PAPER 9

Management as an Alternative Resource

by

Dr. Remy L. A. de Jong
Associate Professor

University of Petroleum and Minerals
Dhahran, Saudi Arabia

The development of the water sector in the Middle Eastern countries is heavily influenced by several unconventional parameters, such as:

Rapidly-increasing, but not necessarily permanent, municipal demands, caused by burgeoning urban populations and by rising standards of living;

rapidly-increasing agricultural demands, resulting from efforts to attain food self-sufficiency; and

high-priority industrial demands, partly in support of lucrative fossil-fuel production, partly to encourage the diversification of the industrial base.

The natural, replenishable water resources are usually not amenable to substantial enhancement since rainfall, the ultimate renewable resource, is scarce and sporadic. Supplemental water resources, such as desalination, weather modification and water importation, suffer from a combination of handicaps threatening their feasibility from a technical, economic, political or security point of view.

Considerable scope of action is still available to establish a water balance by the introduction, and enforcement, of management techniques covering both supply and demand factors. Success of these measures will depend on political will and public awareness, as well as on financial resources. Multiobjective analysis appears to offer local decision-makers a reasonably scientific approach to optimize the use of available resources.

INTRODUCTION

The Middle East has seen rapid, recent economic growth and development based on the exploitation of fossil-fuel resources; this has brought in its wake the need for many other amenities, resources and support facilities. Among these the water engineer will quickly recognize those items which contributed to increased water demands:

The importance of human resources to supplement the technology required for energy exploitation projects;

the surge in the standard of living, particularly in the urban areas, which was an inevitable consequence of the monetary benefits accruing to the oil-rich nations;

the direct or primary water requirements of the oil industry and of its support facilities, all of which are being accorded high priority; and the indirect or secondary water requirements of a wide range of agricultural and industrial entities which were established and subsidized with the aim of converting the oil-income into a more comprehensive commercial self-sufficiency.

All of the above factors have put added pressure on water managers to develop new resources, either by increasing existing production, or by exploring the feasibility of new and unconventional avenues.

The need to make choices among various supply modes, all of which possess some inherent drawbacks, is beginning to shift the focus towards modifying the needs, or towards "demand management".

The following discussion reviews the scope of available resources on the Arabian Peninsula and it illustrates how management techniques are being perceived.

CONVENTIONAL RESOURCES

From a hydrological point of view certain water resources may be classified as conventional, since such waters may be made available for beneficial use with only minor modifications of the hydrologic cycle. The role of those resources on the Arabian Peninsula is discussed below.

Surface water

In the Southwestern portion of the Peninsula farmers have traditionally used flood flows for irrigation and terraced fields line the banks of many wadis in the Yemens and in Saudi Arabia. In Oman and the U.A.E. several wadis are capable of maintaining measureable flows during substantial portions of the year, thereby at least supplementing other resources. Surface-water storage and direct use has been accomplished (eg, Abha, Saudi Arabia) or is being studied (eg, Sanaa, N.Yemen and Muscat, Oman).

Shallow groundwater

This resource is taken here as to include all recharging aquifers, such as the alluvial sands and gravels in wadi beds, or the outcrop areas of major aquifer systems where precipitation is adequate to overcome the combined handicaps of evaportation and run-off to desert or sea. In this connection reference should be made to scattered lenses of fresh water occurring in the U.A.E. and Qatar, which are believed to have their origins in recent precipitation (Pike, 1983).

Quantification of this resource is rather difficult in the absence of a comprehensive system of observation wells; on the basis of earlier work in the U.A.E. (de Jong, 1980), Qatar (Pike, 1982) and Saudi Arabia (M.O.P., 1980), the order of magnitude for the Peninsula may be estimated at 2000 MCMY (million cubic meters per year).

Deep groundwater

Considerable discussion is being devoted to defining the most desirable role of the water stored in the Peninsula's deep aquifer systems, where the word "deep" refers more to the fact that recharge is negligible than to the distance of the water table below the ground surface. These resources have been described in a regional context (F.A.O., 1980), and their significance is illustrated by their role in water planning in Saudi Arabia. That country's Third Development Plan (M.O.P., 1980) estimates "probable" reserves at 5.65×10^{11} cubic meters and it proposes their exploitation at a rate of

3450 MCMY. It is of interest to note that the same reference stresses the technical and economic limitations on the exploitability of those resources; moreover, in a pre-publication newspaper discussion of the Fourth Development Plan the Saudi Minister of Planning also referred to the need for adopting a more economy-minded approach to future development projects (Nazer, 1983). The exploitation of deep groundwater is likely to present many technical and economical problems (eg temperatures in excess of 70°C, salinities in excess of 3500 mg/l, large pumping lifts, etc) and therefore it is clear that the scope for expanding the use of fossil waters is very narrow.

Of direct relevance to water planning in the Peninsula are the principles underlying the exploitation of fossil resources in general (The Economist, 1984); proceeds should not be consumed, but invested, at the highest rate of return, thereby continuing to earn foreign currency either by encouraging exports or by curtailing imports.

Water planners will be increasingly called upon to maximize the rates of return of undertakings which utilize non-renewable resources.

ALTERNATIVE RESOURCES

The sudden economic development, and the geographic location of the Middle Eastern countries, gave rise to the study and sometimes implementation of unconventional techniques and methods for generating additional water supplies.

Desalination

The desalination of sea-water is now being carried out in at least 25 major plants in the region; the technology is well-established and the fact that most population centres are located in coastal regions made the wide-spread introduction of desalination a logical, temporary choice for providing high-quality drinking water. However, with a few decades of experience the drawbacks are becoming increasingly clear:

In spite of economies of scale the cost of production has not dropped below a level of about US $ 2.- per cubic meter;

the life spans of most plants is between 15 and 20 years and replacement of production facilities will begin to put additional pressures on less-abundant financial resources;

the vulnerability to interruption of production due to oil slicks in the vicinity of the intakes has been illustrated in the Gulf;

concern has been growing about the possibility of vulnerable plants being damaged as a result of hostile acts;

the environmental impact of the plants may become significant, salinities of 60,000 mg/l and higher have been observed along the Gulf coast and brine return flows add about 7200 tons of salt per year to the Gulf (Pike, 1982). In this context it should be noted that shrimp normally breed in brackish water with a salinity of about 20,000 mg/l; the combined effects of salt discharges in coastal waters, and of depletion of submarine springs due to abstraction of water from the source aquifers, may have negative effects on the habitat of coastal fish resources.

Therefore, it is clear that desalination is unlikely to continue as a major water resource in the current socio-economic climate.

Importation of icebergs

Numerous studies have been conducted, and some of them present favourable economic conclusions. However, the large investments required, remaining uncertainties, and some technological problems, together with international, political complexities make it unlikely that icebergs will provide a major breakthrough in the near future.

Water transport by ship

Importation of water by tankers, either as backhaul by oil tankers or as a shuttle programme, appears to present only minor technical problems, but the economics have not yet been convincingly demonstrated. Also, the idea of relying on foreign sources for a basic and indispensable resource is not a politically attractive concept.

Wastewater re-use

The re-use of domestic wastewater, after proper collection and treatment, has already become widely accepted, and this resource may receive an added boost from a fairly recent ruling by religious authorities to the effect that there are, in a Moslim society, no religious impediments to the re-use of treated wastewater (Farooq and Ansari, 1981); only stringent quality criteria need to be applied.

Agricultural uses add salts to the water and the salinity of return flows frequently exceeds 4000 mg/l. Research is in progress at the University of Petroleum and Minerals to find ways of direct re-use of agricultural waste-waters without further treatment.

Generally, no major technological problems present themselves, but the cost of collection, treatment and transportation to suitable users has slowed down wider application of re-use techniques. However, Saudi Arabia proposes to derive, by the end of the century, about 23% of its irrigation water from reclaimed urban wastewater (M.O.P., 1980).

Several other potential resources (eg, seawater irrigation, solar distillation, weather modification etc.) are being researched, but major impacts within the next decade are unlikely.

As can be seen, there is some scope for expanding the development of alternative resources to supplement those available by conventional means, but in all cases some drawbacks are present. Therefore, it appears desirable to review the potential for approaching a water balance by demand management, rather than enhancement of the resources.

MANAGEMENT ACTIONS

For the purpose of this discussion the term "management" will be taken to refer to all actions taken to redress the water balance by means of imposing guidance, direction, restrictions and regulations, the result of which is a modification of patterns associated with unrestricted development. Furthermore, it is assumed that, in general, the management approach will pursue the most economic alternatives. The only major exception to this assumption is that water should be supplied to sustain human life, even if it is not economically attractive.

Artificial recharge

Modification of the run-off process or technical management, aimed at enhancing the infiltration of flows into wadi beds has been practiced widely in the Middle East. Frequently retention structures are built to create temporary reservoirs which are allowed to dissipate into the wadi alluvium. From time to time the notion is advanced to stress retardation by means of porous structures, which merely slow down rather than store surface flows, thereby more fully utilizing the infiltration capacity both upstream and downstream of a given damsite (de Jong, 1984).

Demand management by public awareness

There is a large range of simple measures which can be taken to minimize domestic water consumption, but most members of the public are not aware of them until such water-savings techniques have been adequately advertised and explained. A convincing case in point is made by two Arizona cities, only about 150 Km apart in a similar desert setting; in 1981 water use in Phoenix was about 1000 litres per day, whereas in Tucson the comparable figure was 560 litres per day (City of Phoenix, 1982). The City of Tucson is the largest American city totally dependent on groundwater; it has recognized the need for demand management and for several years it has carried on an active public-awareness program. The measures most frequently advocated include the use of simple hardware items designed to cut back water use in showers and toilet fixtures. In addition, there are numerous ways dramatically to reduce consumptive use in the home, by adopting a few new habits, or by changing some old ones (Jordan, 1983). The primary condition for their acceptance and implementation is awareness by the public that water saving is possible, easy and inexpensive.

Demand management by water pricing

An efficient system of water metering, and of enforcing an equitable price structure, has long been recognized as an effective demand management tool. Studies in the U.S.A. indicate that efficient metering and billing generates savings in the 30 to 60% range (ARAMCO, 1983).

Agricultural water conservation

The application of the correct amount of irrigation water requires thorough training and sophisticated equipment. When either condition is not met the farmer tends to err on the side of over-irrigation. Since agriculture is by far the largest water user it also presents the largest potential for savings. In Arizona the management of agricultural-water allotments is based on a Groundwater Code and it involves calculation of a water duty, incorporating required conservation methods with a minimum efficiency of 0.70 (T.A.M.A., 1983).

In the related area of landscaping an awareness of the existence of numerous arid-country plants, coupled with very selective watering practices, has proved to result in dramatic water savings (W.C.O., 1982).

MULTIOBJECTIVE ANALYSIS

The preceding paragraphs have briefly reviewed the range of actions available to redress the balance between water supply and demand, all of those impose certain restrictions and therefore none may be expected to be automatically preferred by decision makers in the water sector. Different combinations of alternative solutions are likely to be required to satisfy different sets of objectives and hence the stage is set for the application of one of several techniques in multi-criteria decision-making, most of which have been discussed in recent textbooks (Goichoechea et al., 1982; Chankong and Haimes, 1983).

One such technique, currently, (in the summer of 1984) is being illustrated at the University of Petroleum and Minerals, using a group of students as simulated "decision makers". Participants are being asked to express their preferences over a range of alternative water-development strategies, each one of which represents a certain mixture of the management techniques discussed earlier. The criteria by which each strategy is judged are:

Safety, the relative assurance of non-interference as a result of breakdowns, hostile acts, lack of supplies or equipment etc;

Autonomy, the extent of independence from external sources for supplies, or for water itself;

Environmental impact, the permanent effects on the local, natural environment;

Financial feasibility, the availability of the investment resources to put a certain strategy into effect; and

Economic feasibility, the value of the economic benefits to be realized from a given water strategy.

The results of this exercise in multiobjective analysis are expected to be available by October 1984.

CONCLUSION

Maintaining a balance between water supply and demand in Middle Eastern countries involves making trade-offs between a large number of techniques or social problems. Decision makers will be expected to evaluate each one of these methods on the basis of suitable criteria, and to fomulate within the relevant framework of time and place a water-development strategy which will satisfy the local objectives in the best possible way.

REFERENCES

ARAMCO, "Aramco long-term strategy for water resources management", Dhahran, 1983, June.

Chankong V. and Y.Y. Haimes, "Multiobjective Decision Making", Elsevier Science Publ. Co., New York, 1983.

City of Phoenix, "A water conscious lifestyle", Public Information Office, Phoenix, 1983.

de Jong R.L., "U.A.E. - Preliminary Water Plan", F.A.O. Technical Report, Rome, 1980.

de Jong R.L., "Geotextiles and geomembranes for rockfill dams; an application in Saudi Arabia", Int. Conf. on Geomembranes, Denver, 1984, June 22.

F.A.O. - Food and Agric. Organ. of the U.N., "Shared Water Resources", Rome, 1981.

Farooq S. and Z.I. Ansari, "Philosophy of water re-use in Islamic perspective", in Desalination, V.39, Amsterdam, 1981.

Goichoechea A. et al., "Multiobjective Decision Analysis with Engineering and Business Applications", Wiley & Sons, New York, 1982.

Jordan A., "Ideas for saving water indoors", Public Information Office, Phoenix, 1983.

M.O.P. - Ministry of Planning, "Third Development Plan, 1980-1985", Riyadh, 1980.

Nazer H.M., "New Era, New Risks", Saudi Gazette, Jeddah, 1983, November 27.

Pike J.G., "The planning of water resources development in an Arabian Gulf State; Qatar, a case study", Journ. Inst. Water Engrs. & Scientists, London, 1982, 36.

Pike J. G., "Groundwater Resources Development and the Environment in the central region of the Arabian Gulf", Int. Journ. of Water Resources Research, 1983, 1.

T.A.M.A. - Tucson Active Management Area, "Water Duty and Water Allotment, Tucson, 1983.

The Economist, London, "When the oil runs out", 1984, June 9.

W.C.O. - Water Conservation Office, "More green per gallon", Phoenix, September 1982.