission members equally used their own individual networks to keep numerous other people informed.

The Commission has published numerous papers in major international journals during the past three years. All these carefully planned activities mean that this has been one of the very few commissions ever established which has ensured regular dialogues with all the interested parties throughout its entire life.

The Sasakawa Peace Foundation is indeed most grateful to the Commission members, Professor Kolars, Dr Murakami, Professor Waterbury and Prof. Wolf, and especially to its Chairman, Professor Biswas, for their excellent work in the complex and difficult hydropolitical issues of the Middle East. Their hard work has already contributed to many significant positive developments in the region. The publication of the present report will no doubt further add to the accomplishments of the Commission. In addition, the many seeds the Commission has sown in terms of new and innovative ideas and through the creation of numerous informal networks, will further add to its achievements.

The Sasakawa Peace Foundation is proud to have played a key role in the establishment of the Middle East Water Commission and its overall functioning. It has been one of our most successful projects. Since no lasting peace in the Middle East will ever be possible without a just and rational agreement on the use and management of its meagre water resources, we sincerely hope that the work of the Commission will play an important role in bringing permanent peace to the region, and will contribute to significant prosperity to all the countries concerned on a sustainable basis.

Akira Iriyama
President
Sasakawa Peace Foundation
Tokyo, Japan

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Preface

Water has always been a scarce resource in the arid countries of the Middle East, where one of the main constraints to development has been water, not land. However, as the population of the countries has steadily increased, both due to natural causes and migration, the situation has progressively worsened in terms of availability of adequate quantity and quality of water. All the current indicators point to the fact that the problems are most likely to worsen even further in the coming years, unless radical changes can be made in its overall management in the foreseeable future.

No sane individual will argue with the fact that lasting peace in the Middle East is not possible without a satisfactory resolution of the main problems associated with water between the countries concerned. While the problems are complex, and the available solutions may not be easily implemented due to a variety of interrelated social, economic, technical, institutional and political problems, both within the individual countries as well as between the countries, the fact remains that, given good will and political will from all sides, the water problems of the Middle East are solvable. It will certainly require enlightened leadership in the countries and strong political commitment to the solutions, but, as the present report of the Middle East Water Commission indicates, there are solutions.

The events of the past few years indicate that there are good reasons to be very cautiously optimistic that the water problems of the region could be resolved some time in the future. There is no doubt that mutually acceptable solutions would take time to surface, and equally the process to reach them would not be linear. There would be reasons for optimism as well as pessimism all along the way until hard and

realistic decisions can be taken by the countries leaders and accepted by the majority of their citizens.

Water has become an integral component of the ongoing peace process for the region. As the various negotiations have progressed, and some bilateral treaties signed, there is more reason for muted optimism now compared to even five or ten years ago. The fact is that, for the most part, parties are meeting each other, officially or unofficially, individually or collectively; new approaches to water acquisition and equitable sharing are under active discussion, regionally and internationally; and possible technological solutions to the growing water scarcities are being carefully studied and some are being gradually put in place. These are positive developments. They can be considered as good omens for the future. In any event, alternatives to the possible solutions are not difficult to contemplate; these can only result in untold misery for the people of the region for many years to come.

When I convened the Middle East Water Forum in Cairo in February 1993, with the support of the Sasakawa Peace Foundation and the United Nations Environment Programme, one of our main objectives was to bring some of the key players of the countries of the region and major international organizations to discuss the various complex and interrelated issues in an informal atmosphere. The success of the Forum led to the establishment of the Middle East Water Commission. Mr Akira Inyama, President of the Sasakawa Peace Foundation, has succinctly outlined the background to the establishment of this Commission in his Foreward to this book. (They will not be repeated here.)

Chairing the Commission has been a challenging experience. When I accepted the Chairmanship, and because I have known the region well for some twenty-five years, I fully expected the task to be difficult and complex, but intellectually rewarding. In retrospect, overall, the task was more or less what I had anticipated, even though some problems turned out more complex than initially foreseen, and others less so.

Many people, both from the Middle East region and outside, have assisted the Commission in our work, for which we are truly grateful. Without their unstinted help and sound advice, we simply could not have achieved what we managed. Because of the sensitive nature of the issues and the large number of individuals and institutions that

have assisted us, no names are being mentioned here. However, without their assistance, their report and all of our other associated activities simply would not have been possible. Our most sincere appreciation goes to each one of them.

The main strength of any Commission, however, comes from its members. I was most fortunate in having some of the best specialists anywhere in the world, on the Middle East water issue, as members of the Commission. They represented different disciplines, and our knowledge and expertise of the region complemented each other remarkably well. In addition, it was a real pleasure and privilege for me to work with each of them intensively and extensively. I am thus most grateful to Professor John Kolars, Dr Masahiro Murakami, Professor John Waterbury and Professor Aaron Wolf for their excellent work as members of the Commission and the outstanding way they performed their individual tasks. Their unrivalled knowledge of the region and objective analyses of the complex issues have been some of the primary causes of the success of the Commission.

Last but no least I wish to express my personal gratitude and appreciation to Dr Takashi Shirasu of the Sasakawa Peace Foundation, Tokyo, His wise counsel and regular encouragement was a source of continuous inspiration to me. He took a genuine personal interest in our work, and we have all benefited because of it. Without his help, the Commission would not have been able to achieve even half of what it did.

Even though the work of the Commission is now complete, members of the Commission will continue to be active in the Middle East water issues in the years ahead. As Chairman of the Commission, I sincerely hope that our work, in some measurable ways, will contribute to the satisfactory resolution of Middle East water issues in the future.

Asit K. Biswas
Middle East Water Commission
Instituto de Ingeniería
Universidad Nacional Autónoma de México,
México, D.F., México

Part I

The Parameters of Water Project Development in the Middle East

1 Thoughts on the Predictability, Reliability, and Costs of Water in the Middle East

INTRODUCTION

A sense of immediacy has influenced peace negotiators in the Middle East. Hostilities and the angst they bring must cease; the window of opportunity must not be missed! The accords between Israel and Jordan and between Israel and Palestine[1] in 1995 seemed impossible only months before. Accompanying such political rapprochements have been parallel efforts to solve the problems of water sharing among the participants. It is in this spirit that such confidence building measures as the completion, in September 1995, of a canal from the Sea of Galilee to the East Ghor canal, which will deliver 50 mcm potable water annually to Jordan, have taken place. The Red-Dead canal and small storage dams on the Jordan also have been proposed for the near future and their feasibility is being studied. Nevertheless, the urgency of time and politics often compel other vital parameters of the regional water situation to be overlooked.

We must not forget that it is an enduring peace which is sought, a peace which must hold not for the moment but indefinitely. Such a peace must include considerations of water supply which can survive pressure from growing populations, wide and unpredictable fluctuations in regional climate, and unforeseen political swings. We disagree with those who tend to downgrade the importance of water in the regional peace process. Our own belief is that the water issue is a necessary though not a sufficient feature of regional co-operation.

Others have discussed the continuing and growing need for water in the Middle East and have painted a broad picture of the priorities involved (Rogers, 1994, Chapter 11). Such efforts describe in general terms the problems faced in satisfying future thirst and their possible solutions, but as is said, 'the devil is in the details'. We hope to exorcise

some of these details in the pages ahead. Our purpose is to suggest a more specific blueprint for the hydro-development of the Jordan river basin and the area which surrounds it. We also intend to extend the planning horizon far enough into the future to consider the possibility of importing water from outside the region.

A detailed look at the region's climate, demography, and economy indicates that no single water project, nor narrowly focused combination of such projects, can serve its future inhabitants. At the same time, increases in population will place additional pressures upon existing supplies. Water-related technologies which determine the expense with which such supplies are obtained will continue to change. So, too, will local supplies of brackish and fresh water vary as old sources are depleted and polluted and new sources become available through improved means of purification and pumping.

This is an attempt to provide a region-wide review of water issues and technologies and to show how they can be welded sequentially into a long-term, integrated system which will serve all the people of the region, not only now but in the future. We do not espouse any particular project or water source, but hope to demonstrate how various approaches when combined will serve the region best.

PARAMETERS OF WATER AVAILABILITY

Water seldom is directly available to the consumer at its source. Water becomes available for consumption only after passing through a complex of natural, social and financial filters. The focus of this discussion is the Jordan river basin and the problems of water supply for its growing populations. This area becomes the core of the study, but does not constitute its geographical limits. Beyond the core are sources of water which may become available to the core through human means. These constitute the periphery.

While the present Middle East water crisis centres upon Israel, Jordan, and Palestine (the West Bank and Gaza), that is the core area, Syria and Lebanon, at somewhat greater remove, are also involved. Turkey and Iraq are even more peripheral but assume importance as the time span under consideration increases. Egypt and the Nile and the Arabian peninsula must also be taken into consideration despite their unique sets of water-related problems. One might possibly think of such matters in terms of the length of time it would take a unit of

water to flow to Amman or Gaza from a well located nearby or through a pipeline from distant mountains. Thus, the concept of core and periphery should be viewed not only in a spatial but also in a synchronous temporal context.

The complex of variables referred to above may also be considered in terms of different rates of change over time, i.e., a diachronous view and Fig. 1-1 illustrates this point. The variables affecting water delivery are grouped according to the basic conditions which determine their impact upon availability: that is, predictability, reliability, and cost.

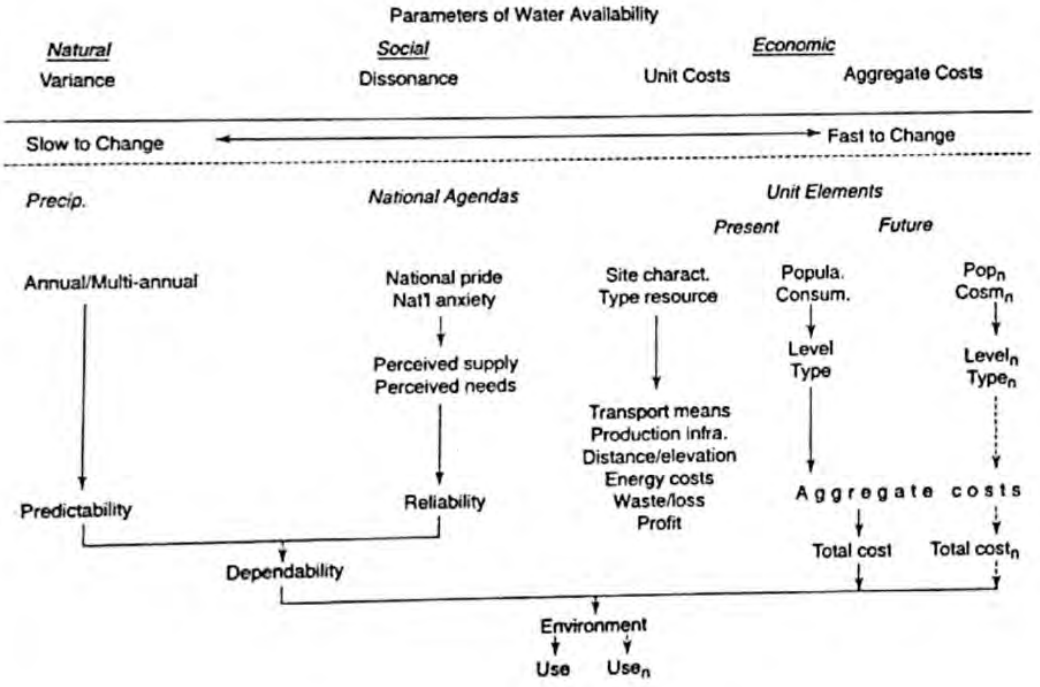

Fig. 1-1: Parameters of Water Availability

Our reasoning is thus: By predictability is meant the variance of a given phenomenon. Annual and multi-annual variance of precipitation are listed under this heading. The uncontested rule relating to precipitation variance is 'the more sparse the rainfall, the more uncertain it becomes as to amount, time, or location'. Unpredictability, the nemesis of agricultural planners and water managers is of particular importance in the core of the study area (Bakour and Kolars). To the south of the core (excluding the valley of the Nile) the deserts of the Arabian peninsula and North Africa are predictably arid; to its north,

the rain-fed lands of Turkey enjoy a more certain climatic regime than do those of the core. World and regional climatic patterns are slow to change, and though it may seem cold comfort to those concerned, the unpredictability of precipitation in the core is a certainty and can be expected to remain predictably so within the limits of any planning period.

Slowest to change are those debatable and imperfectly perceived variables such as global warming and climatic change. Among those quickest to change, and also simplest to quantify, are the engineering and investment costs involved in supplying water. These are expressed by the per unit price and the aggregate cost of water which reflects the size and characteristics of the consumer population.

The per unit price of water is tied to a number of natural and technological factors as well as to the producer's desire for profit. Sources (springs, rivers, aquifers) and site characteristics are primary in these considerations. For example, is the water to be desalinized brackish or sea water? Significant differences in cost stem from this. Is the reservoir site in a deep canyon or on an undulating plain? Water loss through evaporation, plus major differences in dam construction apply here. The means of transfer also influence ultimate cost. If pipelines, how far between source and consumer, and what are the costs of pumping and lifting the water? What waste and loss will occur? The type of production facility plays its role: desalination plant or high dam? What energy costs are involved in reverse osmosis—is hydro-power involved? Or is imported fuel for a thermal plant a concern? Finally, what will the producer and shipper consider to be a reasonable per unit profit? It should be noted that the time horizon for these costs may vary, but all fall within the scope of a few years and are tied to the market mechanism. Therefore, this group of variables has been placed near the 'quick to change' end of the continuum.

When per unit water costs are aggregated in terms of the consuming population not only the size but the projected growth rates are important, as are the level and type of consumption. These measures lead to consideration of even more complex variables that often create social dissonance related to the national agendas of the peoples involved.

The fact that feelings seemingly elude quantification does not preclude consideration of their role in water availability. This parameter

is discussed in Chapter 5 where Coplin and O'Leary's PRINCE Political Accounting System is considered. A few instances of how politics and emotions intersect will suffice at this juncture. International relations can be good or poor, and the perceptions that one nation's population has of another's can also play an important role. National pride which may insist upon the internal production of a resource regardless of its cost is frequently encountered as is national anxiety. The familiar question of food security couched in terms of water availability and security needs little explication. The perception of need and the perception of supply also can be part of the national *Zeitgeist*. Is a nation like Saudi Arabia, which some say is graced with 'Forty Niles beneath its sands', being realistic regarding the future of its water supply? Does such a quantity of water really exist there? And what of Israeli swimming pools and golf courses against an adequate per capita supply of safe drinking water in Gaza? Attitudes and perceptions do change, but more slowly than the size of populations or the stock market. On the other hand the juggernaut like pace of possible global climatic change is slower than the tides of human affairs. In Fig. 1-1 these differences are ranked according to the time line shown on the abscissa.

Each of these groups of variables imply further consequences. Variance necessitates evaluation of precipitation predictability. This leads to consideration of less certain precipitation in the core of the region compared with more certain water supplies on its northern periphery.

Turning to the human side, the social dissonance of national moods reflects on the reliability of international co-operation which combined with the problems of natural supply determine the availability of each water source. This, in turn, must be matched to the affordability of water and each nation's ability to pay the total bill involved. All such considerations are embedded in the question of the environmental impact each project will have on national economies as well as upon an increasingly fragile planet.

THE REGION DESCRIBED: CORE AND PERIPHERY

A salient feature of the Middle East in Southwest Asia is that it can be sub-divided into the better watered areas of Turkey and Iran, the extremely arid Arabian peninsula, and a zone of transition, the Mashreq, lying in between.[2]

The population of the Mashreq is unevenly distributed in a broad arc including the twin river valleys of the Tigris and Euphrates (Fig. 1-2). This better populated band conforms to the foothills of the Zagros mountains, those of the Anti-Taurus mountains of Turkey, and the highlands of the Levantine shore. The interior of the arc is filled by an extension of the Arabian desert which merges northward into a fluctuating zone of transition, the Syrian steppe. Thus, the area where water uncertainty, population growth, and development converge corresponds to the Fertile Crescent[3] of classical archaeology.

Given such a famous and enticing *nom de terre*, a cautionary note should be sounded. Planners and patriots alike may succumb to ambitious hopes that can at best be only partially fulfilled. Although the western limb of the Fertile Crescent, with its transitional climates and high variance, constitutes the core of this discussion, the area cannot sustain limitless development fuelled by relentlessly increasing populations.

The political units of the Mashreq: Iraq, Israel, Jordan, Lebanon, Palestine (the West Bank and Gaza), and Syria, (alphabetical order) occupy a critical position between Europe, Turkey and North Africa. The environments which they share mark a transition between better watered countries to the north, of which, Turkey is not only contiguous but a major source of international rivers, and the truly arid lands of the Arabian peninsula and north-east Africa to the south. Thus, an important lesson is that the core has elements of both the region to its north and the region to its south and that a mix of water technologies is most appropriate in order to solve its hydrologic problems.

TOPOGRAPHY: CORE AND PERIPHERY[4]

The topography of the Mashreq consists of a central alluvial plain formed by deposits from the Euphrates and Tigris rivers and an open, southward facing arc of mountains and foothills which curve from the Mediterranean sea to the Arabian/Persian Gulf (henceforth referred to as the gulf). The lowland stretches from the headwaters of the Gulf to northern Iraq and into Syria where it is known as the Syrian and Iraqi Jezirah.

A more detailed view beginning in the west reveals a narrow coastal plain which includes the Gaza strip, littoral Israel and the shores of

Fig. 1-2: Map o f the Mashreq and Southwest Asia

Lebanon and Syria. This plain is backed in the south by the hills of the West Bank which look eastward over the rift valley of the Dead sea and the Jordan river basin. Beyond the Jordan river rise the hills of the Hashemite kingdom of Jordan which descend gradually to the eastern, central desert.

The hills on both sides of the Jordan valley increase in height to the north with Mount Lebanon to the west in Lebanon and the Golan heights and Mount Hermon to the east. The Jordan river begins in the north with the Hasbani river, a major tributary. (The valley itself is lost to the north in the broken topography of southeast Lebanon.) Farther north and east, the foothills of Syria, marked by the major cities of Damascus, Homs, and Aleppo, give way to the interior lowland. Across a low watershed to the west in Lebanon, the Litani river flows from north to south in the Bekaa valley (a continuation of the rift complex) before turning sharply west to reach the sea. Between the Bekaa and the coastal plain the heights of Lebanon merge northward with the Syrian Jebel Alawi, bordered on the east by the valley of the Asi (Orontes) river and the reclaimed Ghab swamp.

North of coastal Syria, the mountains of Hatay Vilayet (province) in Turkey join the east-west Anti-Taurus range which the Turkish border with Syria and Iraq parallels. These highlands define the northern extent of the Mashreq and provide almost all of the waters of the Euphrates river and nearly half of those of the Tigris. Farther east, the Iran/Iraq border swings south-east following the Zagros mountains from which flow the major tributaries of the Tigris river. These mountains continue along the eastern shore of the gulf, but the Mashreq, itself, is limited by the Arabian desert to the south. Therefore, our tour turns west at the head of the gulf, crossing the desert to end at the hills of Jordan.

HYDROLOGY: CORE TO PERIPHERY

It is within the amphitheatre of the Mashreq as well as in its wings defined by the enclosing mountains that a dramatic search for water is being conducted. The waters originating within the core, as defined above, will not suffice for its future populations and development if current agricultural practices are continued or in a longer view if population growth remains unchecked. As will be shown, they must be augmented by desalination and/or imports from the periphery.

Other means of increasing available supplies, conservation, system repair and maintenance, the recycling of used water, have limited returns. Even water imports will not prevail unless population planning is able to slow the region's swift increase. Nevertheless, each of these elements has its place over time in a comprehensive solution to the problem of supplying water to the people of the core. It thus becomes important to review the hydrology of the entire Mashreq as well as that of its northern periphery.

CLIMATES AND HYDROLOGY

Climates[5]

The climates of the Mashreq are Mediterranean (Csa-Koeppen climate classification), with hot, dry summers and mild, wet winters and 400 to 800 mm of precipitation, and semi-arid steppe (Bsh), having 200 to 400 mm precipitation and cool winters. Both are typified by high variance in precipitation which reflects the changing paths of the jet stream and its attendant rain bearing westerly winds. By the same token, north-south shifts in the sub-tropical high pressure zone, itself responsible for extreme aridity centering upon 30° N latitude, bring periods of drought to the Mashreq. Unpredictable series of arid years are followed by years of bountiful rains. Such was the case when heavy rains and snows in the winter of 1991–2 ended a disastrous multi-year drought. On the other hand, winter rains of such intensity often result in needed water surpluses being lost through flooding which exceeds reservoir capacities.

This climate extends south in a narrow band along the eastern Mediterranean littoral as far as Gaza. It also extends inland to the east, but is greatly modified by higher elevations and a more land-locked situation. To the north in Anatolia a cool and humid, temperate climate (Dsa) with warm summers and cold winters provides 600 to 1000 mm of rain annually with relatively little variance. To the south, the Csa zone merges with the semi-arid steppe (Bsh). Precipitation provides barely enough moisture for dry (fallow) farming on the zone's northern side, and shows increasing variability the farther to the south one travels. Beyond the steppe the arid climate (BWh) of the Arabian desert (with less than 200 mm of rain occurring sporadically, if at all) allows only irrigated agriculture (Fig. 1-3).

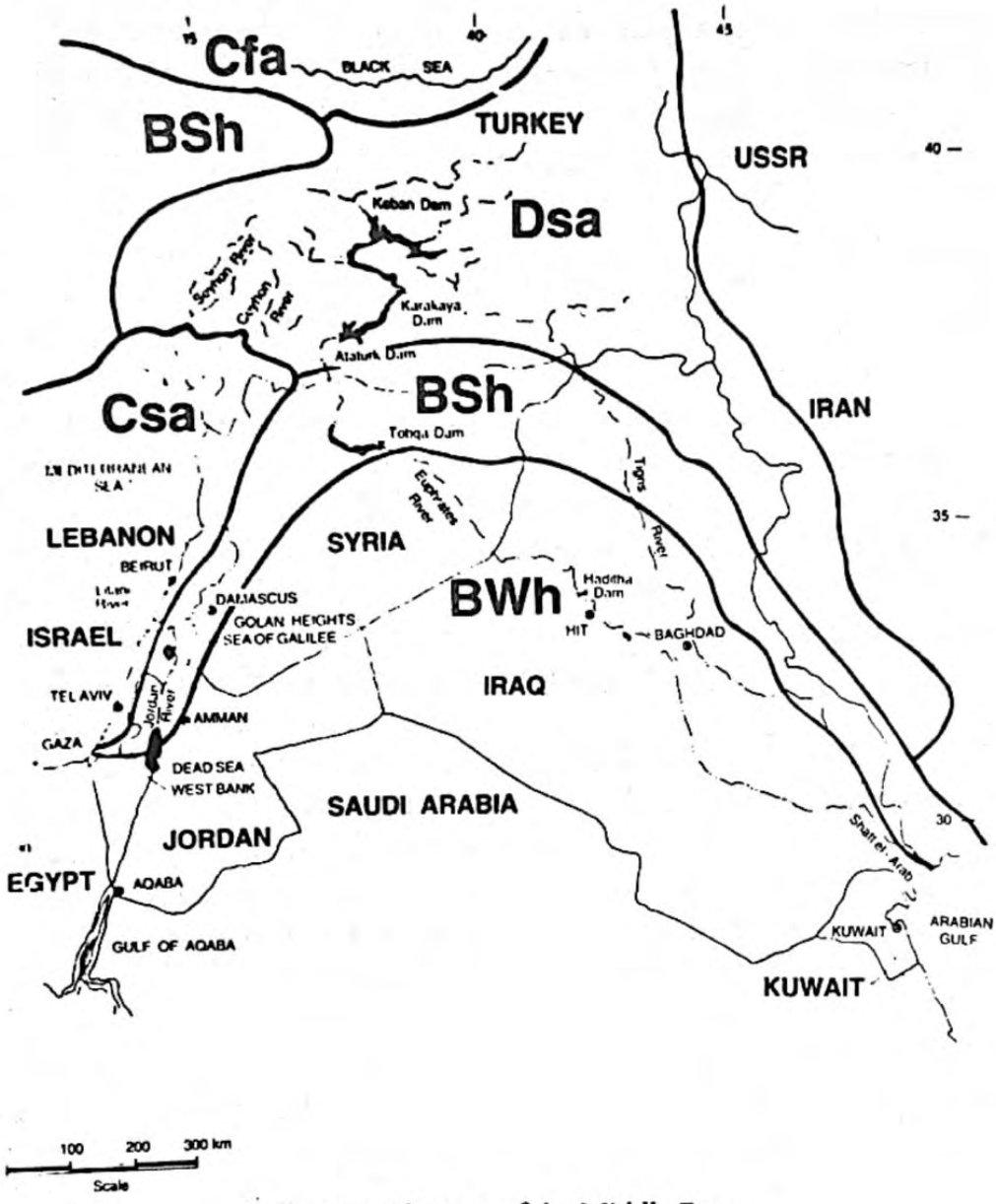

Fig. 1-3: Climates of the Middle East

Variance in precipitation is only one of the challenges that the Mashreq poses. The timing of rainfall and drought is also significant. This is demonstrated by the concept of the water balance which provides a useful overall picture of the problems facing the water managers of the region. Fig. 1-3 shows the water balances for selected stations throughout the Middle East. Note the small potential evapotranspiration (PE) and deficit (i.e., drought) associated with Turkish stations peripheral to the core, the enormous PE and subsequent deficit for stations within the peninsula, and the intermediate values shown for Beirut and other locations within the core. The latter conditions, coupled with variance, where some years may resemble peninsular drought and other years a more northerly situation, emphasize the challenge facing water managers at the core.

Fig. 1-4 shows the diminishing of annual precipitation from north to south on a transect leading from Zonguldak, Turkey, to Aden. A second curve indicates the increasing variance in rainfall as desert conditions are encountered. That is, the drier the climate the more unpredictable precipitation becomes.

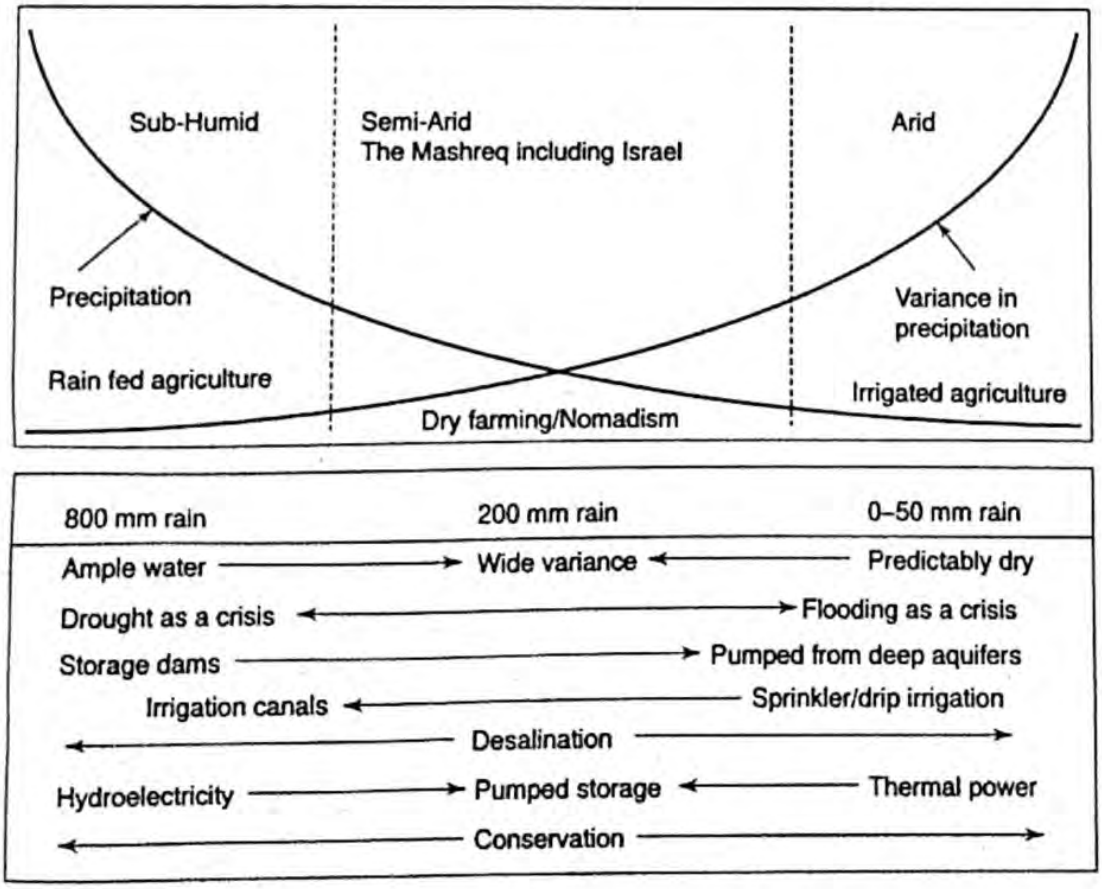

Fig. 1-4: Precipitation and Variability in the Middle East

An initial impression may be that deserts are the least predictable of all environments. A moment's thought, however, reveals that as the predictability of rainfall decreases, the predictability of drought becomes more and more certain. In other words, if one lives in the Sahara or the Arabian peninsula, one should know what to expect, and to prepare for it. But, just as a twenty-five or fifty-year drought wreaks havoc on farmers accustomed to rainfed agriculture, so does the unexpected cloudburst threaten desert inhabitants. The torrential rains and subsequent flooding in parts of upper Egypt in November 1994 are an example of this.[6]

Fig. 1-4 shows that the zone of greatest unpredictability is at the intersection of the precipitation and variance curves. The Anatolian plateau to the north is noted for its rain-fed agriculture and typified by numerous, widely scattered villages. To the south modern sprinkler-fed farms are replacing traditional oases across the Arabian peninsula. Between lies the region which is the focus of this study, the transitional Mashreq with its critical core in which are found truly biblical lands where 'seven years of plenty are followed by seven years of want'.

Hydrology

We must now review the hydrology of the study area in order to appreciate the critical relationship of the core to the periphery.

Precipitation increases from south to north across the entire region both along the Mediterranean shore and in the interior. Kuwait receives an average 111 mm of rain and Baghdad 151 mm. Deir ez-Zor and Hasakah in Syria with 200 mm and 300 mm respectively must rely upon irrigation to insure their crops (Kolars and Mitchell, 1991, Table 9-1). Turkey enjoys an average of 452 mm at Sanliurfa, while Gaziantep (550 mm) and Mardin (686 mm) are within the limits of rain-fed agriculture. Along the Mediterranean littoral Jerusalem averages 492 mm, Beirut 517 mm, Tripoli 745 mm, and Antalya, Turkey 1028 mm. On the Arabian peninsula Aden receives a scant 39 mm, Eilat on the Gulf of Aqaba 27 mm, and Jiddah even less (25 mm). The previous discussion of precipitation variability should be kept in mind, for the aridity of the Arabian peninsula is highly predictable, conditions in the Mashreq are not.

Surface and Underground Waters

Surface water is non-existent in Gaza, and the shallow coastal aquifers have long been over-pumped. The coastal aquifer is said to have had a safe renewable production of 60×10^6 m^3 per year, but current over-pumping is approximately 95×10^6 m^3 annually. This has resulted in seawater intrusion as well as contamination of the aquifer by uncontrolled surface effluents.

Israel fares scarcely better in terms of its water supply within the Green Line, but derives additional waters from the Sea of Galilee and the West Bank (Palestine). Its supplies are so intertwined with those of the West Bank that the situation in the two areas must, therefore, be presented in combination. Sustainable yield of renewable fresh waters in Israel is approximately 1450×10^6 m^3 per annum. Israel had already exceeded this level by the early 1970s, and had to cut 29 per cent from its national water budget (1987×10^6 m^3 in 1987 vs. 1420 $\times 10^6$ m^3 in 1991) due to severe drought. The sources of its renewable supplies are shown in Tables 1-1, 1-2 and 1-3.

Table 1-1: WATERS USED BY ISRAEL

Source	Availability		Usage
Sea of Galilee (Hasbani, Wazani, Dan, side run off)			500×10^6 m^3
West Bank			
Yaqon-Taninim aquifer	340		
Northern aquifer	135		
Nablus-Jenin	70	545	450
Eastern aquifer	125		—
From inside the Green Line (includes the coastal plain aquifer 280)			500
Sub-total			1450
Re-cycled			220
Total			1640
West Bank Palestinians			
Surface springs			55×10^6
Wells			25×10^6
Total			80×10^6

Jordan is mining its non-renewable aquifers, removing an estimated 190 mcm in 1990 (Garber and Salameh, 1992, 10–14). The

Disi aquifer in the southeast also is being depleted by heavy pumping on the Saudi side of the border where it is known as the Saq aquifer (Abu Rizaiza, 66–8).

Table 1-2: RENEWABLE WATER SUPPLY ON THE WEST BANK (mcm/yr)

Aquifer	Fresh	Brackish	Total
Eastern	81	70	151
North-east	61	70	131
Mountain	310	40	350
Total	452	180	632

Table 1-3: USE OF WEST BANK WATER (mcm/yr)

Users P/C Share		Fresh	Brackish	Total
Palestinian (West Bank)		90	20	110 + 8*
Israeli	303 (Mtn) 35 (Eastern)			
	Sub-total	338	184 (estimated)	522
Total		428	204	632

Note: Determining the exact amount of available water and the amount of water used on (originating from) the West Bank by both the Palestinians and Israelis is at best a tentative exercise. The above figures are drawn from Baskin (1994) and Assaf et al (1993). A cautionary note is sounded by the latter authors (p. 109), and the wisdom of such a warning is apparent when Baksin's figures are compared internally (as in the above tables). Baskin has done an excellent job of summarizing the water supply and should not be faulted for the differences shown between Table 1-2 and Table 1-3 *vis-à-vis* fresh and brackish water totals. The differences shown by those totals result from assumptions made by the present authors regarding the estimated amount of brackish water used by Israel.

The Azraq oasis northeast of Amman has also been mined to augment Amman's domestic water supply. Its lake and swamp that were once a stopping place on a major migratory bird flyway were dried up and the groundwater level there dropped seriously. The reversal of the situation in 1994 and the regeneration of the oasis is discussed in Chapter 5, but this happy event is a rare one in Jordan's otherwise bleak picture. Altogether, Jordan's main surface-water

supplies from the Yarmouk and other streams amount to about 715 mcm per year with an expected shortfall of 300 mcm by the year 2005 (Kolars, 1992, p. 115).

Lebanon remains reasonably supplied with water. At present an estimated surplus of surface and underground water of over 2,800 mcm exists. However, much of this supply is widely scattered and not easily stored or diverted. A more positive note is that most of its aquifers are quickly renewable given adequate rainfall. Groundwater consumption in 1975—one of the few years for which a record exists—provided 37 per cent of the total amount used. Surface water accounted for 63 per cent (537 mcm). Major rivers have an average flow of 3,700 mcm annually. Of this, 125 mcm reach Israel via the Hasbani. Less appreciated, but nevertheless important, are the waters of the Asi (Orontes) which rise in the Bekaa valley and flow north through Syria and Hatay province, Turkey, to the Mediterranean. Turkey claims that excessive water use in Syria has depleted the Asi to the point where severe water shortages are occuring near Antakya in Hatay province. (*See* Kolars, 1992a).

Syria's situation *vis-à-vis* its water supply remains open to interpretation. Its position between the Jordan basin and better watered Turkey makes it a key geographical link between the core and the periphery. The country is sometimes listed as being rich in water (Falkenmark and Widstrand, 1989), but such comments are based on Syria's large and assured share of the Euphrates river as well as some portion of the Tigris. Its other streams are of relatively little significance.

The Euphrates rises in Turkey where it receives surface flow equaling 88 per cent of the total entering Syria ($29{,}442 \times 10^9$ m^3/yr). Another 12 per cent ($4{,}015 \times 10^6$ m^3/yr) enters the main stream by way of the Balikh, Sajur, and Khabour rivers in Syria. The latter streams, however, receive almost all of their flow from springs whose catchments are in Turkish territory. Therefore, as much as 98 per cent of the Euphrates ($32{,}788 \times 10^6$ m^3/yr) may be subject to upstream withdrawals. The Tigris, of which an estimated 48 per cent (18.3×10^9 m^3/yr) originates in Turkey touches Syria for a scant 39 km in the north-east of the country where it forms the border with Turkey and Iraq. As the central of the three riparians on both rivers, Syria has much to gain or lose in the ongoing negotiations regarding the use of

these waters, for both Turkey and Iraq have made large claims upon them (Kolars and Mitchell, 1991, Chap. 6).

The show piece of Syrian hydro-development is the Tabqa or Ath-Thawrah Dam on the Euphrates river. Originally intended to supply as much as 60 per cent of Syrian electricity, the dam has been unable to fulfil its promise as the result of low water levels in Lake Assad (its reservoir) resulting from both drought years and upstream activity in Turkey (Cotillon, 1993).

Smaller streams supply the major cities of Syria. The Barada river which serves Damascus has a discharge of 7.4 m^3/sec (233 × 10^6 m^3/yr), and consumption of its waters has already passed supply. Aleppo formerly drew water from the Queik river originating in Turkey, but that source has long since been dried up by removals for irrigation in both countries. The city now depends upon water siphoned from Lake Assad as well as additional well water. The Khabour, mentioned above, has a natural flow of 1.8 bcm per year (56.5 m^3/sec.), but this amount may be significantly reduced by Turkish withdrawals in the catchment area, or increased by return flow from Turkish fields. Its fate remains to be seen.

Syria has recently built a series of small retaining dams on the headwaters of the Yarmouk river, the downstream portions of which it shares with Jordan, and *de facto* with Israel which diverts between 50 and 125 mcm annually into the Sea of Galilee depending upon the extent of winter flooding. Jordan depends upon water from the Yarmouk for its East Ghor canal which sustains irrigated agriculture along the east bank of the Jordan river. The Johnston Plan awarded Jordan 377 mcm, Syria 90 mcm, and Israel 25 mcm of the Yarmouk (Wolf, 1995, p. 47), though this agreement was never officially recognized and has since begun to fray. In any event, the sharing of the Yarmouk's waters must be resolved along with other water issues facing the nations of the Jordan basin.

Syria also uses significant amounts of groundwater. Springs provide slightly more then 2,000 mcm per year while another 3,500 mcm is pumped from relatively shallow wells. Syrian experts have called for exploration and greater use of deep aquifers, but to date little is known about them (Bakour, 1991, 30–3).

Therefore, Syria, though sometimes listed as water rich, faces uncertainties of supply in the years ahead and is inextricably tied to Turkey by the rivers which the countries share. The latter nation is

clearly of vital importance to this study both as a contender for Euphrates waters and as a participant in hydro-diplomacy aimed at supplying water supplements to the core.

Continuing downstream, the twin rivers flow south from Syria through Iraq to their juncture near Qurna in the latter country. Their combined waters form the Shatt al-Arab which flows for another 109 km before entering the gulf east of Bubiyan island. Their volume of 81.9×10^9 m^3 (natural flows: Euphrates = 33,457 mcm; Tigris = 49,200 mcm; Kolars and Mitchell, 1991) rivals that of the Nile at Aswan (84×10^9 m^3).

Like Turkey, Iraq though even further afield, is as intrinsically linked to the problems of water in the Middle East as is Syria. The country is solely dependent upon the combined flows of the Euphrates and Tigris rivers. As indicated above, withdrawals from the Euphrates in Turkey and Syria may significantly reduce the flow of that river into Iraq as well as adding to their pollution. The Tigris river receives 37.6 per cent of its flow directly from Turkey in the main stream. Approximately another 10–12 per cent enters from Turkey via side streams. The remainder enters the left bank from tributaries rising in the Zagros mountains. The waters of the Tigris are reasonably secure from extreme diminution or pollution, but the question of augmenting the flow of the Euphrates remains unresolved, for Iraq feels that it deserves its fair share of the latter river. Syria and Iraq have already agreed that 58 per cent of the Euphrates' flow entering Syria from Turkey will be passed on to Iraq, while 42 per cent can be used in Syria. But the actual volumes involved remain uncertain, in large part due to the high natural variances involved. Just how will the three countries share water in times of severe drought as well as in times of plenty?

A PROLEGOMENON TO HYDRO-POLITICS

Middle Eastern waters fall into three political arenas, those of the Nile basin, those of the Jordan and its tributaries, and those of the Euphrates/Tigris drainages. The waters of a fourth group which originate in Lebanon, the Litani and Orontes (Asi) rivers, are inevitably associated with problems of the Jordan and Euphrates rivers respectively, although each occupies a distinct basin of its own.

We consider the Nile basin, with its ten riparians and the growing

demands of Egypt and Sudan, realistically to fall outside the Mashreq and its problems. Numerous people have suggested transferring water from the Nile at least as far as Gaza. However, as of November 1994, personal observation confirmed that even the water destined for Egyptian projects in the Sinai peninsula has yet to cross the Suez canal. Thus, growing domestic needs in Egypt combined with the awakening expectations of sub-Saharan sharers of Nilotic waters places the topic of their use outside our purview.

The sharing of the trans-boundary waters of the Euphrates and Tigris Rivers among Turkey, Syria and Iraq is inherently complex. The Syrians and the Iraqis claim upwards of two-thirds of the Euphrates flow while the Turks seem inclined to offer one-half. The Tigris seems likely to offer surplus water that might resolve this issue, but while the Turks view the two rivers as occupying a single basin, the Arab states insist that the two basins are separate, and at least the Iraqis invoke a policy of no inter-basin transfers. The Turks feel the need to resolve the uses of the Orontes (Asi) which involve use of its headwaters in the Bekaa in Lebanon, the Ghab project in Syria, and shortages in Hatay province in Turkey.

Nevertheless, the waters of Turkey may possibly offer some respite for the nations of the Mashreq. As we propose, there may well be a time when a reasonable and equitable arrangement between Turkey, Syria and Iraq will allow the movement of water southward into the Mashreq. Technically feasible, economically debatable but possible, political decisions must pave the way for such an outcome.

Until then, the focus of the peace process is upon the core of the Middle East as we have defined it. The resolution of its water supply problems is currently paramount, and it is the principles underlying that situation which we will next address.

NOTES

1. We use the term 'Palestine' to refer to the West Bank and Gaza with no predisposition to the eventual outcome of the Middle East peace talks.
2. The region is sometimes called the Arab Mashreq, or in this case it would be the Arab Mashreq plus Israel. In this discussion it will be referred to as the Mashreq. Although Egypt and the Nile are also considered, they present a separate set of conditions and problems which

involve eight other riparian states in Africa (nine others if a small portion of Eritrea is considered: Burundi, Egypt, Eritrea, Kenya, Rwanda, Sudan, Tanzania, Uganda, Zaire). It is unlikely that agreement among all the Nilotic riparians will come easily even for future sharing of Nile waters within the basin itself, let alone agreeing to inter-basin transfers to the northeast.

3. This term is of relatively new origin. James H. Breasted relates, 'There is no name, either geographical or political, which includes all of this great semicircle . . . For historical purposes, some term designating it is indispensable. In his high school history (Ancient Times) therefore the author suggested the term 'Fertile Crescent'. History teachers have found it instructive and convenient and it is now widely used. *The Conquest of Civilization*, Harper & Brothers Publishers (New York and London: MCMXXIV), note p. 117.
4. The discussion which follows is taken from Bakour and Kolars, 1994, 127–35.
5. The waters of the Nile which reach Egypt from the highlands of Ethiopia and the lakes of central Africa are farther removed in space, therefore in time, and furthermore are less accessible in terms of their political milieu. Therefore, discussion of the Nile basin is of limited scope in this study.
6. These rains were local in nature and resulted in heavy *wadi* flooding from the sides of the valley. They did not represent a basin-wide innundation.

2 Water Problems of the Mashreq: A Political Overview

INTRODUCTION

In the practice and theory of international relations co-operation among sovereign states entails risks as well as opportunities. Heads of state and their advisors generally perceive the risks while third parties, promoting co-operation, emphasize the opportunities. More often than not the views of risk-averse political leaders prevail. Co-operation among states is thus a rare occurrence.

Even when it can be demonstrated by some objective measures that co-operation over the long haul will promote the aggregate welfare of the participating parties more than an absence of co-operation, it is still likely that party leaders will reject co-operation because of short-term risks and fears that the other parties will fail to honour their end of the bargain. Co-operative solutions will not be achieved as long as all or most leaders approach negotiations with this mind set. Nevertheless, such negative perceptions on the part of the leaders may be very well-founded.

The possibility of co-operative solutions to the Middle East's growing water crises is subject to the same dynamic. No matter how compelling the 'objective facts', we should not be surprised if co-operation is difficult to achieve. Let us look more closely at the dynamics of co-operation and non-co-operation in the use of international rivers and trans-boundary acquifers.

The benefits of co-operation in river basin development are typically highly asymmetrical. For example, Egypt receives all its water from the Nile river but Zaire's share of the Nile basin is of negligible importance to its overall water balance. Such combinations of asymmetry and multiple bargaining parties (for example, ten sovereign nations, now including Eritrea, share the Nile basin) render voluntary co-operative solutions extremely difficult. When water is the sole focus of negotiations, gains and losses become apparent in a very real

sense. The recognition of such consequences can lead to paralysis and the non-resolution of the collective action dilemma.[1]

However, when progress is achieved, asymmetries in benefits can be so great that one riparian may agree to bear all or most of the cost of a co-operative solution. Such was the case when Egypt financed the construction of the Jebel Aulia storage dam on the White Nile, just upstream of Khartoum in 1932, and of the raising of the Owen Falls dam in Uganda in the early 1950s. Much more recently, on 3 September 1987, Jordan and Syria signed an agreement for the construction of the Wehda dam on the Yarmouk, under which Jordan accepted the full cost of construction and the payment of compensation to those displaced by the project in Syria, and also agreed to give Syria 75 per cent of all power generated at the dam site. This accord has not been implemented, as Israel is not a party to it, and has been superseded by the peace treaty between Jordan and Israel, signed 26 October 1994.

Asymmetries exist across time as well as in relative degrees of dependence on the resource. Supply or quality crises may drive some riparians to seek co-operation as a matter of the highest urgency, while other riparians can afford to wait. Those most pressed must manipulate incentives and disincentives to bring the less-pressed to the bargaining table. In the countries of the core and periphery with which we are concerned the relative degrees of urgency defining the search for a co-operative solution can be displayed in the following manner:

Relative Urgency for a Co-operative Solution

Gaza-Jordan-West Bank-Israel-(Egypt)-Syria-Iraq-Turkey- Lebanon

Present- -Future

Degrees of urgency are determined by differing combinations of variables. For Gaza, existing supplies from aquifers are being used at unsustainable rates while quality is declining rapidly. A remedy needs to be found now. By contrast, Lebanon's major sources of water come from rainfall and the Litani river which lies entirely within its borders. It has no need to import water nor to deal with other riparians, although shortages in the Shi'ite south remain a source of unrest, and as such may serve as an internationally significant destabilizing influence. Jordan is already dealing with a supply and quality crisis. The

West Bank must establish legal claims to some part of its water resources which, depending on Israeli and Jordanian counter-claims, may or may not be adequate to meet anticipated needs. Israel must assure its future supply, and this can be done either through transfers from neighbours or through desalination. Most of Syria's present water use comes from rainfall and small rivers and *wadis*, but much of its projected water demand will depend on the Euphrates and Tigris, both of which require agreements with Turkey. Egypt has a legally guaranteed supply of 55.5 billion m^3, but it has projected additional needs that could be met either through more efficient use of its current supply or increased supply from its upstream neighbours. Year to year variance in the flow of the Nile can still be a problem, as the drought of the 1980s and the 1994 floods demonstrate, although the latter were driven by local rains rather than basin-wide innundation. Iraq is blessed with large amounts of surface waters, but its delivery infrastructure is concentrated on the Euphrates. It would rather have its acquired rights in that river recognized by Turkey than invest in water transfers from the Tigris to the Euphrates. Turkey likewise has abundant surface waters but with one of the largest populations in the region (*ca.* 61 million) and rapidly growing urban centres, it already faces a growing energy shortage the solution to which is associated in part with increased hydro-electric production.

One way out of such asymmetries is through multi-good bargaining. The bargaining agenda is made more complicated so that disparities in the benefits of co-operation with respect to one good can be overcome or at least obscured by deals struck with respect to other goods. These exchanges may be quite straightforward, such as Iraqi oil for 'Turkish' water. Less obvious would be Palestinian recognition of Israel in partial exchange for recognized rights to West Bank water; Syrian control of Kurdish insurgent raids into Turkey in partial exchange for Euphrates water; Israeli technical know-how in water conservation for a part of the water saved (Kally and Tal, 1989); Egyptian good offices in raising external assistance for all states in the Nile basin in exchange for a binding agreement regarding Egypt's water claims.[2]

But what of involuntary solutions? Co-operation can be imposed. International relations theory refers to these as hegemonic solutions. A pattern of resource use is elaborated by the dominant power in the basin and imposed on the others. Colonial powers have been such hegemonies, defining rights and obligations across the jurisdictional

boundaries of their empires. The British devised an imposed regime for all of the Nile basin (although Ethiopia was never fully integrated into it) as did the Soviet Union in the basins of the Amu Darya and Syr Darya. In the region that concerns us here, it can be argued that Israel has imposed a solution in the Jordan basin, that Turkey may be in a position to do so in the Euphrates basin (and to a lesser extent in that of the Tigris), and that Egypt has acted as a quasi-hegemon in the Nile basin.

It will be noted that the three examples cited include an upstream state (Turkey), a mid-stream state (pre-1967 Israel) and a downstream state (Egypt). Although geographical asymmetries are powerful, position in the basin does not therefore fully determine bargaining power. Unsurprisingly, other resources come into play (Naff and Matson, 1984 and Frey, 1992). If position, military power, and economic resources are all joined in one state, its writ will run in the basin. On the other hand, military and economic power may be so concentrated in states in less favourable locations in the basin that they can impose their own solution (Israel) or so that more favourably located states will think twice before tampering with a strong downstream state's 'rights' (Ethiopia in relation to Egypt).

Somewhere between voluntary and involuntary solutions, and potentially associated with both, are induced solutions. This brings a third party into the bargaining process. It may be a superpower interested not so much in the resource issue *per se* but rather in solving it to further some other purpose. In 1972 the Soviet Union sought to reconcile Syria and Iraq, both countries in which the USSR had a large political and military stake, concerning joint use of the Euphrates. In this instance an induced settlement was not achieved. Similarly today, the US continues to promote multilateral talks on water issues among the actors in the Arab-Israeli theatre on the assumption that progress toward a co-operative solution in this domain may create an atmosphere conducive to an overall settlement.

To date the most effective agents of induced co-operation have been multilateral funding institutions, particularly the World Bank. The Bank has tried, to the extent possible, to condition its financing of large hydraulic projects in international river basins on the prior negotiation of co-operative agreements among the riparian states. This policy was successful in the case of the Nile in 1959 but so far has been unsuccessful with respect to Turkey's Southeast Anatolia

Project (Turkish acronym: GAP), where development has gone ahead without an accord and without Bank funding. In the case of the Yarmouk, the World Bank (and the United States Agency for International Development) continue to attempt to induce an accord among Syria, Jordan and Israel.

Co-operative solutions, whether arrived at voluntarily, induced or imposed, are very difficult to achieve, and once achieved, difficult to maintain. Only in the Nile basin have any significant successes been registered.[3] But the recent literature that predicts acute conflict in the absence of co-operation (Starr, Bullock and Darwish, Hamid Sa'id al-Maw'ad) fails to specify the real dangers. It tends to invoke what may be called the Fashoda syndrome, harking back to the famous incident in 1898 in which General Kitchener met Colonel Marchand on the brink of what seemed to be a possible colonial war for control of the headwaters of the Nile. The problem is that it is not at all easy for one riparian in a drainage basin to deprive another of significant amounts of water, and it is not at all easy to define the military goals to be pursued if there is a resort to force. Again, the nature of trans-boundary rivers creates special characteristics of military encounters that they may engender (Biswas, 1982; Gurr, 1985).

First, to deprive another state of the use of an international river, a riparian must be able to cut off or divert the flow of the river. This costs money and may be as disruptive to portions of the population of the state undertaking the action as it is to the inhabitants of the targeted state. Second, the storage facility or diversionary works may be vulnerable to air, artillery or ground attack, although the Geneva conventions and other principles of the conduct of war expressly forbid targeting such works. The authors have not found cases in which they consider the works themselves to be the *casus belli* (ILC, 1991). Finally, water cannot be stored indefinitely without endangering the storage facilities themselves through excessive accumulations of subsequent high water, or conversely the supply's being depleted through seepage and/or evaporation.

For the most part, water disputes in the Middle East have remained below the military level with two exceptions. The first was the Fashoda incident, which was resolved without bloodshed. The second was Israel's attack over the period 1964 to 1966 on the works in Syria that were being undertaken to divert the headwaters of the Jordan. That project was abandoned. However, there have been a number of tense

moments. In 1925, after the assassination of the Sirdar, Lee Stack, by Egyptian nationalists, Britain punished Egypt by allowing Sudan to begin to design the Sennar dam on the Blue Nile and the irrigation grid that was to become the Gezira scheme (Waterbury, 1979, p. 65). The next bellicose incident, aside from the Israeli attacks of 1964–6, came in 1975 when Iraq mobilized for war as Syria began to fill the reservoir upstream of the Thawra (Tabqa) dam.[4] The Arab League intervened to mediate the dispute. After the Camp David accords, there was talk of Nile waters being delivered to Israel's Negev. This elicited a hostile declaration on the part of the Ethiopian government, to which President Sadat responded with a warning that any state that tampered with Egypt's water supply would risk a military response (cited in Rogers, 1991, p. 22). Finally, when Iraq occupied Kuwait in 1990, it is claimed that Lord Owen urged Turkey to restrict the flow of the Euphrates to Iraq. If such advice was given, Turkey did not heed it.

No matter how acute the crises that may emerge in the coming years over water supply in the Middle East, armed conflict is not likely to be an outcome. Unilateral diversions of the Euphrates have taken place in both Syria and Turkey without an effective military response from Iraq. Whatever arrangements emerge from the current negotiations over water in the Jordan basin, no riparian is likely to be able to challenge Israeli hegemony in the foreseeable future, although mitigating circumstances appear to make such a perceived need unnecessary. Only in the Nile basin, where Ethiopia, perhaps a decade or more from now, might divert significant amounts of Blue Nile water for purposes of irrigation, could we see tensions mount.

In the absence of co-operative arrangements, it is likely that various riparians will pursue costly unilateral solutions to their supply problems that will be indisputably sub-optimal in economic terms. Resources will be misallocated within riparian states and across the basins as a whole. New supply-demand equilibria will not be achieved through warfare and seizure of water resources but rather through disruptive adjustments within riparian states. Agricultural production will be re-configured or curtailed, aquifers will be mined, and costly treatment plants installed to salvage or re-utilize a relatively fixed supply of water of deteriorating quality. Still another solution, a more rational regional division of agricultural production, will not be explored.

RE-CONFIGURING AGRICULTURE

The same risk-aversion that characterizes the difficulties in achieving co-operation in the use of international waters also is a hallmark of agricultural policy in the Middle East. Relying on international markets for substantial supplies of food introduces an element of vulnerability that few regional states are willing to accept. Because they have no feasible choice, Israel and Jordan are already far down the path of trading internationally for food. Other countries have rejected economic arguments of comparative advantage and have subsidized the cultivation of many agricultural commodities. These all have a high cost in terms of water. The present demand for water in the Middle East is not primarily driven by growing populations, nor by increasing standards of living, but rather by the so-far unsuccessful efforts undertaken to feed these populations from local production. As Peter Beaumont graphically puts it, if 183 irrigated hectares in Egypt were taken out of production, enough water would be freed up to provide drinking water to a million people for a year (Beaumont, 1994).

The argument here is by no means to put an end to agriculture but to re-configure it. To do so requires that water be assigned a value in the calculation of production costs and rates of return. Both Israel and Jordan have taken modest steps in this direction, but Syria and Egypt have not, and the West Bank and Gaza have not yet been given the chance. Egypt supplies to water its farmers without charge. The real cost of delivery may be \$0.03–0.05/m^3. A hectare of irrigated wheat using 12,000 m^3, would bear water costs of \$360–600, and yield on average four tons of grain. Those four tons could be bought on the international market for \$750 in 1993 prices (Beaumont, 1994). Syria not only subsidizes water but pays wheat farmers a premium over international prices: in recent years between \$360 and \$661 per ton as contrasted with *ca.* \$200 on international markets (Khaldi, 1992). Peter Hazell et al. (1994) have estimated elasticities of demand for agricultural water in Egypt, and show that if a doubling of price from 5 piastres to 10 piastres per m^3 were made (i.e., from 2 to 4¢) demand for water would decrease by 8 bcm. 'The model utilized in this study shows that if farmers were to pay the full economic price for their water, total water use in agriculture would drop sharply, yet at little cost to agricultural income' (Hazell et al, 1994, p. 19).

Considering water a factor of production like land, labour, capital, and technology would enhance efficiency in its use and force a search for those agricultural products that yield the highest return. It is equally true that such a consideration would lead to the abandonment of some kinds of agriculture that are water-intensive and of low market value. It would limit land reclamation projects to those that reliably produce high-value crops proximate to their markets.

There are several factors that militate against such a re-configuration. We have already noted that the principle of acquired rights in the use of international water courses provides no incentive to conserve water nor to use it more efficiently. Second, the agrarian sectors of the societies under consideration have all nurtured vested interests over time. The most powerful politically may be the most recent in terms of their control of agricultural assets. Private commercial farmers in Egypt's reclaimed areas, coupled with the four million or so farm families in the old lands, while not themselves allied, must be taken into account in any calculus of the political costs of re-configuration. Similarly, several highly placed Jordanians have important stakes in the East Ghor project that would make unlikely any attempt to pass on the operating costs of the canal to the beneficiaries. Although its symbolic importance appears to be receding, the *kibbutz* movement in Israel, so central to the notion of constructing the new Zionist society, still exercises some claims to special treatment in terms of subsidies. Finally, Syria's Ba'ath party regime is often depicted as relying on a small holder, peasant base, which in turn may explain the political attractiveness of subsidizing small holder farming through free water and high farm gate purchase prices.

None of these constraints, even in combination, is insurmountable. Agrarian lobbies are neither well organized nor more significant politically than urban populations. The argument that Islam forbids the appropriation and sale of water is not convincing in that the right to use water can be, and is, appropriated and water sold throughout the Middle East. Egyptians may be much less familiar with water sales than Jordanians or Palestinians, but it is doubtful that exacting some sort of charge for water delivery would provoke a religiously-inspired backlash.

THE ROLE OF LAW

For co-operation's sake, it is fortunate that few states can adopt consistent legal stances because their geographic positions are themselves varied. For example, Syria is mid-stream on the Euphrates and the Orontes but upstream on the Jordan. The Yarmouk forms part of its boundary with Jordan. Syria may sympathize with Palestinian claims to full control of the surface waters of the West Bank, the bulk of which currently drain into the Israeli coastal aquifer, but Syria itself is the beneficiary of a cross-frontier aquifer (the Ras al-'Ain) which drains from Turkey into northern Syria. Similarly, Turkey controls the headwaters of the Euphrates and the Tigris but is the downstream state in the Orontes (a relatively minor consideration for Turkey given the Orontes' small annual discharge of some 570 mcm).[5] Israel, although it has captured the headwaters of the Jordan (but not of the Yarmouk), is faced with the possibility of giving up that control one day, and therefore cannot take a firm stand for sovereign upstream rights. Moreover, if that principle is extended to the aquifer that drains the West Bank, a future Palestinian state might challenge Israel's acquired rights.

In the Middle East and elsewhere, international law comes into play mainly to sustain bargaining positions already adopted by contending parties. On the one hand, we have the discredited but still invoked Harmon Doctrine laid down by the US Attorney General Judson Harmon in 1895. He opined that there were no principles of international law that would oblige the US to take into consideration Mexico's needs with respect to the Rio Grande. He continued that any concessions the US might make to those needs would be based on 'comity' rather than international law and thus would not constitute a legal precedent. On the other hand the concept of the community of basin interests, with an attendant right of any riparian to block unilateral actions by any other, is straight-forward but so fraught with the prospect of paralysis that few nations have endorsed it.

The middle ground, where most states feel most comfortable, is governed by principles that are the difficult to define in operational terms. This ground is defined by the concept of limited territorial sovereignty, itself rooted in the classical injunction *sic utere tuo ut alienum non laedas*: 'thus use what is yours so as not to cause harm to another'. A corollary is that a riparian should make a good faith effort to obtain the acquiescence of other riparians in the basin to water

projects it wishes to undertake, but that these riparians enjoy no legal right of veto. The Lake Lanoux arbitration of 1957 between France and Spain invoked 'the rules of good faith' that enjoin any riparian to take into consideration the interests of other riparians to the extent compatible with the pursuit of its own interests (Michael, 1974, p. 53). In turn the guiding principles of 'good faith' are avoidance of causing appreciable harm to other riparians and the pursuit of equitable or reasonable use.

Herein lies the problem. There are no broadly accepted definitions of what is appreciably harmful, nor equitable and reasonable. In the most important attempt to operationalize these concepts, the Helsinki Rules of 1966 [*see* International Law Association (ILA, 1967), and International Law Commission (ILC, 1979)] lay out eleven principles to guide water use. These range from the social and economic needs of populations, to established patterns of use, to geography. No single principle takes priority over another.

Let us look at some specific Middle Eastern examples. Turkey invokes equity in developing irrigation in the backward region of southeast Anatolia while Iraq invokes appreciable harm to established patterns of use and the need to protect its committed infrastructural and social costs. Who is to choose between the equity aspects of absorbing Soviet Jews into the Israeli economy and the harm that their demand for water may cause Palestinians? Is it 'reasonable' for Egypt to cultivate sugar-cane when Sudan can cultivate it with much less surface water? How does one choose between long-term economic returns and short-term social welfare concerns, or between the welfare of future generations and that of the present?

One may extract or infer from various official reports and newspaper accounts the following principles or interests advanced by Middle Eastern riparians to defend or lay claim to shares of transboundary waters:

a. economic potential, future acreage: Ethiopia, Sudan, Syria, Turkey
b. existing acreage: Egypt, Iraq, Israel
c. existing population: Egypt
d. per capita water availability: Syria, Turkey
e. equity, national security: Egypt, Israel, Lebanon, Turkey[6]
f. Harmon Doctrine: Ethiopia, Israel, Turkey

In the 1991 report of the ILC, the section on the law of the

non-navigational uses of 'international water courses' revisited and extended the Helsinki rules (*see* ILC, 1991, 152–98). However, the report does not break new ground. It condenses but does not modify the eleven guidelines of the ILA Helsinki Rules; it cites the obligation not to cause appreciable harm and the obligation to co-operate, largely if not exclusively through the exchange of data. It sets forth rules of notification of unilateral initiatives, providing a six-month waiting period for replies and protests, and another six-month period of obligatory negotiations. Significantly the report makes no provision for failed negotiations; presumably in the event of failure the initiator is free to proceed, having made a good faith effort to obtain approval.

There have been a few attempts to operationalize various criteria of equitable use and appreciable harm. The most parsimonious is Peter Rogers' in which he applies Baumol's measure of 'super fairness'[7] to international water resources (Rogers, 1991). He successfully determines a 'core'[8] that is dependent on measuring only economic returns to the riparians involved. It does not directly address or quantify issues of security and non-material preferences.

A more elaborate set of measures has been advanced by James Moore (1992) utilizing four variables — population, existing patterns of water utilization (i.e., acquired rights), natural flow, and shares in recharge area. As he notes, there is no standard by which one can weigh the relative importance of these four variables in determining an equitable allocation of the resource, but by weighing them equally he is able to minimize the 'error distance' of a range of solutions from a 50–50 division of the resource.

Finally, Nurit Kliot (1994) tackles the Helsinki Rules' guideline head on, attributing numerical scores to thirteen variables directly or indirectly derived from them. However, like Moore's operationalization, Kliot does not assign weights to the variables and, as suggested above, it is precisely because riparian nations will differ on the relative importance of variables that the Helsinki rules will break down as effective guidelines to co-operative solutions.

There is one distributional principle that has some currency in practice, mainly because it can be measured in both quantitative and qualitative terms. It is that of acquired rights, i.e., prior usage, or the conferral of quasi-property rights to water on the basis of demonstrated use over time.[9] This principle can only be challenged by invoking an allegedly superior need that we will term economic potential.

Whereas acquired rights, both to the waters of rivers and aquifers, are most often invoked by downstream states which first exploited the waters, upstream states, whose claims to water come historically much later, are apt to invoke economic potential. In the periphery of the region with which we are concerned, there are two dyads of states locked in dispute over these principles: Egypt and the Sudan in the Nile basin, and Iraq and Turkey on the Euphrates. The acquired rights of Egypt and Iraq, the downstream states, are based on millennia of demonstrated use. By contrast, the Sudan and Turkey argue that the vast economic potential of their underdeveloped, irrigable regions, between the Blue and White Nile for Sudan, and in southeast Anatolia, generate legitimate claims to water that should supersede or counterbalance acquired rights. Turkey also has resorted to claims of unrestricted territorial sovereignty as embodied in the Harmon Doctrine.

The contrast, however, is not as sharp as indicated above because even the upstream states implicitly acknowledge the power of claims derived from acquired rights, as does Israel which can now cite thirty years of use of the upper Jordan (albeit contested) through the national water carrier and perhaps twenty-five years based on annual abstractions from the Yarmouk, as well as long-term use of the waters of the Yargon Taninim aquifer which descends from the West Bank to the Israeli coastal plain.

The point is that the principle of acquired rights gives any riparian an incentive to increase use and to establish new, water-intensive projects in order to come to the bargaining table with as strong a position as possible. Recall that Sudan's acquired rights, first codified in 1929, were based on the unilateral development of the Gezira over the protests of the Egyptian government.

Similarly, the acquired rights principle provides little incentive to conserve water and to use it more efficiently. If one is able to do more with the same or less amount of water, then the logic of acquired rights is undermined because their normative underpinning is the idea that any reduction in the acquired amounts will have significant welfare costs. Doing more with less suggests that the absolute amounts at stake may not bear directly on welfare, thereby posing the open-ended question as to just what amount is necessary for the population's welfare.

The disincentives to efficiency are particularly important when one

approaches the issue of re-configuring the use of water in agriculture (discussed earlier). However, in the core area increased demand and constraints on supply have created such severe imbalances that the need to conserve has overwhelmed the logic of establishing new use rights through new water-intensive projects. It is, rather, in the periphery that this logic may still prevail.

It is rightly part of folk wisdom that threesomes are particularly unstable groups whether among children, consenting adults, or nations. In the Euphrates, the Jordan, and the Nile basins, the game is played primarily among triads: Turkey, Syria, and Iraq; Jordan, Syria, and Israel; Egypt, Sudan, and Ethiopia. There are disincentives to co-operation among triads, because virtually any combination of two against one can provide a dominant coalition that can impose its solution upon the third. Any member of the triad has an incentive not to commit to co-operation in order to extract the highest possible price for it and will threaten to ally with the other member of the triad if it is denied its price. Once it has committed itself it loses its bargaining leverage unless it threatens to defect. Thus the tendency is for no member of the triad to commit to any other. Only when one of them is as powerful or more powerful than the other two combined can a hegemonic solution be imposed. Turkey approaches that position on the Euphrates, while Israel is hegemonic on the Jordan though only in the purely military sense. Egypt cannot impose its will upon both Sudan and Ethiopia and probably upon neither. Egypt's nightmare is that Sudan and Ethiopia ally in the use of the Blue Nile. Sudan, however, would probably rather bargain with both Egypt and Ethiopia without committing itself to either. One will immediately recognize that Sudan thereby penalizes itself doubly: it denies itself the benefits of tripartite co-operation as well as those of selling its co-operation to one partner.

In sum, no matter how compelling the logic of co-operation, it is most likely to come about through imposition or inducement, not through enlightened voluntary action. Material inducements from outside the arena of conflict can alter the asymmetries that characterize relations among the contending parties. But there is another facet of inducement to which this report directly speaks. We may know the objective facts of a conflict situation: who controls what armed force and of what quality; the geo-strategic givens of the situation; the relative technological capacities of the contending forces, etc. These

constitute a measurable *rapport de forces*. However, how leaders perceive this reality is as important as objective reality. Both history and recent experience may shape how leaders define degrees of vulnerability or of capability. Grievances of the past may be taken as grievances of the present. But crucial variables such as available technology, the changing weights of productive sectors in the economy, fertility, and population growth rates may have changed fundamentally the context in which co-operation is sought.

This means that advocates of alternative dispute resolution are, in the final analysis, concerned with changing the perceptions of the negotiating parties to better reflect new realities and new possibilities. Second track diplomacy cannot change the *rapport de forces*, but it can change how leaders and citizenries perceive what is achievable within a given balance of power (Delli Priscoli, 1992, p. 11). There is no magic here. Co-operation in these terms will not mean that all parties are equal but rather that all parties may improve their well being.

NEEDS-BASED CRITERIA FOR EQUITABLE WATER SHARING SETTLEMENTS

Many of the common initial claims for water rights are based either on geography, i.e., from where a river or aquifer originates and how much of that territory falls within a certain state, or on chronology, i.e. who has been using the water the longest. The extreme positions of either definition have been referred to as 'the doctrine of absolute sovereignty' in the first case, stating that a state has absolute rights to water flowing through its territory, and 'prior appropriation' in the second, that is 'first in time, first in right'.[10]

These conflicting doctrines of geography and chronology clash along all of the international rivers surveyed, with positions usually defined by relative riparian positions. Downstream riparians, such as Iraq and Egypt, often receive less rainfall than their upstream neighbours and therefore have depended on river-water for much longer historically. As a consequence, modern 'rights based' disputes often take the form of upstream riparians such as Ethiopia and Turkey arguing in favour of the doctrine of absolute sovereignty, with downstream riparians taking the position of prior appropriation.

In many water disputes which have been resolved, however, the

paradigms used for negotiations have not been 'rights based'. In agreements between Egypt and Sudan signed in 1929 and 1959, for example, allocations were arrived at on the basis of local needs, primarily of agriculture. Egypt argued for a greater share of the Nile because of its larger population and extensive irrigation works. Current allocations reflect these needs.

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

One pattern which emerges, is that most international water negotiations begin with differing legal interpretations of geography and chronology, and yet, all of the settlement of negotiations regarding the rivers as shown in Table 2-1, with the exception of the Mekong, rely to some extent on a needs based measure for criteria for water allocations. These latter observations suggest potentially useful strategies at the negotiating table.

Table 2-1: CRITERIA FOR WATER ALLOCATIONS

Basin	Criteria
Ganges	Percentage of flow during dry season
Indus	Historic and planned use (for Pakistan) plus geographic allocations
Jordan (Johnston Plan)	Amount of irrigable land within the watershed; countries could then use water how and where they wished, including out of basin
Mekong	Allocations have not been an issue; 'reasonable and equitable use' for the basin defined in detail since 1975
Nile	Acquired rights plus even division of any additional water resulting from development projects

NOTES

1. While excluded from the overall discussion, Egypt and the Nile river are included at this point for purposes of comparative analysis.
2. We list these as examples stated by others, and make no claims as to their alleged authority.
3. Even hegemons are seldom the unitary actors the term implies. Robert Collins (1990) shows how divided British colonial officialdom was in the early 20th century with respect to the Nile. Officials in Uganda, Sudan and Egypt often came to promote 'their country's' interests. The hegemonic solution thus tended to be the result of bargaining among colonial dependencies rather than a blueprint produced in London.
4. The Syrian action coincided with Turkish filling of the Keban reservoir and a year of heavy drought. Both events exacerbated the Syrian/Iraqi situation.
5. The figure given represents flow altered by human activity. Natural flow of the Orontes in Turkish Hatay might be as high as 1,100 mcm/yr but for upstream removals. *See* Kolars, 'Water Resources of the Middle East', p.112. Turkish reports indicate that present flow into Turkey may be far less than the amount given in this discussion.
6. This rubric is not self-evident for Turkey and Lebanon. For the first, the GAP project is both an equity and a security issue in that all the 'neglected' populations of south-east Anatolia are to benefit, but especially the Kurdish populations, parts of which currently constitute a threat to Turkey's internal security. Likewise Lebanon needs to use the Litani to develop the Shi'ite south of the country upon which the future stability of the 'third' Lebanese republic will depend (Kubursi and Amery, 1992).
7. Super fairness obtains when no party to a co-operative solution would prefer to trade its benefits for those of another party. In Roger's application, returns to the use of water, i.e., a single-good bargain, determine the net benefits. It might complicate formalization, but simplify reaching a solution, if the core (in game theoretic terms) were determined in a multi-good bargain.
8. The term 'core' in this case is drawn from economic theory and refers to that area where the preference curves of two or more parties overlap. Within this 'core' no party would want to trade its benefits for those of any of the other parties. This usage should not be confused with the core of periphery and core used throughout this study.
9. Daniel Hillel summarizes the several terms alluding to water rights as follows:
   (1) absolute sovereignty—each state has an unrestrained right to use the water resources within its own territory, (2) riparian rights—every

state along the course of a river has an inherent right to the water of that river, which is not to be diminished or degraded without that state's concurrence, (3) river integrity—all riparians are required to preserve the natural course of the river and utilize it within the natural watershed rather than divert waters out of the basin, (4) historical rights—(i.e., prior rights, authors) a state that had used the resource consistently in the past has the right to continue using it; (5) optimal development (i.e., economic potential, authors)—each river basin should be developed optimally as an integrated hydrological unit (Hillel, 1994, 270).

10. The comments in this section are drawn from Wolf, 1995.

3 Economics, Population and the Environment

Political considerations may seem to be the overwhelming issue in any discussion of Middle Eastern water. However, in the final analysis, economic constraints and possibilities, population growth and changes in levels of living (with accompanying changes in water consumption), and the impact of demand, supply and disposal upon the fragile environments of the region will ultimately determine, far more than politics, the uses of regional water supplies. It is with this in mind that the following comments are presented.

POPULATION: THE EXPLOSION THAT IS NOT

The reader may be momentarily reassured by the title of this section, or may be appalled by the authors' seeming naïveté. We intend neither interpretation. Our point is that the popular phrase, 'the population explosion' is dangerously misleading. An explosion releases its energy in one catastrophic instant. Its survivors pick themselves up and set about restoring order and going on with their lives. Population growth is just the opposite. Its progress is slow at first and its impact difficult to detect. Only as time passes does the devastation resulting from it occur. By that time, little can be done, for even low rates of increase in population which would seem desirable at the beginning result in large increments if the base upon which they are computed is enormous. In this case, the base upon which they are computed far exceeds the carrying capacity of the environment upon which the given population depends.

An analogy between population growth and the famous 'Man in the Iron Mask' would be more accurate. His head was locked in a metal mask as a form of punishment. Though uncomfortable, the situation was at first bearable, but with the passage of time, his beard and hair grew and grew and gradually began to suffocate him. A tiny

increment of growth each day eventually became an overwhelming problem. So too with population in the Mashreq. When all else is said and done, when all the water projects are in place and all the available water delivered and recycled and conserved, when agriculture has completely given way to domestic use, a critical shortage of water for human consumption will persist unless population growth stabilizes.

The relationship between population and water availability in the Mashreq is a direct one. There are three basic uses for fresh (i.e., sweet) water: human consumption and necessary domestic use (i.e., bathing and cleaning[1]), agriculture, and industrial uses. At present, agriculture (i.e., irrigation) accounts for 70 to 90 per cent of all the water consumed in the region. This in turn relates to the perceived need for food security based on irrigated agriculture. It may be argued that with the exception of Turkey (on the periphery) none of the nations in question is self sufficient in food. Even today, every country must import food, and its supply and security is already a matter of continuing activity and negotiation. Despite all manner of problems, the food keeps coming. A total food embargo would be almost impossible to enforce or maintain in today's world. Therefore, we consider the question of food security as moot, and by extension, agree that for the near future there should be sufficient water for domestic and industrial purposes through conservation, recycling, and reasonable decreases in agriculture.[2]

This idea may be further amplified through consideration of conservation. For example, during recent drought years Israel reduced its use of agricultural water by 39 per cent without parallel losses in net agricultural output (Chapter 5). By the same token, it is unlikely that any of the Mashreq countries will develop industries that will become major consumers of water. Pollution from small industrial sources may still pose a problem, but, given the critical nature of the situation, should be quickly controlled.

Nevertheless, while conservation and improved technology (water applications and new drought resistant species) are necessary components of any action plan, in the long term such measures will not suffice. The poor distribution of water resulting from geographical location and/or political inequities still must be resolved. Beyond such solutions, unchecked population growth remains the ultimate threat to water sufficiency. This discussion attempts to lay out in terms of

absolute population growth the dimensions of water consumption, real and pending, for the countries of the Mashreq.

The sobering impact of population growth is made evident in Table 3-1. High and low growth estimates based on 1991 data have been used to compute future populations for Israel, Jordan, the West Bank, and Gaza. Water consumption is then equated with estimated populations. Low water demand shown in the table assumes that urban use grows at current per capita usage; high demand allows 100 cubic metres per capita per year for urban use. The low rate of population growth assumes that one million Israeli immigrants reached Israel by 1993; the high rate assumes that two million immigrants will arrive by the year 2000. Jordan is assumed to have received 300,000 refugees shortly after the Gulf war, the West Bank's low rate of growth assumes no immigration; the high rate assumes 600,000 immigrants between 1995 and 2005. Gaza is assumed to receive no immigration.

Projections of individual nation's growth rates are presented in the table. The critical insight to be gained is what to expect if high rates of growth occur. By the year 2020 Israel can expect an absolute water deficit—that is current annual natural potential minus projected demand—of 800 mcm. The Israelis anticipate meeting this demand through improved technology and intensive sea water desalination. On the other hand, they assert that they cannot relinquish any of the major water sources upon which Israel now depends.

Jordan's deficit could reach 730 mcm in the same period of time. This deficit alone would be double its present total consumption. Desalination cannot serve all the country's needs, for its only contact with the sea is at Aqaba. While the water projects suggested in the second part of this book could satisfy local demands for that port, the cost of pumping water from either Dead Sea desalination plants or from those proposed for Aqaba to Amman and other northern cities would be prohibitive. Thus, the importation of water from the periphery, as suggested in Chapter 7, becomes plausible.

The hydrologic future of Palestine (the West Bank and Gaza) is even less certain. There will be an absolute deficit of 395 mcm without immigration and 525 mcm if the suggested immigration were to take place. Gaza alone will need an additional 60 to 180 mcm by the year 2020, and this assumes that the natural supplies of water there will

Table 3-1: PROJECTED POPULATION AND WATER DEMAND[11]

Entity	Population (millions)	Water Needs Low Demand[a] (mcm/yr)	Water Needs High Demand[a] (mcm/yr)	Low/High Water Deficit[b] (mcm/yr)
		Israel		
1 million immigrants:[c]				
1991	4.80	1800	1800	200/200
2000	6.44	2000	2000	400/400
2020	8.85	2200	2200	600/600
2 million immigrants:[c]				
1991	4.80	1800	1800	200/200
2000	7.46	2100	2100	500/500
2020	10.01	2400	2400	800/800
		Jordan		
300,000 refugees				
1991	3.60	870	980	0/110
2000	4.91	960	1100	90/230
2020	9.76	1300	1600	430/730
		West Bank		
No immigration				
1991	0.90	115	180	0/65
2000	1.21	120	210	5/95
2020	3.67	170	460	25/215
600,000 immigrants[c]				
1991	0.90	115	180	0/65
2000	1.61	125	250	10/135
2020	3.67	170	460	55/345
		Gaza		
1991	0.60	95	140	35/80
2000	0.81	100	160	40/100
2020	1.58	120	240	60/180
		Total Demand—Low Estimates		
		(1 million Israeli, no West Bank immigrants)		
1991		2880	3100	235/455
2000		3180	3470	545/825
2020		3760	4370	1090/1725
		Total Demand—High Estimates		
		(2 million Israeli, 600,000 West Bank immigrants)		
1991		2880	3100	235/455
2000		3285	3610	640/595
2020		3990	4700	1345/2055

remain clean enough to use. Desalination plants may help solve Gaza's problem, as well as the importation of Palestinian water from the West Bank. On the other hand, the West Bank's own needs emphasize the importance of seeking an equitable and lasting solution to the hydrologic needs of the Mashreq.

Another element that must be considered is the rapid rate of urbanization in all the countries of the Middle East including the Mashreq. Table 3-2 illustrates this point. Amman is expected to grow from 1.44 million in 1990 to 2.7 million in 2010; Zarqa from 530 thousand to 999 thousand in the same period (Garber and Salameh, 1992). Tel Aviv may reach 2.28 million by the year 2000, and Damascus may increase from 2 million in 1990 to slightly more than 3 million in the following ten years (UN, *World Urbanization*, 1991). As this urbanization occurs, domestic water needs will increase at an even faster rate. Thus, in the not too distant future, an additional demand will be placed upon existing natural water supplies and the need to appropriate water from the agricultural sector will accelerate.

Table 3-2: PER CENT OF POPULATION IN URBAN AREAS IN MIDDLE EASTERN COUNTRIES 1950 AND 1990

Country/territory	1950	1990
Bahrain	64	83
Egypt	32	44
Gaza	51	94
Iran	27	57
Iraq	35	72
Israel	65	92
Jordan	35	68
Lebanon	23	84
Saudi Arabia	16	77
Syria	31	50
Turkey	21	61
UAE	25	81

Source: Omran and Roudi, 1993, Table 6, p. 20.

It also must be emphasized that there is no guarantee that population will not increase after 2020. That date is only twenty-five years in the future, but attempting to project population growth and water needs beyond that time is unrealistic. What we wish to emphasize is that

an equitable, integrated, long-term as well as short-term planning strategy is critical, not only at this moment, but in the quarter century ahead.

ECONOMIC CONSIDERATIONS

Economics, with the individual as a rational maximizer of satisfaction in a world of relative scarcity, offers a useful paradigm for water conflict analysis. When deciding between several possible water development options, for example, benefit-cost analysis—an economic tool by which all of the future benefits and costs of a project are reduced to a single amount representing the net benefits in current dollars—can help determine which project would be the most beneficial.

Economic theory also provides guidelines for policy options for efficient water distribution. It argues, for example, that only when the price paid for a commodity is a reasonable reflection of the true cost, can market forces work for efficient distribution of the commodity. In the Mideast, as elsewhere, the cost of water to the user is highly subsidized, especially water earmarked for agriculture. The true cost of water would reflect all of the resource development, pumping, treatment and delivery costs of that water, most of which are not passed on to the user. In Israel alone, 20 per cent of the country's energy is used solely to move water from one place to another (Naff and Matson, 1984, 12).

Subsidized water, it is posited, leads to waste in agricultural practices, too little incentive for research and development of conservation techniques and practices, and, finally too much water being allocated to the agricultural sector as opposed to industry. Take away subsidies and allow the price to rise, and market incentives are created for both greater efficiency on the farm and a natural shift of water resources from the agricultural sector to industry, where contribution to GNP per unit of water is usually much higher. Since in each of the geographical areas discussed, between 70 per cent and 90 per cent of water use is allocated for agriculture, the savings in water could be substantial (Wishart, 1990). Thomas Naff has recommended such a shift of 35–40 per cent of agricultural water in both Israel and Jordan.[3]

If the price of water reflects the true costs of its development, and if property rights to water are clear, then a 'water market' can be

established to allow buying and selling, ensuring through the 'invisible hand' of the marketplace that each unit of water is being used most efficiently. Water markets, whether national or international, can provide clear incentives for efficient use and guidelines for trades or transfers. Howe and Easter (1971) have derived the necessary conditions for economically efficient inter-basin water transfers in the United States, and Dinar and Wolf (1992) have discussed international water markets using a hypothetical Nile to Jordan basin transfer as a case-study. Zeitouni et al. (1992) discuss trading water rights in an international context, and Gonzalez and Rubio (1992) show that the amount of water to be transferred between basins in a Spanish case could be reduced if economic factors were considered as opposed to straight extrapolations of need.

Economic analysis may also create a framework for easing regional water tensions. According to Wishart (1990), 'conflicts over water rights are easier to resolve if transaction costs of resolution are lower, and if opportunities exist for improving the efficiency of water use and discovery'. In other words, if it is cheaper for people to co-operate and save water than it is to fight, they would rather co-operate.

Some other considerations which have been used in the past to enhance the potential for economic co-operation between players include:

- Recognizing that while water itself is a finite commodity, and therefore conducive only to zero-sum solutions ('distributive' or 'win-lose', in the language of Alternative Dispute Resolution—ADR), the benefits or welfare, derived from water are variable, and therefore tradable for non-zero-sum ('integrative' or 'win-win') solutions.
- Welfare can be measured basin-wide and among all the co-operating players, so that even when one player's individual welfare is not immediately enhanced by the loss of the resource, the resulting pay-offs of trade should result in the region as a whole being better off.
- Infrastructural considerations can enhance the argument for co-operation, especially when considering the variable aspects inherent to water resources. One or another of the players may have better resources to deal with fluctuating quantity or quality —

more storage potential, or better developed water treatment for example—which can help encourage an alliance.

There are, however, problems inherent in using economic theory as the tool for water conflict analysis—problems which can lead to weaknesses in the economic solutions prescribed. One problem is that water is not a pure economic good. Options to the consumer of most goods include migrating to where it is cheaper or abstaining from it altogether if the price is too high. Given small, neighbouring countries with restricted borders, migration to water sources is not a viable alternative, nor, for more obvious biologic reasons, is abstaining. Presumably, though, the analysis is restricted to water for agriculture where there is ample room for reducing demand before running into such limits.

Another problem with economic analysis is more serious because it has to do with a force much more fundamental than economic theory—that is, national emotions. All the countries on both sides of the Jordan have been built from the farm up and for the agriculturist, whether the *fellah* or the *kibbutznik*, land holds a special mystique, ergo the water serving the land. Both Arabic and Hebrew ideologies are rife with slogans of 'making the desert bloom' and 'nations rooted in their land'. In this context, water invariably becomes the 'life blood' of a nation. One result of this has been a certain leeway granted to agriculture in the area, both political, as noted previously, and economic.

One striking example of water 'diseconomy' is the case of Israeli settlements on the Golan Heights. The twenty-four, mostly agricultural settlements of the Golan have a total population of about 3500. In 1980, approximately 80 per cent of the 50 mcm/yr used by these settlements was pumped up from the Sea of Galilee—a height differential of 600 metres (Davis, 1980, p. 27; Inbar and Maos, 1984, 22). Each cubic metre of water weighs a metric ton. Were the settlers to include the costs of the energy required to lift that much water that high, their crops could not possibly be competitive. But settlements on the Golan heights are viewed as more than a source of agricultural production. They are also outposts, whose presence creates a kind of first line of defence against the Syrians.

This perceived connection between settlements and security holds true throughout the country. As Frey and Naff (1985) write:

Israeli agriculture is not merely an ordinary economic sector. It is linked to the crucial matter of settlements, and settlements are linked to defense and national security.

This is what makes Golan cotton competitive in the eyes of the Israelis. Whether or not the pricing of water will play a role in the ongoing negotiations regarding the Golan Heights remains to be seen.

Economists, especially those from outside the region, who overlook this fundamental aspect of a 'national water ethic' held by each of the countries involved, can be confounded by unanticipated recalcitrance among the players. Cal Burwell, former director of research for the proposed agro-industrial complex (Chapter 6), recently commented that, 'Some of what's valuable to the folks over there just doesn't fit into what our folks would call "good economics".'[4]

Economists increasingly recognize the overpowering non-economic values water users sometime attribute to the water which they utilize and/or need. These may include (Wolf, 1992):

- Political attributes of water, e.g., perceived past injustices, national pride
- Co-operation *per se* (e.g., the World Bank does not include international co-operation as a benefit in benefit/cost analyses (Olivares, 1986)
- Physical security
- Perceptions of beauty in the environment
- The 'land ethic'—inherent value of 'non-economic' species and landscapes
- Food or water security—the psychological value of control
- Open space

The last item represents a departure from historic economic arguments in the Middle East. In Israel, for example, water has been subsidized for years as a means of promoting population dispersion and food security. These subsidies have diminished somewhat in recent years, as the ministry of agriculture has accepted a more market oriented approach to planning. However, as population continues to soar with natural growth and extensive immigration, the suggestion has been made to increase subsidies once again as a way to preserve open space throughout the extensive developments.[5]

Additional factors often convolute the possibility for traditionally economic analysis, particularly in an international setting. These

political and institutional constraints to economic co-operation include:

a) Some level of hostility between the players. Hostility can be between basins (e.g.., northern and southern California), between economic sectors (urban versus agricultural users), or, especially, between political entities (e.g., the case of the Turkish Peace Pipeline, Akdogan, 1992; Nile water transfer, Dinar and Wolf, 1992).

b) Property rights (ownership of water) are often unclear and, occasionally, bitterly contested. Although water is internally nationalized in all of the cases discussed in this work, international ownership is often unspecified.

c) State subsidized water often makes the economics of any transfer or trade unclear, as described above.

d) National prestige can be tied up in the population's perception of its water resources, decreasing the apparent desirability of co-operation. National pride in 'Israeli oranges', or 'Egyptian cotton', for example, may preclude a shift to other agricultural products or to industry, even if the former product(s) can be imported at less expense from abroad.

e) Usually, when an inter-basin or international exchange is agreed upon, it is for a specific amount to be delivered annually. Because of treaty or infrastructural limitations (such as pumping, storage, or delivery capacity), the 'solution' is discrete, and cannot be arrived at dynamically. This limits the potential for efficient water market transactions, which often rely on variable solutions (e.g., Lekakis and Giannias, 1992; Zeitouni et al., 1992).

f) Insulation from the total picture can also play its part. Negotiating teams usually include diplomats and engineers whose primary considerations are most often politics and reliable delivery, rather than economic efficiency.

Nevertheless, while recognizing such limitations, one can still use economic analysis as a useful tool to provide guidelines for increasing hydrologic efficiency. Following these guidelines can be crucial, particularly as limits on water supplies are approached. Whereas diseconomies dictated by ideology might be tolerated under conditions of water sufficiency, such diseconomies cannot continue indefinitely, especially with regard to investments under conditions of system shortages (Galnoor, 1978).

THE ENVIRONMENT

While the water supply of a country remains constant unless augmented from external sources or depleted by severe mismanagement, as discussed above, populations will steadily increase in the foreseeable future.[6] At the same time, urbanization and the 'revolution of rising expectations' assure increasing per capita water demands. The demand for more water and the search for it can have severe adverse effects on agricultural lands, forests, fisheries, and even on local communities. Therefore, any attempt to develop water resources inevitably results in some modification of the environment. This, in turn, necessitates 1) recognition of the concepts of sustainable development and resilience, 2) the adoption of a comprehensive viewpoint for planning purposes, and 3) the pursuit of greater efficiencies regarding both water consumption and the development of projects intended to augment water supplies.

In response to this issue, the assessment of the impact of water development projects on the environment has come to be recognized as an integral part of planning.[7] Water management agencies almost everywhere are conscious of the need to identify and evaluate the impact of projects on the ecological systems involved, and their many component parts. It must be recognized, however, that assessments of projects that recognize only the negative impacts, and ignore the positive ones are both incomplete and counterproductive. The old adage, 'You can't make omelettes without breaking eggs', certainly applies in this case. For example, the decline in fish stocks in the Mediterranean, so often cited as a negative impact of the High Dam on the Nile river has actually been compensated by later increases in production both in the Mediterranean and in Lake Nasser (Biswas et al., 1993, p. 49).

The situation is further complicated by the fact that while the environmental impact assessment (EIA) process has become mandatory in many industrialized countries, its actual use so far in developing countries has been slowed by the lack of operational methodology appropriate to nations with limited expertise, resources, data, and time. What is needed is the development of new guidelines that can actually be used for planning and water management in those areas. However, the search for such guidelines is often impeded by

inter-ministerial rivalries which inhibit co-ordination and co-operation on an intra-mural level.

The constraints involved in the search for sustainable, environmentally correct water project development cover a broad spectrum of activities. These include:

- Debts and financial deterioration in developing countries.
- Lack of appropriate and consistent policies.
- Delays in the completion of ancillary projects (canals, etc.) after completion of major elements (e.g., dams) which slow the realization of potential benefits.
- Absence of or inadequacy of monitoring, evaluation, and feedbacks at both national and international levels.
- Lack of technical manpower and training facilities.
- Lack of beneficiary participation in planning, implementation, and operation of projects.
- Lack of knowledge, appropriate research, and incentive to use new technologies and approaches.
- Institutional weaknesses and lack of co-ordination between ministries.
- Lack of donor co-ordination which results in conflicting advice.
- Inappropriate or insufficient project development by donor agencies (e.g., irrigation development without drainage or attention to runoff disposal).

In order to meet the needs of planning for sustainable development and to counter the constraints which such a search inevitably encounters, seven sets of concepts or themes have been identified as necessary:

1) The adoption of a comprehensive viewpoint.
2) The promotion of a search for the widest possible range of choice.
3) The recognition of water as an economic good.
4) The use of the river basin as a unit of area in various phases of river management.
5) The involvement of the public in planning and policy making.
6) The assessment of social impacts.
7) The consideration of environmental impacts.

In turn, the review of such environmental impacts must include not only short-term phenomena such as migratory project workers as vectors in the spread of disease, but also long-term environmental consequences. Among the latter are impact on water quality, ground

water, and on soil; the possibility of earthquakes which may result from water impoundment and seepage and/or the risk of dam failures; ground water mining; effects on climate; impact on living organisms and on human health—particularly through water related diseases (N.C. Thanh and Tam, 1990, 10–20).

In considering the natural environment within the Mashreq, little definitive research has taken place. The call for such work is increasing, but planning to date has tended to consider creating infrastructure rather than worrying about the possible negative results of such projects.

This is not a new picture. A visit to the Cedars of Lebanon reveals denuded hillsides stripped of trees, other vegetation and soil, with only what once must have been a sacred grove surviving. The question is, will the 21st century see even more devastating environmental impact, or can the water projects which are planned and anticipated be translated into some form of sustainable development? Such an open situation necessitates a broad approach to the types of environmental deterioration which have already or will soon be taking place in the Mashreq's core and periphery.

Environmentally affected areas or elements (aquifers, ponds, springs, rivers, lakes, etc.) are almost always viewed as isolated phenomena. But such a perspective is misleading. For example, a river considered environmentally has three aspects. There is the river itself and its ecology; there is the inter-action between the river and the immediate area through which it flows (Tenenbaum, 1994), and there is the river's function as a route whereby exchanges take place between widely diverse environments (i.e., from its often cool mountain headwaters to its debouchment—again often—in arid or humid tropical zones) (Dynesius and Nilsson, 1994, p. 753).

Point locations, e.g., isolated oases such as the (Al) Azraq in Jordan can serve the same functions. The Azraq oasis, before its deterioration at human hands, in addition to having its own special ecology and also serving the desert matrix in which it exists, was a major stopping point on an important migratory bird flyway between northern Asia and Africa. Whether or not its recent restoration will restore it to its original condition, including serving the purposes of avian migration, remains to be seen.

An examination of Table 3-3 reveals the diversity and interconnectedness of the impacted and potentially impacted environments of the Mashreq.

Table 3-3: A GEOGRAPHIC SPECTRUM OF EXISTING AND POSSIBLE WATER RELATED ENVIRONMENTAL IMPACTS IN THE MASHREQ

Type of Pollution	Open Sea	Gulf & Inshore	Tidal Zone/ Littoral	Underground Waters Aquifers/ Groundwater
Removals				
Water	XX	XX	XX	Depletions: Saq. Syrian, Jezirah, West Bank, Jordan
Soil	XX	XX	XX	XX
Biota	Over fishing	Over fishing	XX	XX
Additions (Pollution)				
Silt	XX	Northern Gulf	Deltas	XX
Salts	Northern Gulf	Aqaba & return flow Dead zones	Desalination intrusions	Salt water
Heavy metals and Sewage, etc.	XX	Bilges	General: no nesting/ feeding grounds	e.g., Gaza
Inundations	XX	XX	XX	Waterlogging in Saudi Arabian cities
Biota	XX	XX	Bacteria	Bacteria
Visual & Acoustical	XX Oil rigs	Off-shore Desal. plants	Oil spills Flotsam & jetsam	XX

Type of Pollution	Springs & Oases	Rivers & Streams	Lakes & Reservoirs	Playas & Salt Lakes
Removals				
Water	Israeli coastal springs; Azraq Oasis	Euphrates Asi Jordan	Lake Assad	Dead sea

(*Contd.*)

Table 3.3 (contd.)

Soil	XX	Erosion	XX	XX
Biota	Azraq Oasis bird life	possible loss of spawning fish	XX	XX
Additions (Pollution)				
Silt & Sand	Algerian Oases overwhelmed	Euphrates	Lake Ataturk Lake Assad, etc.	XX
Salts	Possible	Euphrates Shatt Al-Arab lower Jordan	Possible	XX
Heavy Metals & Sewage, etc.	Possible	As with above salts	Possible	Possible
Inundations	XX	Runoff into Syrian Jezirah	Sea of Galilee water capacity	Possible Dead sea flooded shorelines
Biota	Bacteria	Schistosomes bacteria	New macro species schistosomes	XX
Visual & Acoustical	Desiccation	XX	Shifting shore line factories	Factories & chemical plants

The continuum of environments is listed along the table's rows, and begins with the open waters of the Mediterranean and the Red seas. These are followed by gulfs and inshore waters and tidal zones and littorals. Underground waters are listed next, including aquifers which often reach seaward beyond the tidal zone as well as appearing as springs and natural oases on land. The famous submarine fresh water springs of the Gulf, which in recent years have ceased to flow because of excessive pumping on shore, are an example of the former. Groundwater, *per se*, is closely connected both to surface seepage and flow to and from aquifers. Rivers and streams, lakes and reservoirs follow logically, as do playas and salt lakes (e.g., the Dead sea).

The columns of this table follow a similar pattern. In the final analysis environmental deterioration results from the addition or removal of substances at a rate beyond the capacity of the existing

natural system to replace, or integrate, or neutralize them. Thus, removal as a general category includes water depletions or subtractions, erosion of soil and nutrients, and the destruction or diversion of biota, both flora and fauna. Pollution, conversely, means the deposition of water borne silt or wind blown materials such as salts, the precipitating of salts on irrigated lands, or the introduction of dissolved materials into nearby streams. Heavy metals and artificial contaminants such as DDT, PCBs, and petroleum derivatives also constitute polluting additions. Introduced biota represent a special category whether they are microscopic (e.g., bacteria and schistosomes) or unwanted macro-species (rabbits to Australia, zebra mussels to the Great Lakes).

Inundation as well as temporary flooding either by polluted or clean waters can also be destructive (Tenenbaum, 1994). Finally, visual and acoustical pollution can become serious problems if they destroy the tourism potential of an area, or adversely affect local residents (desalination plants near tourist beaches).

Table 3-3 shows a number of such examples. Certain cells are marked where the possibility of environmental deterioration exists. The reader undoubtedly can supply numerous additional examples.

Removals from the open seas include over-fishing and the diminishing of nutrients (a result of their entrapment in the silts of upstream reservoirs), and thereafter, the depletion of fish stocks. Additions include oil tanker spills and the flushing of bilges.[8] Another example of pollution, although the water involved may be of reasonably good quality, is the waterlogging of areas of Riyadh through excessive application of irrigation water. On the other hand, the excessive removal of water for irrigation may seriously deplete the Euphrates river in the near future. Even the Dead sea, as this text indicates elsewhere, is either perilously low, or in future danger of over-filling, depending upon the viewpoint of the observer.

Thus, the environmental assessments of a Med-Dead or Red-Dead canal need to be complete and rigorous (Wolf, 1992). The Aqaba pumped-storage scheme will have less environmental impact if a wastewater treatment system is incorporated into the regional development plan. But the environmental dangers in this case would come not only directly from the movement of saltwater through fragile desert eco-systems and unregulated return flow to the Gulf of Aqaba, but also indirectly, from population moving to sites offering new

opportunities and the impact of the infrastructure necessary to serve such groups.

The major environmental concerns with desalination have to do with the waste heat and air pollution in energy generation. Appropriate methods for disposing of the brine, which is an inevitable by-product of the process and which can be a hazard to delicate marine eco-systems, must also be considered. No serious consideration of controlling related air pollution has come to the attention of these authors.[9]

Another issue which should be raised with large-scale reliance on desalination is the question of coastal aesthetics. Most large-scale desalination plants currently produce to the tune of 20,000–40,000 m^3/day of sweet water. If Israel were to try to de-salt 400 mcm/yr., as some have suggested, this would require between 27 and 55 large-scale plants. At perhaps 1/2 kilometre of coast necessary for each plant, this would require dedicating between 13 and 27 kilometres of prime coastal land to nothing but desalination. The visual impact of such plants as viewed from pristine, recreational beaches might have a deleterious effect upon the tourism potential of the coast.

Other hazards relate to the possible Med-Dead or Red-Dead canal schemes. These include the unknown consequences of mixing water from two chemically distinct sources and what chemical reactions and precipitates may result (Ross, 1983). Questions like these will have to be answered before the Dead sea project's implementation. This list might be extended into volumes, but our intention here is to emphasize the necessity of maintaining a holistic point of view during the planning process.

CONCLUSIONS

This prognostication need not be entirely one of gloom and doom. One clear environmental benefit of a canal project would be the restoration of the Dead sea to its historic level. Without such a project, the Dead sea will continue to shrink and its level drop. Although not much wildlife is affected (except for bacteria, the Dead sea is appropriately named), potash works and health resorts on both shores will continue to contend with the inconvenience and costs of an increasingly distant shoreline. With inflow from either the Mediterranean or the Red sea, the Dead sea would be restored to its historic

level in about twenty years.[10] In another example, the 'Jordan Valley Peace/Salt Drainage Canal' (*see* below) should be designed to protect the fresh water environment and eco-system of the lower Jordan, and be given high priority in the water master plan (shown in Table 3-3).

The deterioration of Jordan's Azraq oasis has been mentioned earlier. The oasis has now been restored to much of its former verdure by means of a reclamation programme recently carried out under the direction of Dr Ghaith Fariz of the University of Jordan. Through careful monitoring of the water supply in Amman, periods of low urban water use have been identified during which reverse pumping from the city to the oasis helps create equilibrium between the two areas. But even when positive steps are taken, the need for vigilance regarding the environment remains important. The question persists, can such restoration endure in the face of long-term population growth?

The true import of this chapter's discussion will become apparent only as planners, diplomats, and engineers attempt to forge a lasting, equitable, and environmentally sustainable peace. The environment must remain clean and hospitable. Population increase is an *eminence gris* to be dealt with. Economics represent the key that must be fashioned to unlock the door to peace which population and environment define.

NOTES

1. Waste disposal (i.e., human sewage) requires significant amounts of water. In most situations where flush toilets are available potable water from a single domestic system is used. Under ideal circumstances, gray water or salt water would be substituted.
2. This question is undeniably rendered very difficult because of the national perceptions and symbolic behaviour discussed in Chapter 1.
3. Lecture delivered at University of Wisconsin, Madison, in March 1990.
4. Interview, February 1990.
5. Interview, Martin Sherman, Economist, Ministry of Agriculture, Israel, November 1991.
6. A less certain but ominous constraint is the role played by climatic factors such as global warming (*See* Issar, 1995).
7. The following discussion is derived from Biswas, 1993.
8. It should be noted, that the Mediterranean Sea and the Arabian/Persian Gulf are natural waste traps where inflowing surface currents which

compensate for high evaporation from the enclosed bodies of water carry in all manner of detritus (e.g., tar balls and styrofoam cigarette filters) which is trapped by the lack of return surface currents.

9. The closure and depth of the Dead Sea valley may form a natural atmospheric trap. The possibility of this should be investigated along with other environmental impasse questions.
10. The amount of inflow would then be pared back to equal the natural evaporation rate.
11. a. Projections assume constant demand for agriculture growth to come through technology; low demand assumes urban use grows at current per capita usage; high demand allows 100 cubic metres per capita for urban use.

    b. Projected deficit equals annual natural potential minus projected demand.

    c. Assumes 1 million immigrants to Israel by 1993, 2 million by 2000; Palestinian immigration is assumed to be between 1995 and 2005, all to the West Bank.