STRATEGIC OPTIONS FOR ALLEVIATING CONFLICTS OVER WATER IN DRY AREAS

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Strategic Options for Alleviating Conflicts over Water in Dry Areas

Professor Adel El-Beltagy

I would like to thank Crawford Fund for giving me the opportunity to be with you today and to speak about the very source of our life—water, which, unfortunately, is also a cause of conflict. This meeting is especially timely because the Middle East, an important part of the West Asia and North Africa (WANA) region, is currently undergoing the huge challenge of making the peace process successful. In the late 1980s and early 1990s several visionaries predicted conflicts over water in this region. They were not entirely wrong, because tension prevails in several parts of the region over sharing water resources. On the other hand, we are witnessing unprecedented will and momentum among the people of the region to establish peace. Although 'land for peace' is what we hear repeatedly as the basis for a solution, sharing the water resources, by implication, is an important element in the peace process. We need to mend our ways to address the 'thirst-driven unrest', where it exists, and keep water as the essence of life and a vehicle for peace, not war. In this context, let me quote from the May 1993 issue of *National Geographic*: 'If there is political will for peace, water will not be a hindrance. If you want reasons to fight, water will give you ample opportunities.'

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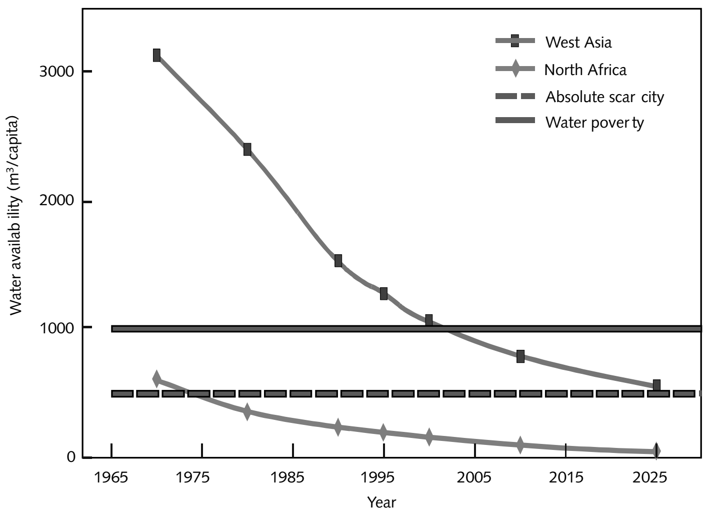
Water Scarcity in Dry Areas

Water in the Middle East has shaped up some of the greatest civilisations in the history of mankind along the Tigris, the Euphrates and the Nile. Over the years water has always played a crucial role in the development and stability of this region. The demand for water, however, has increased with ever-growing population and economic development. Currently, water is the scarcest natural resource in the region.

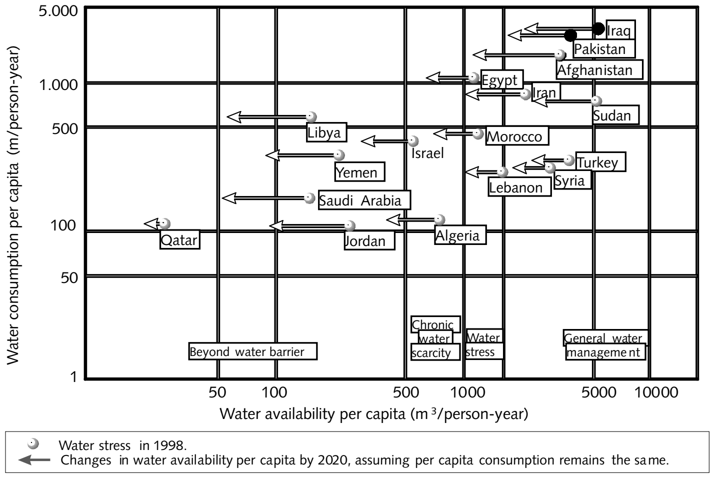
The World Resources Institute (1999) has compiled important data on water resources in the dry areas of WANA. The average annual per capita renewable supplies of water in WANA countries is now below 1500 cubic metres (m^3), well below the world average of about 7000 m^3. This level has fallen from 3500 m^3 in 1960 and is expected to fall to less than 700 m^3 by the year 2025. In 1990 only 8 of the 23 WANA countries had per capita water availability of more than 1000 m^3, the threshold for water poverty level. In fact 1000 m^3 level looks ample for countries like Jordan, where the annual per capita share has dropped to less than 200 m^3 (Margat and Vallae 1999). Mining groundwater is now a common practice in the region, which puts at risk both water reserves and quality. In many countries securing basic human water needs for domestic use is a major issue, as well for agriculture, industry and environment.

Figure 1. Projec tion of water availabil ity per capita (Shiklomanov 1998).



The water scarcity situation in WANA is getting worst every day (Figure 1). It is projected that the vast majority of the nineteen WANA countries will reach severe water poverty level by the year 2025; ten of them are already below that level. Over the coming years this situation will worsen with increasing demand, given the fact that the possibility of new supplies is limited (Figure 2). The increasing pressure on this resource will, unless seriously tackled, escalate conflicts and seriously damage the already fragile environment in the region. This is particularly obvious between countries with shared water resources.

Figure 2. Water stress codes for selected Middle Eastern countries (Lonergan & Brooks 1994).



In WANA about one-third of the renewable water supplies are provided by rivers flowing from outside the region. Two-thirds of the Arab people, forming the vast majority of the region, depend on water flowing from outside the Arab countries and about one-fourth live in countries with no perennial water supplies (Ahmad 1996). Under the prevailing conditions, the principle of integrated water resources management is widely accepted as the best way of managing shared water at the basin level. However, considering the importance given to national sovereignty, and the fact that international laws on shared water resources are still inadequate, potential conflicts between two or more countries is a reality.

Water is a vital element in the continued economic development of the dry areas, especially in the Middle East. The current water supplies will not be sufficient for economic growth in all of the countries of the region, with the exception of Turkey and Iran. Water scarcity in this region has already hampered the development in all countries of the Arabian Peninsula, Jordan, Palestinian territories, Egypt, Tunisia and Morocco. Other countries of the region such as Syria, Iraq, Algeria and Lebanon are increasingly affected as water scarcity grows every year. It is therefore essential that substantial changes be made in the way water is managed to help overcome potential conflicts.

It is estimated that nearly one billion people live in the dry areas. About half of the workforce earns its living from agriculture, and water scarcity adds to their misery. An estimated 690 million people presently have an income of less than 2 dollars per day; of

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these, 142 million earn less than one dollar per day (Rodriguez and Thomas 1999). Rural women and children suffer the most from poverty and its social and physical deprivations, which include malnutrition and high rates of infant mortality

Water-Related Issues

Despite its scarcity, water continues to be misused. New technologies have provided tools that enable farmers to extract water at rates far in excess of the recharge. This is depleting aquifers to exhaustion. Desertification or land degradation is another challenge in the dry areas, closely related to water. It has come to the forefront of global concerns, as reflected in a number of international conferences and conventions, most recently the Convention to Combat Desertification. Climatic variation and change, mainly as a result of human activities, is leading to depletion of the vegetative cover, loss of biophysical and economic productivity through exposure of the soil surface to wind erosion and shifting sands, water erosion, salinisation of land and water logging. Although these are global problems, they are especially severe in the dry areas of WANA.

Compounding these problems is the expanding human population. Population growth rates in the dry areas (up to 3.6%) are among the highest in the world. The total population in West Asia and North Africa alone is expected to more than double, approaching 930 million by 2020. This will also affect the amount of food deficit, which depends on water supplies. For example, according to an ICARDA study, the grain gap is projected to increase from 51 million tonnes in 1995 to 109 million tonnes by 2020 in 23 countries of the region (Nordblom and Shomo 1995). This is a conservative estimate that assumes no growth in per capita consumption. Assuming grain would be priced at only 130 dollars per tonne, 109 million tonnes of grain would cost 14.2 billion dollars!

This is not to paint a gloomy picture of the future of the dry areas, but rather to point to the challenges that lie ahead for all of us, and to the amount of effort that is needed to face them successfully.

Water and Food Security

The key to alleviating conflicts on water resources is to secure adequate water supplies to meet basic human needs, which will enhance the wellbeing of all countries of the region. Equitable distribution of water and protection of the environment are very much linked to sustainability of the solutions. There are several options for overcoming the consequences of water scarcity:

New water supplies

There is great potential for benefiting from non-conventional water resources. Desalination is gaining more importance as advances in the appropriate technologies are made. Desalting technology, such as multi-stage flash distillation and reverse osmosis (RO), has been used in many areas of the world to produce freshwater by removing the salts and other impurities from marine and marginal-quality waters. The RO technology, the most promising and widely used one, has been documented in various publications and its use has been demonstrated in many locations worldwide (Lee 1990).

Desalination is an expensive process, and hence is currently mainly used in areas where an affordable energy source is available. In Saudi Arabia, for instance, there are some thirty water-processing stations of various sizes, scattered over the country, and using different processes. The total production of fresh water may reach up to 913 billion m^3 annually for some18 million inhabitants. In the United Arab Emirates, desalinated water is expected to increase from 318.8 million m^3 in 1995, which is 12.5% of the total desalinated water in the world for that year to 1,223 million m^3 by 2025. The situation is similar in other Gulf countries such as Kuwait, Bahrain, Qatar, and Oman. In these countries part of the desalinated water is actually used for irrigation. The cost ranges between US$1.00–1.80 per m^3 to desalinate seawater as compared to about US$0.16 per m^3 for water available from conventional sources (Karajeh 2000). Desalination can become an economically feasible method, particularly with the development of new technologies, which can possibly make use of natural gas as a source of energy. Reduction in the cost of desalination would open up great opportunities for several countries of the region. However, our aspirations for a breakthrough in the desalination technology are hampered by lack of funds to support research in this field.

Rainwater harvesting provides opportunities for decentralised community-based management of water resources (World Water Vision 2000). Hundreds of billions of cubic metres of rainwater in the drier environments are lost every year. This loss occurs mostly in the marginal lands, which occupy a major part of the dry areas, and occurs mainly through lack of proper management. The development of water harvesting systems in these areas can save substantial amounts of water that is otherwise lost. ICARDA has demonstrated that over 50% of this water can be captured and utilised for agricultural production if integrated on-farm water-use techniques are implemented properly (Oweis et al. 1999). However, issues of policies and socioeconomic aspects require special attention for achieving greater success.

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Developing marginal-quality water resources

The development and use of non-conventional water resources offers great promise. Potential sources include natural brackish water, agricultural drainage water, and treated effluent. Research shows that substantial amounts of brackish water exists in dry areas that can either be utilised directly in agriculture or desalinated at low cost for human and industrial consumption. The treated effluent is an important source of water for agriculture in areas of extreme scarcity, such as Jordan and Tunisia (El-Beltagy et al. 1997). It is, however, a great environmental issue in other countries.

In Jordan, treated effluent annually available for agriculture use is expected to increase from currently 87 million m^3 to 140 million m^3 by the year 2010, which is15% of the current total water supply in the country (Garber and Salameh 1992). In Yemen, available quantities of treated wastewater are growing rapidly. It is estimated that approximately 55 million m^3 per annum could be available for beneficial use, forming about 3% of the current irrigation needs for the country. Egypt is currently adding about 1.2 billion m^3 per year of recycled water from the city of Cairo to the total available water resources in the country; and it is predicted to increase to 1.93 billion m^3 by 2010 from Cairo, and to 4.9 billion m^3 year in the country as whole, amounting to over 8% of the total current Nile water supply to Egypt (El-Beltagy et al. 1997).

Nowadays, the proper reuse of drainage water in agricultural production is becoming an appealing option to many countries. This is not only to protect natural resources from deterioration, but also to make a new non-conventional water resource available for agriculture to irrigate salt tolerant crops, euhalophytic trees and herbaceous species. In the last two decades, the reuse of drainage water in agriculture and its impacts on the environment have become the focus of research scientists in many parts of the world, particularly in dry areas, such as California, Egypt, Jordan, India and Pakistan. (El-Beltagy 1993).

In Egypt, for example, officially reported annual reuse of drainage water increased from 2.6 billion m^3 per year in the 1980s to about 4.2 billion m^3 per year in the early 1990s. Two new projects, the El Ummum Drain and the Salam Canal, when established, will bring the total reused drainage water in the Nile Delta to approximately 7.2 billion m^3 per year, which is 13.5% of the 55.5 billion m^3 total current Nile water supply to Egypt (Karajeh 2000).

Water transfers

Major water transfers between water basins and across national borders have been extensively discussed in the region over the last two decades (Kally 1994). Importation of water is being actively considered in the Middle East. The two options most relevant involve transportation by pipeline (Turkey's proposed peace pipeline) and by ship or barrage (big tanks or 'Medusa' bags). Both suggestions are subjected to economical, political, and environmental measures, which are yet to be examined within the context of a peace treaty (Lonergan and Brooks 1994). In the WANA region, attempts to transfer water by balloons and tankers have been made, but the cost is still too high for agricultural purposes. The project to transfer water by pipelines from Turkey to the Middle East countries was unsuccessful because of economical and political reasons. The potential for such projects can only be realised with good regional cooperation and trust between the various parties. As water scarcity in the region grows, the issues associated with cross-boundary water resources become urgent and require solutions. Internationally agreed laws and code of ethics need to be developed to ensure water rights and to open the way for innovative projects in the region.

Improving water management

The effective management of water could become a vehicle for collaboration as much as its absence could be a source of conflict. Improved water management involves all sectors, but since agriculture is the main user of water, any success in this sector will have the greatest impact on the total water situation. It is, however, a complex matter and involves social, economic, organisational and policy issues in as well as the technical ones. I will focus on this option as it has substantial potential for balancing the demand and supply of water and is less constrained by sociopolitical issues.

Effective Water Management

Agriculture is the major consumer of water in the WANA region. Currently over 75% of the total water resources are used to produce food but, with fast growing population and improvement in living standards, more water is diverted to high priority sectors such as domestic and industry, leaving less water for agriculture. Ironically, as water for agriculture is declining, more food is needed. This can only be achieved by increasing the water-use efficiency (mass of agriculture products per unit water used). Is this achievable? Research at ICARDA and other institutes has demonstrated that proper management can more than double the return from water (Oweis 1997). One cannot but mention the impact achieved by the green revolution on water savings by developing cultivars, which doubled the yield using the same amount of water. Other examples are available about the benefits from the proper management of water and cropping systems (Drek 1994). The following measures are the major contributors to improved water management.

Water cost-recovery

There is little incentive to farmers to restrict their use of water or to spend money on new technologies to improve the use of available water.

Although water is extremely valuable and essential in this region, it is generally supplied free or at low and highly subsidised cost (Cosgrove and Rijsberman 2000). There is, therefore, little incentive to farmers to restrict their use of water or to spend money on new technologies to improve the use of available water. International agencies, donors and research institutes are launching a huge campaign to adopt a pricing scheme for water services based on total operational costs. Although it is widely accepted in the region that water pricing would improve efficiency and insure better investment levels in water projects, the concept is seriously challenged in many countries of the region.

The reasons are mostly sociopolitical. Traditionally, water is considered in many countries of the region as God's gift and hence should be free to everyone. Farmers' pressure for subsidised inputs for agriculture makes it difficult for decision-makers to implement water pricing. There is also a fear in many countries that once water is established as a market commodity, then prices will be determined by the market where the poor may not be able to buy water, even for domestic needs. Downstream riparian fear that upstream riparian may use international waters as a market commodity in the negotiations on water rights.

One cannot ignore these concerns, as they are real and derived from the societies concerned. With difficulties in pricing water in this region, innovative solutions are very much needed to put a real value on water for improving efficiency. At the same time it is necessary to find ways from within the local culture to protect the right of people to access water for their basic needs. Subsidies to support the poor farmers may be better provided in areas other than water where they do not adversely influence efficiency. On the other hand it can be seen that in countries with increasing water scarcity there is a tendency to recover the running costs of operation and maintenance of the irrigation supply systems.

Also, the need to shift the approach, from supply to demand and to deal with water-resource problems is not just a Middle Eastern issue, it is a worldwide problem. The traditional strategy of responding to water shortages by increasing water supplies through capital-intensive water transfer or diversion projects has clearly reached its financial, legal and environmental limits.

Attention must now shift from development to management (El-Ashry 1991).

Improved technologies

It has been claimed that existing technologies may at least double the amount of food produced from present levels of water use, if applied in the field (Drek 1994). Implementing precision irrigation, such as trickle and sprinkler systems, laser levelling and other techniques contribute to substantial water savings and improve water productivity. Along with the development of technologies to capture new water such as water harvesting techniques or to improve the water productivity of the available resources, policies to implement and transfer these technologies are vital. There is a need to provide farmers with economic alternatives to the practices that lead to wastage of water, and with incentives that can bring about the needed change.

Improved water productivity

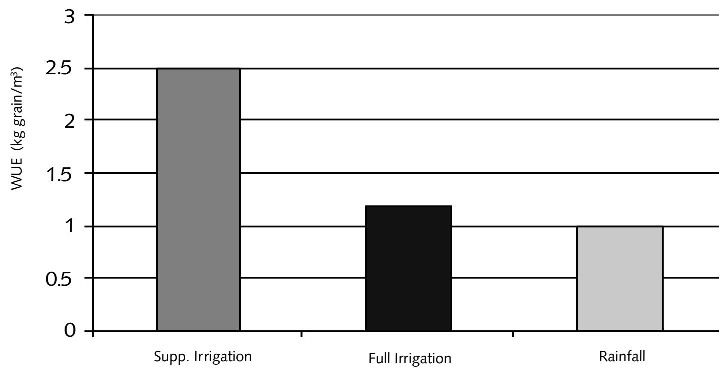
Research at ICARDA has shown that a cubic meter of water can produce several times the current levels of agricultural produce by adopting efficient water management techniques. In supplemental irrigation limited amount of water is applied to rain-fed crops during critical stages resulting in substantial improvement in yield and water-use efficiency (Figure 3). Water application based on deficit irrigation can maximise the return per unit of water rather than per unit of land (Oweis 1997). Application of water to satisfy less than full water requirement of crops was found to increase water productivity and spare water for irrigating new lands. Such strategies are important in the dry areas because water, not land, is the most limiting factor in agricultural production. This situation requires, as scarcity grows, an immediate adjustment to the conventional guidelines of irrigation in this region.

Application of water to satisfy less than full water requirement of crops was found to increase water productivity and spare water for irrigating new lands.

Optimising agribusiness practices and inputs such as selection of appropriate cropping patterns and fertility can also increase the water-use efficiency. Selection of crops should ensure that water used in its production is cost-effective in terms of social and economic considerations. It is, however, a dynamic process since the land-use in this area will be affected by globalisation and the new world trade agreements.

Using both Mendelian breeding techniques and modern genetic engineering, new crop varieties can be developed that can increase the water-use efficiency while maintaining or even increasing the yield levels (Singh and Saxena 1996). For example, through breeding, we have developed winter chickpea and drought-resistant barley varieties that use substantially less water to produce normal or higher yields (Figure 4). More work is needed to integrate all the above-mentioned approaches in

Figure 3. Water use efficiency of supplemental irrigation compared to full irrigation and rainfall in producing wheat grain in Syria (Oweis 1997).

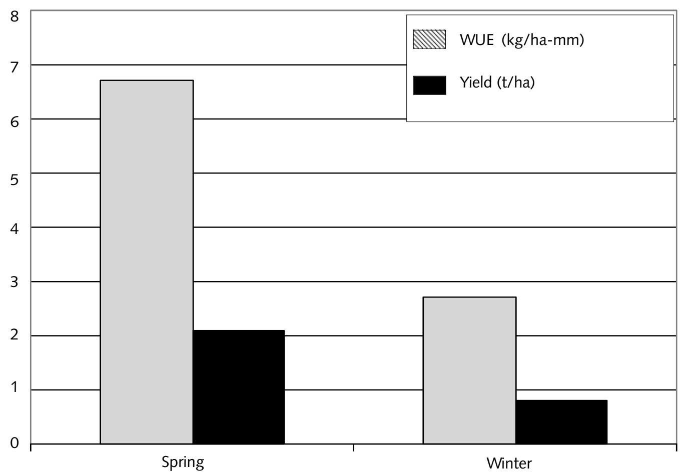


practical packages to achieve the largest return from the limited water available.

Participation of all concerned in the management of scarce water resources is the key to successfully implementing more effective measures of water management.

Participation of all concerned in the management of scarce water resources is the key to successfully implementing more effective measures of water management. Players include public and private sectors but, most importantly, the representatives of

Figure 4. Water use efficiency and grain yield of spring and winter-planted chickpea in Syria (Singh & Saxena 1996).



the users of water, particularly farmers and pastoralists, who should be involved in the decision-making on water management issues. Users cannot, without appropriate policies, achieve the objectives of effective water management. It is widely agreed that lack of proper policies in this region is the main constraint to improved water use.

The Challenge of Change

The world is passing through an exciting time, a time in which social, political, economic and scientific realities are changing, in which a growing recognition of collective responsibility, facilitated by modern information technology, is driving the struggle for change. Our success in the dry areas lies in integrating natural resource management, including water management, with crop improvement, and in developing agricultural systems that will contribute to food security in the dry areas of the developing world.

Fortunately, we now have new science available to us to improve the pace and efficiency of our work on dealing with water scarcity and bridging the knowledge gap. The application of biotechnology/genetic engineering has made it possible to develop crop varieties that produce more with less water. Advances in information technology have placed in our hands computer systems to use as important tools for technology dissemination and precision agro-management. Developments in the implementation of remotely sensed data, GIS, and simulation models are helping us to achieve improved water-use efficiency. We believe that these new tools will go a long way in meeting the objectives of our research to solve the problems associated with water scarcity.

Conclusion

In the 1997 World Water Forum meeting in Marrakesh, Morocco, Anthony Milburn of International Association of Water Quality called for a Blue Revolution in the productivity of fresh water sector to implement Chapter 18 of Agenda 21 (Aiat-Kadi et al. 1997). This vision can only be attained by huge changes in attitudes and behaviours. He stated that now mankind was challenged, through the Blue Revolution, to increase water productivity if humanity was to attain sustainable development and avoid water wars in the future.

The Word Water Council recently established a water vision (World Water Vision 2000): 'Our vision is a world in which all people have access to safe and sufficient water resources to meet their needs, including food, in ways that maintain the integrity of freshwater ecosystems. The vision exercise's ultimate purpose is to generate global awareness of the water crisis that women and men face and of the possible solutions for addressing it. This awareness will lead to the development of new policies and legislative and institutional frameworks. The world's freshwater resources will be managed in an integrated manner at all levels, from the individual to the international, to serve the interests of humankind and planet earth—effectively, efficiently, and equitably.'

'Our vision is a world in which all people have access to safe and sufficient water resources to meet their needs, including food, in ways that maintain the integrity of freshwater ecosystems

Water scarcity is a serious problem in the dry areas of WANA and is a cause for possible conflict, particularly among countries with shared water resources or water basins. The possibilities for an increase in renewable water resources are currently limited, either because the resources have been explored up to their safe-yield potential or because of economic considerations. Breakthroughs in desalination of seawater and brackish water may be achieved with substantial support to research. Major water transfers across basins and national boundaries are constrained by political and economic considerations and require substantial regional cooperation and active international efforts. Reducing water demand by changing the water delivery scheme from a supply- to a demand-driven basis; improving the efficiency of water use through advanced technologies; improved water management; appropriate cropping patterns; improved germplasm; and appropriate cultural practices can play a great role in alleviating conflicts in this region. Supporting research on the management of water under scarcity is vital to achieve this objective through developing new technologies, approaches and solutions to the growing problems.

'Cultivate your world as if you would live forever, and prepare for your hereafter as if you would die tomorrow.'

It is widely accepted that any agreement based on military balance is definitely temporary. The history of conflict over water in the Middle East teaches that water settlement must be a main part of a comprehensive peace agreement based on recognition of the basic rights of the people in the region.

Water, if properly managed, can be a vehicle for peace and regional cooperation and prosperity instead of a source of conflict and wars.

Ismail Serageldin, in his summation report of the 1997 World Water Forum in Marrakesh, Morocco, concluded, (Ait-Kadi et al. 1997) 'Above all, it is the values which we bring to the tasks that will make all the difference… They are values rooted in our common humanity, in the respect of all living things, in our determination to give voice to the voiceless, and to think of future generations and act as true stewards of Earth, which we did not inherit from our parents but borrowed from our children.'

So goes a saying of prophet Mohammed in the Hadith (Al-Azhar 1891): 'Cultivate your world as if you would live forever, and prepare for your hereafter as if you would die tomorrow.'

References

Ait-Kadi, M., Shady, A. and Sozollosi-Nagy, A. (eds.) 1997. Water, the world's common heritage. Proceedings of the First World Water Forum, Marrakesh, Morocco, 21–22 March 1997. The Netherlands, Elsevier Science Ltd.

Ahmad, M. 1996. Sustainable water policies in the Arab region. Paper presented at the Symposium Water and Arab Gulf Development: Problems and Policies. University of Exeter, England.

Al-Azhar 1891. The Hadith, Vol. 4, No. 4, 309–315, 1891.

Biswas, Asit K. (ed.) 1994. International waters of the Middle East: from Euphrates-Tigris to Nile. Bombay, India, Oxford University Press.

Cosgrove, W.J. and Rijsberman, F. (eds.) 2000. World Water Vision: making water everybody's business. London, World Water Council, Earthscan Publications Ltd.

Drek, T.E. 1994. Feeding and greening the world: the role of international agricultural research. The Crawford Fund for International Agricultural Research, CAB International.

El-Ashry, M.T. 1991. Policies for water resource management in semiarid regions. International Journal of Water Resources Development, 7 (4).

El-Beltagy, A. 1993. Capacity building for agricultural water management in Egypt. In: Proceedings of Technical Consultation on Integrated Rural Water Management, Rome FAO.

El-Beltagy, A., Hamdi, Y., El-Gindy, M., Hussein, A. and Abou-Hadid, A. 1997. Dryland farming research in Egypt: strategies for developing a more sustainable agriculture. American Journal of Alternative Agriculture, 12 (3).

Garber, A. and Salameh, E. 1992. Jordan's water resources and their future potential.Proceedings of the Symposium 27–28 October 1991. Amman, Friedrich Ebert Stiftung.

Kally, E. 1994. Cost of inter-regional conveyance of water and costs of sea water desalination. In: Isaac, J. and Shuval, H. (eds). Water and peace in the Middle East. Amsterdam, The Netherlands, Elsevier Science B.V.

Karajeh, F.F. 2000. Use of non-conventional water resources makes a lot of $ense. Proceedings of the 2nd World Water Forum, Special Session on Non-Conventional Water Resources, 17–22 March 2000. (In press).

Lee, E. 1990. Drainage water treatment and disposal options. In: Tanji, K. (ed.). Agriculture salinity assessment and management. New York, American Society of Civil Engineers

Lonergan, S. and Brooks, D.B. (eds.) 1994. Watershed: the role of fresh water in the Israeli-Palestinian conflict. Ottawa, Canada, International Development Research Center (IDRC).

Margat, J. and Vallae, D. 1999. Water resources and uses in the Mediterranean countries: figures and facts. Blue Plan, UNEP-Regional Activity Center.

Nordblom, T. and Shomo, F. 1995. Food and feed prospects to 2020 in West Asia/ North Africa Region. Social Studies Paper No 2. Syria, NRMP, ICARDA.

Oweis, T. 1997. Supplemental irrigation: a highly efficient water-use practice. Aleppo, Syria, ICARDA.

Oweis, T., Hachum, A. and Kijin, J. 1999. Water harvesting and supplemental irrigation for improved water use efficiency in dry areas. Research Paper SWIM 7. Sri Lanka, IWMI.

Oweis, T., Zhang, H. and Pala, M. 2000. Water use efficiency of rainfed and irrigated bread wheat in Mediterranean environment. Agron. J, 92, 231–233.

Rodriguez A. and Thomas, N. 1999. Mapping rural poverty and natural resource constraints in dry Areas. Social Sciences paper No 6. Syria, Natural Resource Management Program, ICARDA.

Seckler, D. 1996. The new era of water resources management; from 'dry' to 'wet' water savings. Sri Lanka, IWMI.

Singh, K.B. and Saxena, M.C. 1996. Winter chickpea in Mediterranean-type environments. Technical bulletin. Aleppo, Syria, ICARDA.

Shiklomanov, I.A. 1998. World water resources: a new appraisal and assessment for the 21st century. Paris, United Nations Educational, Scientific and Cultural Organization.

World Resources Institute 1999. World resources: a guide to the global environment. Special focus on climate change: data on 146 countries. New York, Oxford University Press.

World Water Vision 2000. A water secure world: vision for water, life and the environment. Thanet Press, U.K., World Water Council.