WATER IN THE ARAB WORLD
Overall Perspectives on Countries and Regions

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ABSTRACT

The match between the supply and demand for water in Arab countries has been unsatisfactory since the middle of the twentieth century and progressively more serious since 1970. The paper provides, first, an overview of the water budgets of the Arab countries of the Middle East and North Africa and of feasible augmentations of supply. Such additional water as has been engineered and managed in the second half of the twentieth century will be even more necessary during the coming decades. Secondly it summarises the history of water allocation and management in the region stressing the shift of emphasis from engineering storage and supply to improving the efficiency of distribution and use.

The paper argues for the urgent adoption of allocative and management practices which will direct water to sound and safe uses which will be economically and environmentally sustainable. Finally the issue of demand management is identified as the approach which will dominate the next decades, serving as the means for water authorities in Arab countries to achieve a measure of balance between supply and demand. It is recognised that the implementation of water allocation policies such as the re-allocation of water from agriculture to municipal and industrial uses and demand management policies, will require major political adjustments. Such adjustments will require that policy is made with the cultural grain of the peoples, rather than against it, taking into account their traditional views on water which are integral to their culture.

Key words: water resources, water allocation, water management, Middle East, North Africa, political economy of water, water and culture.

INTRODUCTION: WATER IN THE ARAB MIDDLE EAST AND NORTH AFRICA

The availability of water has always affected life and livelihoods in the Middle East and North Africa. Throughout history the peoples of this region have been short of water in the summer, except for those living on the banks of major rivers. Huge tracts have been waterless throughout the year. The river valleys, together with the favoured tracts which received winter rains along the Mediterranean coast and on the plains of northern Syria and Iraq, have always been the most popular places to reside. There crop production was developed, as well as the economic and social systems which in turn led to a sequence of civilisations, usually hydraulically based. The rest of the region has been sparsely populated. The economies of these dry tracts made few demands on scarce water resources before the past half century, but their water use has risen since then, especially in the past two decades when new technologies transformed the capacity to lift and move water.

The peoples of the Middle East are remarkable, not so much in the scale of the water shortages which they have faced as in the numerous ways in which they have continuously adjusted to deficiencies in water supply since the days of hunter gatherers. Concern has been expressed since the bronze age about the reliability of water supplies in the Tigris-Euphrates region. In Egypt in the Hyksos period (c. 1600 BC), and in Mameluke Egypt (15th century AD) expeditions were sent to the upper Nile, as they were in the Ottoman period. The British were particularly attentive to Egyptian concerns in the late nineteenth century and in the 1929 Nile Waters Agreement they were able to impose what proved to be unsustainable constraints on their upper Nile colonies in East Africa to refrain from using Nile tributary waters. It is only in the past forty years, however, that ministers, officials and journalists have identified water deficiencies as being of economically strategic significance and have raised the level of regional hydro-paranoia so that it has become a potentially significant de-stabilising element in the affairs of Arab countries.

By concentrating public attention on the growing water gap and de-emphasising the demographic explosion which is its cause, and at the same time being less than frank about the remarkable economic adjustments which national economies have achieved in the recent past, the political leaderships and the region's selectively critical media have slowed the pace at which any understanding of the real status of resources and of the real economic options have been assimilated by leaders and peoples. The measures adopted to date, namely the non-sustainable over-use of water resources and the importation of food, are damaging. In due course they will be abandoned in favour of strategies guided by principles of water demand management.

The present juncture in the region's water management history is particularly interesting because such a thoroughgoing suite of adjustments is required to re-shape water allocation and management policies and practices to meet the economic and political challenges posed by water shortages. To date national leaderships and water managing institutions of the individual countries of the region are unable to provide the necessary inspiration to set new directions and implement new policies at the pace demanded by the growing water resource gaps. New policies would be unpopular and against the interests of key players in the politics and the economies of the region.

Nevertheless, throughout history adjustments to the availability of water have been the rule. The adjustments were initially made to the absolute shortages of seasonal water supplies and were manifested in the location of populations and economic activity in favoured sites; further adjustments were needed as naturally available and engineered water supplies proved inadequate to meet increasing volumes and patterns of demand. These adjustments took the form of the development of new water, but since the early 1970s many countries have been faced with such levels of water shortage that they have had to seek solutions outside the narrow confines of their national water budgets, drawing on their respective larger national economies and ultimately on the international economy. The approach taken in the following discussion will be first to direct attention to:

- the limited availability of water - that is the limited supply.
- the growing demand for water.

Secondly, the paper will show how adjustments have been and will continue to be made:

- by increasing the availability of water as well as moving it to preferred locations by engineering and technological interventions. The analysis will show that this approach will play a decreasing role in future.
- by improving the productivity of water use by delivering water less wastefully and more effectively and particularly by deploying more efficient methods of water utilisation by crops at the point where irrigation water is delivered to the plant. Also by reducing water losses in systems delivering water to domestic and industrial users. This aspect has only been addressed to a limited extent to date in the Middle East and North Africa and will be a major area of focused innovation and investment in future.

Thirdly the analysis will indicate how in future the above methods will be augmented by a suite of new approaches which will enable the peoples of the region to utilise water according to different and more realistic assumptions concerning the value of water and its place in their regional and national economies. At the same time there will be a re-evaluation of its strategic importance as well as of the place of water in their interests internationally. These approaches will include:

- the adoption of principles of allocative efficiency which lead to the utilisation of water first in the economic sectors which bring the best returns to water, that is, in industry and services rather than in agriculture. Secondly water will be used within each sector in the productive activities which generate sound economic returns - for example for crops which command a high price on world markets rather than in crops such as sugar, wheat and rice where other producers have access to free or nearly free water. A more controversial application of the principle would be that of using water in those parts of river basins where water could be used most effectively in contrast with current patterns of use where evaporative and transpirational processes lead to extreme water losses. It is recognised that such arguments are unlikely to gain currency as long as conventional attitudes to resource ownership prevail, and in the almost complete absence of water markets for the water flowing in international river systems. The recent agreement between the Government of Lesotho and the Government of South Africa, where the former has undertaken to sell a secure volume of water to its downstream neighbour is a welcome precedent. (Agreement between Lesotho and South Africa, 1991)

- a number of technological and institutional instruments which together will enable principles of demand management to be integral to the allocation and management of water. The technologies will include monitoring and metering of water use as well as the improvement of distribution systems and water treatment and re-use. Improved institutions will be even more important than new and improved technologies as these will be needed to ensure the effective deployment of both the engineering and the management instruments. The latter will include economic and financial instruments (markets for water), and regulatory and legal frameworks. Such measures will reduce the use of water in municipalities, industries and agriculture so that there will be sufficient safe water to sustain the health as well as diverse and adequate livelihoods for the peoples of the region. Properly approached it will also be possible to ensure that the environment will also be secure and sustainably managed. (Lutz and Munasinghe, 1991; Pearce et al 1989; Pearce and Turner, 1990)

Table 1 shows the major factors which must be considered in the interdisciplinary approach which scientists as well as politicians, both national and international, necessarily must adopt if they are to provide for individual countries and for regions as a whole, systems of water use which will be economically sound, socially and politically acceptable, safe in terms of ensuring health, and environmentally and ecologically sustainable. The political leaderships in the region have not yet adopted the principles implicit in such an approach in all respects, but they have had no option but to adopt a number of them despite appearing in their public statements on food security to claim that they have not. (Allan, 1983) This contradiction has been possible because water is only part of the natural and other resource endowments which make up a national economy. Economies as a whole, sometimes with outside support, have been sufficiently strong to overcome the potential constraints of water deficits.

Economies can substitute for scarce resources in one sector with resources mobilised in other sectors. A crude indicator of the effectiveness of the management and operation of a national economy is its capacity to substitute for a scarce resource. Despite the difficulties which politicians, officials and especially water users in general have with the non-intuitive notion of substituting for water in a national economy, it has in practice proved to be possible to achieve such substitution in a variety of ways, albeit unrecognised, in the Middle East and North Africa .

In the oil rich countries for example, energy resources are used to create fresh water by desalination. But desalination produces only tens of millions of cubic metres of water per year out of the approximately 150 billion cubic metres (150 cubic kilometres) of water used annually by Arab countries, or very much less than one per cent of the total water budget of Arab countries.

The system which has indirectly mobilised massive volumes of water, perhaps five hundred times as much as that produced by desalination, is the familiar device of world trade in food. The author estimates that in the early 1990s fifty cubic kilometres of water per year were imported 'in food' into the region - equivalent to the annual flow of the Nile in Egypt and to about 30 per cent of the region's total annually

available surface water. Such figures show that international economic systems in which the region's public and private enterprises play their part are extremely significant in enabling the peoples of the region to enjoy their 'entitlement to food'. (Sen, 1981) The governments of the region have been particularly successful in achieving the economic and political stability which depends to some extent on their capacity to deliver this entitlement, which is no longer possible on the basis of indigenous water. The collective achievement of Middle Eastern and North African governments in this regard contrasts markedly with the capacity of the governments of other regions, sometimes better endowed environmentally, to provide food entitlements for their peoples.

Table 1 (not supplied as of 8/15/93 on disk; in Word printout)

WATER SUPPLY IN THE MIDDLE EAST AND NORTHERN AFRICA

The water endowment of the countries of the region

It is extremely difficult to draw up a schedule showing the water budgets of the countries of the Middle East and North Africa which would withstand scientific, never mind political, scrutiny. Scientists are aware that many of the data have not been adequately researched, and more important, that heroic assumptions are involved in the estimates of groundwater and especially in that very important part of the water budget for some countries which derives from rainfall. A proportion of such precipitation infiltrates the soil profile and is retained there. Such water, occurring naturally in soil profiles, is amongst the most precious of all renewable natural resources as soil water provides the essential starting point in the food chains present in both natural and agro-ecologies. Naturally occurring water coming as a free good through rainfall is not equally allocated in volume or reliability amongst the countries and populations residing on the Earth's surface. The countries and communities of the Middle East and North Africa have been, and will continue to be, particularly ill-provided.

In addition a high proportion of all rainfall falls on tracts which cannot be cultivated because of the steepness or roughness of the terrain and as a consequence the proportion of rainfall which forms usable reservoirs of soil moisture represents only a tiny proportion of the depth of water naturally precipitated. Of the tens and sometimes hundreds of cubic kilometres of water which falls on each of the countries of the region only fractions of between one and ten per cent ends up in the tissue of vegetation and crops of economic significance. Nor can this position be expected to change significantly in future in that climate change is too difficult to predict (Conway, 1993), and in any event such change would be small compared with other elements on both the supply and the demand side of water budgets in the region.

The element of national water budgets which is most reliably monitored in Arab countries is gross surface run-off. Gross figures of surface run-off can, however, provide misleading impressions of the water security of a country in that the capability of a water resource to provide the basis for economic activity and further economic multiplication depends on a large number of associated geographical and economic variables. It is becoming increasingly clear that successful and economically effective development of such surface resources depends on social and political circumstances as much as on factor endowment. Traditional perceptions and political institutions, both of which evolved in periods of water surpluses, are proving in combination to be a very dangerous inspiration for those allocating and managing water in the contemporary Middle East and North Africa where the problem is how to respond radically and constructively to severe water deficits.

Geography also plays a role but by no means a determining one. The shape of the terrain and the location and seasonality of rainfall and surface run-off have determined, and will continue to determine, whether water can be stored, and together with technology, will determine whether its distribution can be economical. For example, Egypt and the Sudan have few sites to engineer water storage; Ethiopia has many. Some geographies make the use of water difficult in the country where it reaches the surface. For example the springs at the foot of Jebel Sheikh - the Hasbani, the Dan and the Banias, taken by Israel with the rest of the Golan in 1967, were of little use to Syria before 1967 because of their position and elevation. Their waters were for a period, therefore, destined for use by Jordan in the mid-1960s until the project to engineer the water to the Yarmuk River was interrupted by the Israelis. Many countries in the region have water in relatively low lying surface water systems while their main populations prefer to live in high and otherwise more habitable tracts. Jordan's surface water in the Yarmuk and the Jordan rivers, the majority of national water, flows at elevations 1000 metres below its main urban centres; the cost of lifting it the major concentrations of population could be over US$1. per cubic metre. Libya's future water lies 1000 kilometres to the south of its major population zone (Allan, 1989b).

Table 2 provides some estimates of the water resources of the countries of the region. The reliability of the data is limited, but the information offers a perspective on a number of types of water economy. Notably, they can be categorised according to the extent to which they are in surplus or in immediate and long term deficit.

Table 2 not supplied on disk; provided on paper in Word 5.1

Table 3 The status of the water economies of the region with respect to the economic strength of the respective countries

Economies in water surplus	Economies in immediate or long-term water deficit
Oil economy	*Oil economies*
Iraq	Saudi Arabia
	Kuwait
	UAE
	Qatar
	Oman
	Libya
	Partial oil economies
	Egypt
	Yemen
	Syria
	Tunisia
	Algeria
Non-oil economies	*Non-oil economies*
Lebanon	Jordan
The Sudan	Morocco
[Turkey]	

According to the information summarised in Table 2 and the analysis of the economic circumstances in Table 3, it is evident that water resource availability is a serious and urgent issue for Egypt, Jordan, the Yemen, Syria and the Maghreb countries. For all of them, it is an important or very urgent issue with respect to agriculture, and Jordan, the Yemen, Syria and the Maghreb countries have difficulties in supplying reliable water to domestic users in the cities in the summer. Libya amongst the oil rich countries also has problems with urban water supply as does Iraq in its current economic and infrastructural predicament in the aftermath of the 1991 Gulf War. All the oil rich Arab countries except Iraq have water deficits, but such deficits can be accommodated within these relatively strong economies, which have the capacity to import water or to utilise expensive water such as that pumped from deep aquifers or converted from saline or brackish supplies.

Augmenting water supplies in the future

The governments of Arab countries, both their political leaderships and their officials, in public statements at least, are still very much committed to augmenting national water budgets with new water. The most popular means to achieve this end in the past, especially in the present century, was to control surface flows by creating multi-purpose reservoirs. Such activity is still very appropriate for upstream neighbours in the Nile and Tigris-Euphrates catchments. Turkey is well advanced in creating such structures (GAP, 1990), and Ethiopia would very much like to embark on a similar programme (Abate, 1992 and 1993). However, this approach is no longer an option for the Arab countries of the Middle East and Northern Africa.

By the end of the twentieth century there are few or no major dam sites which would store water for power or agricultural purposes in the arid and semi-arid Arab countries. Those sites which could be said to exist, such as the Meroe (Fourth Cataract) site in the northern Sudan, are economically and internationally very controversial. Storing water in sites which generate evaporative losses of three metres depth of water annually from the surface areas of reservoirs is no longer regarded as economically feasible in river basins where water has become scarce.

In the absence of opportunities to deploy conventional engineering practices of controlling the storage and distribution of flowing surface water, governments and water managing institutions have had to seek new water in other parts of the hydrological system. An approach favoured by those who would benefit has been the drainage of wetlands. The best known project is the Jonglei Scheme which was designed to yield annually four cubic kilometres of water to be shared equally by the joint investors in the scheme, Egypt and the Sudan. The construction stopped in the early 1980s as a result of violent opposition by the local communities who did not want their livelihoods and ways of life changed by the draining of the swamps of the Sudd, and especially not by the proposed second stage of the project (Howell et al 1988, p462, Collins, 1990).

In contrast the scheme to drain the swamps in the lower Euphrates in Iraq is going ahead rapidly at the time of writing. Here the politics and the purposes of the drainage are different from those in the south of the Sudan. Mobilising new water is only a minor factor. However, the activities in the lower Euphrates are interesting in that they contribute evidence to the debate on the importance of wetlands which is being pressed by those international institutions concerned with the conservation of natural resources and their ecologies as well as with the preferences of the people who have created unique ways of life. In the case of southern Iraq, traditional interests are being ignored by a central authority, the Iraqi Government and its agencies, which have the power to coerce local populations to accept the environmental impacts of drainage (North, 1993). The decisions to drain have a number of complicating political factors linked to national security perceptions of the Iraqi leadership. The intent is to prevent cross-border infiltration by those using the waterways of the marshes, which lie in some cases across the international border with Iran. In addition the leadership wishes to constrain, and ultimately prevent totally, elements of Iraqi's Shi'a opposition from using the marshes as a refuge.

More broadly, the option to drain marshes is being severely restricted by the international community which has during the past decade become increasingly concerned about ecological issues. Wetlands are no longer regarded only as water resources ripe for development. They are integral to the survival of local wild-life and often essential for intercontinental and inter-regional migration of species, especially birds. The economic impact of such changes of opinion are difficult to quantify, as are the benefits of maintaining wild-life and species diversity, but the effect on decision making by international agencies has become very clear and it is tending to favour non-intervention especially after the 1992 UNCED conference (UNCED, 1992).

With the possibility of mobilising new water from surface flow having become unfeasible economically and politically, it has been natural to develop accessible groundwater and then to search for further supplies of water which can be economically exploited. The region has massive groundwater reserves and these have become accessible with the emergence of technologies to detect and engineer them and of economies to provide the necessary capital to develop them. Unfortunately, it is expensive to appraise both the quantity and the quality of extensive groundwater aquifers, and there are no comprehensive and reliable data on the extent and usability of the region's groundwater (Edmunds and Wright, 1979; Lloyd, 1990; United Nations, 1973 and 1981). Groundwater resources are nevertheless very extensive indeed, especially in Northern Africa in the vast Intercalaire formations which underlie parts of Algeria and Tunisia (Unesco, 1972). The groundwaters of Libya are relatively well researched and the Libyan authorities have experimented with *in situ* development as well as with the construction of major water carriers to move water from remote desert locations to centres of population at the coast (Allan, 1981, 1983, 1988, 1989a and 1989b).

Water provision for more numerous future users by re-allocation

Later sections will deal with the possibilities of freeing for the more numerous Arab water users of the future by re-allocating water from economically water-inefficient applications, such as irrigated agriculture, to water-effective sectors and uses. Such an approach does not create new water but it does provide a sound basis for both policy and practice in the utilisation of the region's scarce water. The argument rests on the inescapable duty of future governments and water authorities to provide domestic and municipal water for the larger populations of the future, especially urban populations in the decades ahead. Fortunately, there are a number of technologies which could be more extensively deployed than at present if the costs of supplying water were to be met by the municipal users.

The possibility of gaining water from existing systems to provide supplies for additional users in other sectors where higher economic and social returns exist will be an increasingly important strategy but such strategies have not yet entered the policies of Arab governments or the water managing institutions of Arab countries. For the reasons already discussed in the preceding paragraphs as well as in the following analysis of the traditional place of water in the economies and cultures of the region such policies are difficult to adopt and deploy. For those who consider that new water is the only solution and that the political problems of re-allocation are insurmountable the approach of reallocation is not yet a relevant option. For those on the other hand who consider that serving the interests of as many effective water users as possible is the major issue then the re-allocation of water will be a major feature of their future water policies. (is this material repetitive of what will follow, or out of sequence?)

New water - long-distance water transport: pipelines, sea movement, desalination, water purification, and water re-use

One Arab government has gained experience in financing and engineering a water transport system at a national scale. Libya's Great Man-Made River is a bold attempt to address the water deficits of its coastal tract by moving water from its aquifers below the deserts of the south, since *in situ* development there has proved to be socially and institutionally difficult as well as non-economic. The pipelines have been designed to convey between two and three cubic kilometres of water per year which far exceeds the present approximately 1.5 cubic kilometres of national usage (Allan, 1989a). The most notable feature of Libya's water-carrier is the economic and technical challenge associated with the project. The project was an economically digestible enterprise when the decision to go ahead was taken at the end of the 1970s when oil income was buoyant. It became progressively more uncomfortable as the economy weakened with the decline in oil income during the 1980s. It could be argued that a more modest project, to meet a future demands for municipal and industrial water only, would have been more appropriate, especially as its US $1. per cubic metre cost makes the delivered water too costly for economic crop production. That irrigation use still figures in Libya's water allocation plans confirms that Arab governments have not yet grasped the irrelevance of expensive water to agriculture despite almost three decades of contrary counsel. (No protest on mining aspects?)

Such projects can only be contemplated by states which have strong economies where users, or a subsidizing government, can bear the high cost of developing and delivering the water. Libya was such a state when it planned and commissioned the construction in 1979/80 at the height of a surge in oil prices and its own revenues, but Libya's experience thereafter in the 1980s is a parable which other leaderships in the region should observe closely.

Libya's revolutionary leadership took power in 1969 during a phase of rising prosperity. Resource mismanagement costs then were unaccounted noise amongst the rise, sometimes very rapid as in 1973 and 1979, in income derived from oil. For an increasingly prosperous Libya, it was possible to contemplate high cost solutions to its water problems. The Great Man-Made River project was embarked upon with a first phase costing about 15 per cent of one year's oil revenues earned in 1980 ($US 23B). Further phases and related investments were to cost at least four times this sum. Devoting about 12 per cent of GDP over a period of a decade to securing the nation's strategic water supplies was not an unreasonable prospect. Unfortunately the parable took a very different direction when during the 1980s

Libya ceased suddenly to be a rich nation. Revenues fell to one quarter of their 1980 levels and the strategic investment in water security began to dominate the national economy even though the construction schedule was extended to two decades rather than one. Much the most disturbing feature of the parable is not so much the dramatic change in economic fortunes as the unwillingness of the Libyan leadership to shift its perception of the value as well as of the cost of developing its water resources with respect to the changed economics of the 1980s. The intent of the Libyan government at the time of writing is still to devote a high proportion of the costly water, delivered at the coast at an estimated cost of US $1. per cubic metre, to irrigated farming. This is despite the implied economic folly of devoting over US $10,000 of water per hectare (not to speak of other inputs) to produce crops which will yield only US $1,000 to US $2,500 per hectare.

The Libyan example is an extreme case of the political interests of leaders and those of minority constituencies over-riding medium and long-term national interests. It is also an example of the inability of leaders and opinion formers to disggregate water supply according to cost and to disaggregate water demands according to the capacity of various uses to bear the real costs of water inputs. The special significance of Libyan case is that the extreme contradiction between the current politically driven policy to mis-allocate water and the underlying economic forces associated with developing and transporting deep and distant fossil water is to be exposed during a period of economic weakness rather than in an era of continuing oil derived prosperity. The economic stress of operating a system delivering water to a non-viable irrigation sector will be unsustainable and the consequences of mis-allocation will not be submerged in the surge of funds available in the 1970s. Libya's rich country approach to water resource development is no longer fits its economic circumstances.

The Libyan experience tells us a great deal about the relevance of water-carriers to solving the water resource problems of the region. They can deliver significant volumes of water, approaching two cubic kilometres per year in the east of Libya and about one cubic kilometre in the west. These volumes are almost twice Libya's 1993 water usage. Even more important than the modest, though significant, volumes of water delivered is the high cost of the water. Poor economies will have the resources neither to finance the development the water carriers nor to operate them. On the demand side only the domestic and industrial users will be able to bear the costs of such water and then only those in strong economies.

Other national water pipeline projects are active. Water for Aleppo, about 80 million cubic metres per year, is already conveyed by pipeline from Lake Assad. In Jordan the proposed project to move water from the Disi aquifer on the Saudi border is at an advanced stage in what is always a protracted suite of authorisation and financial preliminaries. The destination of the water will be the domestic and industrial users of the Amman urban area who suffer restrictions annually, and severe ones in drought years. Both projects deliver or will deliver expensive water.

International water transfers by pipeline have significant potential but to date have not become operational. This is surprising in that relatively small volumes of water can be of great significance to countries trying to manage on water budgets of under one cubic kilometre annually. Jordan and most of the states of the Arabian Peninsula make do with less, and Palestine would be another entity with very modest water resources. International water carriers have not become operational because of their

perceived strategic vulnerability. Such fears have been given substance by the outcome of the Arab initiative in the early 1960s to prepare for the transfer of water from the Banias spring, a major spring feeding the Jordan, across Golan and into the Yarmuk to increase the volume of water available to Jordan's irrigation schemes in the Jordan Valley. Military intervention by Israel interrupted the construction and most Arab leaders feel that similar fates would befall other international projects. These considerations have shelved the Turkish Peace Pipeline proposed in the early 1990s, which could convey significant volumes of water - about two cubic kilometres - from sources in southern Turkey that are of no immediate value to Turkey.

These three cases highlight the difficulties facing those making policy on water in the region. The sources of new water are never unencumbered. They are either politically insecure, meager in quantity, or ill-located and therefore difficult to develop, and sometimes they are subject to a combination of these disadvantages.

Long-distance water transport: sea movement

The transport of water from water surplus regions will continue to receive attention and will be stimulated in the region as a whole by studies and innovative engineering experiments in Turkey. Turkey has regions enjoying water surpluses but also has areas on the mainland, and in neighbouring Cyprus which it wishes to support, which suffer seasonal and accelerating water deficits. As a result, technologies are being tested within the national economy of Turkey which will demonstrate the relevance of sea transport of water over distances significant also to users in Arab countries on the southern shore of the Mediterranean and beyond. The water could be modestly priced, in the order of US $0.20 per cubic metre (including development, operation and the provision of capital), according to the designers of the Medusa Bag project. This is an unattractive cost for agriculture but a very favourable cost to supply coastal urban settlements and coastal industrial complexes such as in the countries of the Maghreb, Libya and even in the more distant Gulf (Cran, 1992). Important to note is that the volumes of water being discussed by Turkey are very significant to many national entities in the Arab world. The US $0.20 cost per cubic metre is based on the transport of 250 million cubic metres per year over 650 kilometres, with additional water handled in the same system costing only 10 cents per cubic metre (Cran, 1992, p.8). Amounts of only 100 million cubic metres of water annually are very significant to Jordan and the putative Palestine as well as to the cities of the Maghreb and Libya.

Desalination

Desalination is another source of potential new water for a limited range of uses. There are Arab countries such as Abu Dhabi where desalinised water is used as if it was not costing over one US $1. per cubic metre in sectors with negative economic returns. And Abu Dhabi is the extreme example of the imaginative use of expensive desalinised water to provide green amenity in its urban areas and alongside its major roads. The city of El Ain in Abu Dhabi is a remarkable garden city in the middle of the desert served by a mixture of groundwater and desalinised water. A feature of the Abu Dhabi water economy is that reused municipal water is an element in the water budget and processed waste water is a significant contributor to the supply for the gardens and green areas in the cities of the emirate.

Desalination is a technological option for all Arab countries but only an economic one if there are oil or other revenues to subsidise building and operating the desalination plants. Operating costs vary according the cost of the energy used and it is being suggested that plants could be built to produce desalinised water for less than US $1. per cubic metre. Oil exporting countries have cheap energy and the option to devote their energy resources to desalinising water. Desalinisation has the advantage of providing a measure of security in water supply but as shown in the 1991 Gulf War the desalinisation plants are extremely vulnerable to attack from the air or by missile and they can be seriously threatened by off-shore pollution.

An important part of the desalinisation scene is the improvement of brackish water rather than the very saline waters off-shore of Arab countries. Brackish waters range from those with 1500 parts per million of total dissolved solids (tds) which are usable on many crops but not conventionally for human consumption, to waters with 5000 (ppm of ?) tds or more. These waters are very much cheaper to improve for municipal and industrial use than sea water with 35,000 (ppm of ?) tds or more. Countries with serious water deficits such as Jordan, with limited economic options, are looking closely at the purification of brackish water as a viable economic option.

Water re-use and the purification of municipal and industrial waste water

The re-use of water occurs naturally especially in irrigated farming and the use of treated industrial and municipal waste water is becoming common at least in pilot schemes. The hydrological cycle moves water naturally from channels to the soil and then into groundwater flows and storage. The Egyptian irrigation systems have been engineered in particularly favourable geomorphological circumstances in naturally well drained alluvial deposits which allow the re-use of water between two and four times during the flow of Nile waters from Aswan to the Mediterranean Sea. This natural use is not counted in a formal economic way but it does play a part in enabling Egyptian engineers to argue that the average annual volume of water required to irrigate a hectare is 10,800 cubic metres per hectare (4500 per feddan - a feddan is almost equal to an acre). This is possibly an optimistic estimate but it does not differ greatly from the figure derived from dividing Egypt's estimated annual water use in agriculture of c. 38 cubic kilometres by the estimated area irrigated of close to 2.9 million hectares (c. 7 million feddans), which gives a figure of c. 13,500 cubic metres per hectare. These water re-using practices in irrigated farming enable an overall water efficiency of over 70 per cent, which compares very favourably with any system even where advanced systems of water distribution and delivery of water have been deployed.

Another way of looking at water re-use is to estimate the gross equivalent of the water in a system in which there is significant water re-use. In a country such as Egypt it could be estimated that the water applied annually to its irrigated fields is much greater than the nominal 38 out of the 55.5 cubic kilometres shown in national statistics. Depending on the assumptions concerning consumptive use by the plant and the returns to groundwater and the drainage channels from the volume spread, sprayed and dripped on to Egypt's crops would not be less than 60 cubic kilometres and it could be as high as 80 cubic kilometres. These figures when used to calculate the water applied per hectare produce an estimate of 20,700 cubic metres per hectare (8,600 cubic metres per feddan) and 27,600 cubic metres per hectare (11,500 cubic metres per feddan) which are close to the numbers calculated to be necessary

for effective irrigated crop production by consulting engineers in the international agencies (Aboukhaled et al, 1975, pp 41-51).

Egypt is exceptional in the region in its agricultural water re-using practices, however, partly because water in such quantities as in the Nile system exist elsewhere in the Middle East only in the Euphrates and Tigris systems in Syria and Iraq. Here, however, the terrain and soil qualities traversed by the rivers are much less amenable to agricultural use. The hydraulic circumstances are different in that effective drainage is much more difficult to engineer and the soils are saline and expensive to reclaim. In other Arab countries surface flows are minor in scale and nowhere are the hydraulic and soil circumstances as favourable as in Egypt for agricultural water re-use. The effect on water quality of re-using water in irrigation systems is well understood and there is a progressive deterioration in water quality with the number of soil profiles infiltrated by the water. Water which enters the system at Aswan at 300 ppm of total dissolved solids emerges at various points in the system at progressively higher levels until it reaches the drains at the northern end of the Delta at toxic levels over 2000 ppm of tds.

Most governments in the region are looking at the treatment and re-use of urban and industrial waste water. Only the Gulf countries have had the capacity to incorporate these important recovery systems in their water management practices partly because they have the resources to implement the expensive engineering but also because the volumes of water to be treated are modest. In Egypt, Cairo has recently attended to handling its waste water with a new major sewage system and close consideration is being given to the construction of sewage treatment which would yield two to three cubic kilometres of water annually of a quality adequate for crop production. The uneasiness of people throughout the world about consuming products produced with treated urban waste-water is a socio-political challenge for governments and national and international agencies attempting to encourage the utilisation of such treated water. That people adamantly oppose the use of water treated in proposed plants does not prevent them from simultaneously feeling an irrational sense of security when consuming water treated in older plants which for decades have improved many-times-used Nile water, water which in traversing the Nile systems after leaving Aswan, has become very far from pure by the time it reaches Cairo.

The volumes of water handled in urban and industrial waste-water systems are in absolute terms small, only between ten and twenty per cent of the total water in the regional system. In Egypt the actual volume of treated water which could enter the system will be small and even if all urban waste water in the country were to be treated such water would only amount to between 3.6 and 5.4 per cent (for an assumed water treatment producing two and three cubic kilometres per year respectively) of the total water in the system. As indicated in the preceding paragraph the estimates of the amount of water utilised in Egypt varies according to whether one considers only the water which enters the system (55.5 cubic kilometres per year) or the total water which is utilised through 'natural' re-use and engineered agricultural re-use (60-80 cubic kilometres per year).

The notable feature concerning Egypt in Table 4 is that the proportion of water which will come from the various endeavours to mobilise expensive new water will be a small proportion of the water in the system. The calculations under-estimate the contribution of any water which might be jointly developed by Egypt and the Sudan in that any water that enters Lake Nasser/Nubia is worth at least 50 and 100 per cent more than its original input volume as a result of re-use in the Egypt's irrigation system. On the other hand the losses in evaporation during storage in Lake Nasser/Nubia could also be considered and these would reduce the volume contributed by between five and fifteen per cent. Lest it be assumed that the Egyptian case can be extrapolated it is relevant to compare the position in immediately upstream Sudan which contrasts markedly because of environmental circumstances there. There is effectively no natural water re-use in the Sudan's major irrigation scheme, the Gezira Scheme, because of the nature of the black cotton soils which prevent deep infiltration. Water stays on or near the surface and there is a tendency for excessive applications of water to be wasted through evaporation.

The Jordanian case is very different. The sources of new water from municipal re-use though small in volume would be very significant in terms of the national water budget. The treatment of urban waste water would bring at least as much new water as the water saved through improvements in the systems of distribution, and of course can be added to savings in distribution. The important figures to note, however, are the proportional contributions likely to be made to the total national water budget by such new sources of water. Relatively small volumes of water of 0.1 cubic kilometres per year are significant to national entities such as Jordan and the putative Palestine as well as to the Arab Gulf states.

Table 4 Estimated proportions of potential treated urban and industrial waste water of estimated future water in Egypt and Jordan

EXISTING WATER				TOTAL	NEW WATER						TOTAl
Water available	In agriculture Single use	With re-use		From		From improved systems & irrig-ation effic-iency	From Jonglei I (unlikely		urban waste-water treatment to be com-pleted)		of all water includ-ing all re-used water
Country	km3	km3	km3	km3		km3	km3	% (of Z)	km3	% (of Z)	km3 Z
EGYPT											
Usual estimates	55.5	38	-	55.5	*Scenario* *Low*	5	2	3.2%	2	3.2%	62.5
					High	10	2	3.2%	4	6.4%	64.5
Accounting for agric-ultural re-use	55.5	38	Scenario Low 22	77.5	*Scenario* *Low*	5	2	2.5%	2	3.2%	79.5
			High 42	97.5	*High*	10	2	2.0%	4	4.0%	99.5
JORDAN							From fossil resources *Scenarios*				
Usual estimates	0.8	0.6		0.8		0.1	0.1	8.3%	*L*0.2		16.7%
1.2											
							0.2	14.3%	*H*0.4		28.6%
1.4											

Sources: Column A official data from the Ministry of Public Works and Water Resources of Egypt and the Jordanian Water Authority. Other figures are author's estimates.

Water in fractured rock zones, and structural instability from major faults of the region

The widespread search for oil since the 1940s revealed that there are vast reservoirs of groundwater throughout northern Africa and Arabia, unfortunately often in difficult to develop aquifers (Wright et al, 1971; Pallas, 1980). In the past two decades it been argued that there are subsurface zones or conduits traversing vast distances within the surface formations of the sedimentary mantle of north-eastern Africa (Ahmad and Eddib, 1975). Whether some of the remote groundwater is still being recharged, as argued by Ahmad for the Kufrah aquifers (Ahmad and Eddib, 1975), is unresolved because techniques to detect subsurface conduits have not yet been developed at this stage.

Subsurface flows of water have been given attention in the recent past due to the detection of zones of geological stress in western California in which fractured materials form significant subsurface channels for groundwater flows sufficient to augment the water supplies of the severely water stressed communities of coastal California. The same detection techniques, involving the processing of satellite imagery and structural geological surveys, are being deployed in water scarce Jordan where it is hoped that the zones of stress associated with the major rifts of the Jordan Valley and Dead Sea will contain subsurface water (Anderson, 1993). The geological indicators are, unfortunately, not favourable in that the zones of stress being examined in Jordan are for the most part far below sea level and in addition ill located vis-à-vis the centres of population and water demand. Moving Disi groundwater from the southern border to Amman is already a deterringly expensive prospect; to develop water from even deeper levels in the fractured zones is even less likely to be economically feasible.

Neither the delivered cost of water nor capacity to pay for it is uniform

One of the problems facing discussion of water in the Middle East at a macro-scale is the inevitable tendency to consider national water budgets and the augmentation of supply as if all water uses could be considered in a single category. Water can be categorised according to a number of criteria associated with the supply of the water as well as with the another suite of criteria having to do with demand. On the supply side, water availability can be categorised in terms of volume, reliability, quality, and cost of delivery, as well as whether it comes as rainfall or from indigenous surface flows, cross-border surface flows, groundwater storage, cross-border sub-surface flows, re-used water, desalinated water, imported water as water and finally imported water in the form of other imported products.

With respect to demand water can be categorised according to very similar criteria to those relevant to supply. These criteria are to do with the requirements of different uses of water in terms of volume, reliability (both environmental and political reliability), quality and cost for various uses and sectors. The economic context in which water supplies and water demands are expressed are also relevant.

Water enters the national water resource budgets in different volumes, qualities and costs and is more or less available for economic and social use according to its location. On the other hand water requirements for particular uses vary greatly with respect to volume, quality and cost. Intuitively, it would seem appropriate to match the characteristics of demand to those of the supplies currently available or to

those supplies which could be delivered through technological and/or economic interventions. The analyses in Tables 5 and 6 illustrate the different types of water which could be available to states on the supply side as well as the characteristics of the water demands for the major uses of water in national economies.

Where there are unlimited supplies of water of high quality there is no problem in matching supply and demand. Such circumstances only existed in the past in the Middle East. By 1970 all Arab countries were facing difficulties, in some cases already serious, such as those in Egypt and Jordan, in matching supply and demand despite heroic efforts to augment supplies and control their reliability through works such as the Aswan High Dam.

A major problem affecting those responsible for addressing the national water deficits and considering how to augment national water supplies is that they approached the water issue as if all water was the same and all users equally entitled to free water. In practice cheap water is always limited and new water is almost always going to be expensive or very expensive in arid countries, unless there is some breakthrough in solar energy generation applied to water purification.

If one approaches the problem of water deficits using the analyses provided by Tables 5 and 6 for matching disaggregated supplies and disaggregated demands it is clear that no Arab country has a water shortage with respect to their municipal and industrial needs. There is sufficient water, some of it expensive, for non-agricultural uses and where new expensive water is or will be needed to meet the increasing demand for municipal and industrial water it will be able to be reallocated or the high costs of development afforded.

The problem lies in the politics. No political leadership nor any traditional high volume users of water are prepared to disaggregate either the supply or the demand for water.

Table 5 An analysis of types of water availability - water supply - with respect to their cost of delivery and reliability of water supplies in Arab countries and showing relevant uses vis-à-vis water delivery costs

	Volume	Reliability - environmental	Reliability political & technical	Quality	Cost of delivery	Water type
Free or low cost water suitable for all types of use including irrigated farming						
Rainfall	*****	****	*****			
Indigenous surface flows	********	****	****			
Cross-border surface flows						
• no control	* to ****	*	* ****	****		
• engineered	* to ****	*****	* ****	****		A1
Cross-border sub-surface flows	* to **	************	*****			A2
Groundwater - renewable • from less than 100 m depth	* to ***	(short term) **** (long term) *	****	** to ********		A3
Groundwater - non-renewable • from less than 100 m depth	* to ***	(short term **** (long term) *	****	** to ********		A4
Expensive water suitable for water uses able to bear high water charges						
Groundwater - renewable • from over 100 m depth *(no long-term role)*	* to ***	(short term) **** (long term) *	****	** to *****		B1

	Volume	Reliability - environmental	Reliability political & technical	Quality	Cost of delivery	Water type
Groundwater - non-renewable • from over 100 m depth *(no long-term role)*	* to ***	(short term) **** (long term) *	****	** to *****		B2
Re-used water	*	*****	*****	****	*	B3
De-salinised water	*	*****	*****	****	*	B4
Imported water as water	*	*****	**	****	*	B5
A very flexible, reliable but expensive source of water						
Imported water in other imported products	****	*****	*** *****	*		B6

* very unfavourable
** unfavourable
*** appropriate
**** favourable
***** very favourable
Operationally usable

Table 6 An analysis of types of water demand in Arab countries and the nature of the water required to meet such demands

Volume	Reliability: Environmental & technical	Reliability: Political	Quality	Cost of delivery	Water type	
Free or low cost water required - $US 0.0 to $US 0.01 per cubic metre						
Irrigation	*****	****	****	***	*	A1,A2 A3, A4
Medium to high cost water can be used - $US 0.2 to $US 1.0 per cubic metre						
Industry	*	*****	*****	**	****	B1-B5
High cost water can be used - $US 1.0 or more per cubic metre						
Municipal use						
• for green amenity						
• in weak economies	*	****	****	**	(*****)	B1
• in strong economies	*	****	****	**	*****	B1-B5
• for domestic consumption						
• in weak economies	*	****	****	**	(*****)	B1-B5
• in strong economies	*	****	****	**	*****	B1-B5

*	Very low	****	High
**	Low	*****	Very High
***	Medium	(*****)	Very High but too expensive to deploy

WATER DEMAND IN THE MIDDLE EAST AND NORTHERN AFRICA: EMERGING PATTERNS

Evolving patterns of demand

Water demand and supply are in practice closely linked, both in the sense that increased demand poses challenges for those responsible for arranging supply, and because adjustments in the demand for water can have a very dramatic impact on the levels of supply required in a economy. The pattern of water demand in the region has changed throughout history and until the nineteenth century the available supplies of water were adequate for the needs of the economies and peoples of Arab countries. The challenge since the beginning of the twentieth century has been to meet water demands by engineering new water.

For the past two decades the region's leaderships and peoples have remained in a phase of assuming that past water demand management practices were appropriate to meet the challenges of the late twentieth century and beyond. They have further assumed that new water will be found to meet rising demand despite sharp evidence to the contrary, such as the region-wide and rapidly rise in food imports. Because of this misreading of the position, and possibly more importantly because of the effectiveness of the international food trade and of the ability of Arab countries to pay for food imports, the issue of water demand management has been neglected. An examination of demand management options is particularly important because in the immediate future the political economy of water in Arab countries will be increasingly dominated by the development and application of such policies. Although not a significant feature of water policy to date, demand management will dominate approaches to the use of water in the coming decade and beyond, despite current resistance by political leaderships and vested interests throughout the region.

Water demand in Arab countries is driven by four main factors. The first is the level of population and its rate of increase. The second is the standard of living of the population and its expectations. It is the third factor which is by far the most significant, however, namely the way that water is allocated between economic sectors: agriculture, industry and municipal. This includes allocations at lower levels of an economy, for example, dividing water on a farm between the different crops. Fourthly water demand is affected by the efficiency of the systems used to distribute it. A measure of efficiency in municipal systems is the level of unaccountable losses; losses of under 20% are regarded internationally as a reasonable level of efficiency. In the Middle East and northern Africa unaccountable losses of over 50 per cent are commonplace.

Measures to modify and improve patterns of water demand

The issue of water demand must be addressed because if per capita use is not modified in Arab countries the amount of water needed in 20 to 25 years to feed, maintain the health, and satisfy the amenity expectations of their peoples will double. This will destabilise economies and unneccesarily increase the levels of dependence of the region on imported food. The consequences of severe pressure on water resources have been avoided for the past two decades by importing food and this practice will continue to be the central element in the water policies of the region for the foreseeable future. Figure 1 indicates the proportional dependence of some of the economies of the region on water imported in food.

Both the oil rich such as Saudi Arabia and economies with small or no oil revenues such as Egypt and Jordan are dependent on 'imported' water in this form.

Achieving changes in water allocation and consumption behaviour at the state level, as well as by individual families, will be a major challenge for political leaderships and for officials concerned with managing water. The subject is a major one and can only be briefly outlined here. The two major issues to be addressed are revising the allocation of water at all levels of the political economy of water, and secondly the improvement of the systems of delivering and using water

Figure 1

Application of principles of allocative efficiency

Economic principles are impossible to advocate and pursue when the real costs of inputs and their real value to an economy, and to individuals within it, cannot be identified. Since water is with few exceptions treated as a free good in the region and especially in agriculture, the sector which uses most water, the vested interests supporting free water provison are very powerful indeed. As a result it is impossible to have the economic value of water recognised as significant, never mind using economic valuation as the basis of future water policy. Nevertheless, it has to be emphasised that the principle of 'returns to water' is a powerful underlying economic principle. If ignored when a resource is finite or scarce, it will return to haunt water users in all parts of an economy.

Allocation is a political act and it is for this reason that users and politicians prefer to ignore the issue of the cost of delivering water and especially the consequences of pricing water at its real cost of delivery. Major changes in livelihoods would be involved. Nevertheless international experience points to the adoption of policies based on such principles.

System improvements to reduce water demand

The efficiency of water distribution in agricultural, industrial and municipal systems is a complex subject, as evidenced by the discussion above of water re-use in the irrigation sector in Egypt. Water infiltrated from irrigated fields can either enter groundwater and drainage systems which provide effective re-use and further re-use, or it may enter a saline aquifer and be permanently degraded and lost to the economy. Water in municipal systems is conveyed through pipes which leak. It is used wastefully by consumers, and in systems which are metered it is common for a proportion of the water to be tapped from the system illicitly. While the data are everywhere very imprecise, it is generally recognised that 50% is a reasonable starting estimate for such losses.

Systems can be improved first by investing in physical upgrading by replacement and repair, as well as by institutional remedies such charging for water after installing use meters. This last is a major engineering challenge in itself. The costs of system improvements can deter implementation and the introduction of water charges will always be resisted by users especially where they have been used to receiving free or nearly free water.

A BRIEF OVERVIEW OF THE HISTORY OF WATER MANAGEMENT IN THE MIDDLE EAST AND NORTH AFRICA

Since antiquity farmers and engineers have been moderating the natural flows of surface water and lifting water from the ground, for, first, domestic water supplies, secondly to provide water for livestock and thirdly, for crop production. The latter has demanded the most ingenuity and effort because crops require large volumes of water –normally over ninety per cent of all the water used by a community enduring an arid climate. A version of the history of water use in the Middle East and Northern Africa is shown in Table 7, which illustrates a number of important developments in the handling of water,

especially during the present century. The evolution of management responses suggests, as discussed above, that by the late twentieth century the option of augmenting water supplies with new water from the countries of the Arab World was no longer available. New water mobilisable within national boundaries either does not exist or could be only a minor source of water for most Arab countries. Moreover, the surface water supplies in some of the region's most important rivers are likely to be diminished by the use of Nile water by Ethiopia and of Euphrates and Tigris waters by Turkey during the next half century.

Table 7 Past water resource allocation and management practice in the Middle East and Northern Africa and future options.

	Natural water	Natural water	Natural water	Natural water	New water	New water
	Surface storage & & withdrawals from groundwater	Distribution & drainage - agriculture	Distribution - domestic & industrial	Quality assurance	Waste disposal & water re-use	Desalination
Limited management of water supplies						
Pre-19th century	No control - some natural surface storage	Minor canalisation. Natural re-use of Nile in agriculture	None	None	Limited - some careful management at some periods in Cairo	None
	Traditional groundwater use	Traditional systems - qanat and falaj				
Limited supply management - significant advances in distribution and drainage						
19th century	Minor control works on surface water	Major canalisation in late 19th century	Limited piped supplies in late part of century	None	Limited	None
Increasing supply management of surface water - beginnings of major groundwater use						
1900-1950	Major dams on Nile constructed. Groundwater development	Major canals & drainage	Major cities provided	Limited	Limited	None
Control of surface water supplies and heavy use of groundwater						
1950-2000	Aswan Dam & other major dams on Tigris-Euphrates. Widespread construction of minor storage works. Major groundwater use	Water carriers Libya - (also in Turkey)	Urban provision including system improvement; reduction of system waste. Beginning of water charging. Efficient systems in agriculture.	Improving	Initiated in most cities eg Egypt, Some rural provision.	In strong economies (Gulf)
Demand management to adjust demand to scarce surface water and scarce and expensive groundwater						
2000-2050	Major dams in upper Niles. Total control.	Additional water carriers	Urban and rural piped supplies	Widespread	Widespread water re-use of urban water for use in agriculture & other sectors.	In strong economies

The major shifts in the approaches to water development and use in the Arab World during the past 10,000 years came slowly, but within the last one hundred years, there have been very important technological developments, along with a progressive rise in population. In the past half century, moreover, the varied and changing economic fortunes of different Arab countries have been very significant in enabling --or not enabling-- the deployment of advanced technologies to lift water from great depths and to move it in major water carriers. Meanwhile with the very important and strategic shift in the Arab economies from being either food exporters or food self-sufficient countries, to being food importers, the position of water in these economies changed. Where food has had to be imported, by implication water was also having to be imported. And at the time of writing, possibly the most important factor of all is beginning to affect current and future water allocation and management: namely an evolving awareness of the real economic role of water in national and regional affairs and the need to derive sound and efficient economical returns from scarce water used in national economies.

2000-2050 - Demand management: adjustment of demand to scarce surface water and scarce and expensive groundwater (note: previous headings shown in contents have been dropped)

The major shifts in water management policy and practice during the past century are summarised in Table 8 which indicates the major issues given priority by those devising water policy as the deevelopment context changed. The changes in context include the technological context, the pressure on natural water resource endowments from growing populations, the ability, or lack of it, to substitute for water, as well as the awareness of the economics of water. There are some other additional factors which are as yet poorly understood and even more difficult to operationalise in any comprehensive analysis of evolving water policies, never mind in the real world of water allocation and management. These include the allocation of safe and adequate supplies, the enablement of access to equitable benefits from water and the use of water in an ecologically sustainable way. The shifts in approach can be summarised as follows:

Table 8 The major shifts in approach in the policies and practices of managing and allocating water in the Middle East and North Africa

FROM THE MANAGEMENT OF SUPPLY	TO THE MANAGEMENT OF DEMAND
Old solutions:	New Solutions:
Increasing the volume and timeliness of water availability:	Reducing waste - reducing evaporation from surface storages
- dams, water storage, canals, pipelines	- reducing water leakage in systems
- enhancing natural re-use in agriculture	- increasing water treatment and re-use
FROM IGNORING THE ECONOMICS OF WATER USE IN ALLOCATION AND MANAGEMENT POLICIES	TO THE INCORPORATION OF ECON PRINCIPLES IN WATER ALLOCATION AND MANAGEMENT POLICIES
Old and current practices:	New practices:
Assumption that water is a free good	Attempts to charge for water in all sectors. Recognition of principles of environmental economics.
FROM TRADITIONAL INEQUITABLE PRACTICES	TO THE RECOGNITION OF PRINCIPLES OF EQUITY
Old and current practices:	New practices:
Some traditional practices were devised according to principles of equity especially at the local level of allocating and managing irrigation water.	The adoption of concepts of entitlement to secure supplies of domestic water. The recognition of the value of water and the need to allocate water to sound econonmic uses.
The international division of water has generally been inequitable.	At the international level the adoption of Helsinki and ILC Rules.
FROM IGNORING ECOL. IMPACTS AND THE SUSTAINABILITY OF WATER PRACTICES	TO RECOGNITION OF ECOLOGICAL SUSTAINABILITY PRINCIPLES
Old and current practices:	New practices:

Little recognition of the consequences of water and soil mismanagement

The adoption of methods of Environmental Impact Assessment

SOCIAL, POLITICAL, INSTITUTIONAL AND LEGAL ISSUES AFFECTING WATER ALLOCATION AND MANAGEMENT

Water in the culture and society of the Middle East: the meaning of water and its impact on the management and politics of water

'We made from water every living thing.' (*Qur'an*, 21:30)

'He created everything and ordained it in due proportion.' (*Qur'an*, 25:2)

'Strong vested interests in using water aligned with widely held fundamental beliefs in God's existence, and in His unity, power and care, and in the resurrection, all of which are symbolised in Islam by water, appear to be a combination of beliefs much too powerful for mere authoritarian governments to confront.' (Author)

Arab countries are predominantly Muslim and Arab peoples are imbued with the precepts of Islam as articulated in the holy *Qur'an*. The concise and powerful statement above quoted from the Qur'an draws attention to the vital importance of water.' (Abdel Haleem, 1989, p34) 'The Qur'an...is a book for the guidance of mankind. ...it treats the theme of water in its own way and for its own objectives and [identifies water] not merely as an essential and useful element, but one of profound significance and far-reaching effect in the life and thinking of individual Muslims and of Islamic society and civilization. On the theme of water, Qur'anic material and the way it is treated, is lively, exciting and particularly intimate to man.' (Abdel Haleem, 1989, p33-34)

'Qur'anic statements about fresh water constantly remind the reader that its origin is with God and not with man.' Water is sent down to man. 'Water is from the sky where it is held by His power and at will He brings it down. ... The *Qur'an* never says that it falls.' (Abdel Haleem, 1989, p36) 'We send down pure water from the sky, that We may thereby give life to a dead land and provide drink for what We have created - cattle and men in great numbers.' (*Qu'ran* , 25:48-49) 'And you see the earth barren and lifeless but when We send down water upon it, it thrills and swells and puts forth every joyous kind of growth.' (22:50) There are in addition numerous references in the *Qu'ran* to the bounty that derives from water. (*Qu'ran* 6:99, 7:57, 35:27, 22:63, 50:9-11, 80:24-32)

There is also reference to the distribution of water on the earth's surface and beneath it. 'He leads it through springs in the earth', (39:21) He also 'lodged it in the earth' (23:18) and (is the subject of this clause God, or the *Qu'ran* or the Prophet?) challenged the reader to contemplate the value of soil moisture and groundwater in the comment, 'Think: if all the water that you have were to sink down into the Earth, who would give running water in its place.' (67:30) In this passage there is recognition that naturally occurring soil moisture, well distributed through the seasons, is the most important water of all, only exceeded in importance by that water 'which... [makes] ... every living thing' (21:30). The value of water is given a remarkably early citation in the economic history of water in the Prophet's urging that in the practice of cleansing themselves for the Friday prayer they should do so 'even if a glass of water would cost a dinar'. (Abdel Haleem, 1989, p39.)

In addition to the sixty references to water in the *Qu'ran* there are over fifty to rivers (Abdel Haleem, 1989, p40). Rivers are seen to be cooling and to be providers of irrigation water and to be environmentally enhancing. River waters are also frequently connected with references to Paradise which makes water an important element in the after life as well as in contemporary livelihoods and ritual (Abdel Haleem, 1989, p.40). The same author argues that water is probably more significant to Muslims than to any other people in the world. 'It is a subject of profound significance, and man's senses, emotions and reason are constantly brought into play in discussing it.' (Abdel Haleem, 1989, p. 45) The extent to which water has 'infiltrated' the language, society and religion of Muslim peoples cannot be over-estimated. That water is also an element in livelihoods and national economies will never, therefore, be the only explaining variables in the behaviour and policy-making of farmers, of agricultural and irrigation officials, and of politicians in ministries of irrigation and agriculture who together have influence over the vast majority of water being used in a the region's national economies.

Agricultural water accounts for between seventy and ninety per cent of water use in most of the countries of the Middle East and Northern Africa. The 'meaning' of water in the minds of Muslim peoples includes the ideas, first of 'water being the proof of God's existence, unity and power', secondly of being 'the proof of God's care', and thirdly as being proof of the Resurrection through the every day evidence that water can restore life. It therefore behooves those who attempt to understand and afterwards possibly modify water-using policies and practices to be particularly careful. They must give close attention to cultural factors especially where the traditional values and 'meaning' attributed to water reinforce the interests of elements of the agricultural communities, elites and bureaucracies who together influence water allocation and management in the region. Strong vested interests in using water aligned with widely held fundamental beliefs in God's existence, and in His unity, power and care, and in the resurrection, all of which are symbolised in Islam by water, is a combination much too powerful for mere authoritarian governments to confront.

Water use and water law in Islamic countries

The meaning of water as expressed in the rituals and traditions of Islam is not only important in framing the approach of Muslim peoples to water, it also has a number of important influences on water management practices and has an important place in the *shari'a* (Islamic law). Ibn Manzur (d. 711AH/1311 AD), the most famous Arab lexicographer, mentions in his dictionary *Lisan al-'Arab* under the root 'sh r' that 'shari'a is the place from which one descends to water ... and shari'a ...[for]... Arabs is the law of water (shur'at al-ma') which is the source for drinking which is regulated by people who drink, and allow others to drink, from.' (Ibn Manzur, 1959, 175 ff.) Mallat (1993, p.3) points out that a later classical dictionary is even more specific: '*Ash-shari'a*', writes Zubaydi,

> is the descent (*munhadar*) of water for which has also been called what God has decreed (*sharra'a:* legislate, decree) for the people in terms of fasting, prayer, pilgrimage, marriage etc ... Some say it has been called *shari'a* but comparison with the *shari'a* of water in that the one who legislates, in truth and in all probability, quenches [his thirst] and purifies himself, and I mean by quenching what some wise men have said: I used to drink and remained thirsty, but when I knew God I quenched my thirst without drinking.'

Mallat points out that 'the connection between *shari'a* as a generic term for Islamic law, and *shari'a* as the path as well as the law of water, is not a coincidence, and the centrality of water in Islam is obvious in the economic as well as a ritualistic sense (Mallat, 1993, p 3). The jurists who expounded the shari'a were inspired by this centrality to develop a highly sophisticated system of rules covering the whole field of law, initially purely religious law which developed into the common law of the Muslim world. The unity of religion, law and the state which exists in Islam means that exhortations in the *Qu'ran* concerning the distribution and use of water are important. A principle stated in the *Qu'ran* is that the vital resource of water should not be monopolised by the powerful and privileged against the poor. The references in the *Qu'ran* to water distribution ' provide the basis upon which much legal thought was formulated' in the *shari'a* (Maktari, 1971, p 28). That water should be divided is an important principle as indicated in the *Qu'ran* in the exhortation, 'tell them that water is to be divided between them' (54:28 and Yusf 'Ali, 1971).

Abdel Haleem (1989, p 47) points out that the Prophet said that 'people are co-owners in three things: water, fire and pastures', and 'God does not look with favour upon certain kinds of people ' one of these is a man who has surplus water near a path and denies the use of it to a wayfarer, and secondly ' he who withholds water in order to deny the use of pasture, God withholds from him His mercy on the day of the resurrection'. He also notes that 'a man who is thirsty is permitted to fight another, though without the use of any weapon, if the other has water and denies him the right to quench his thirst' (Maktari, 1971, p 21). (Maktari or Haleem?)

Islamic tradition and conservation

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

> Sharah al hadith al-nabwi - a saying of the Prophet in the *Hadith*, as quoted by 'Ali Mubarak (administrator and engineer in Egyptian governments between 1848 and 1892) in *al-Azhar*, Vol 4, No 10, May 1891, pp 309-315.

The *Qu'ran* as well as prohibiting the monopoly of access to water prohibits the wasteful use of water. There are general exhortations to 'eat and drink but not be excessive' (7:31) and 'Do not squander your substance wastefully, for the wasteful are the devil's brothers.' (17:26). With an exquisite prescience for the circumstances which have developed during the second half of the twentieth century when riparians of shared rivers face inadequate flows to meet all demands, the Prophet said 'Excess in the use of water is forbidden, even if you have the resources of a whole river' (Abdel Haleem, 1989, p 48).

The pollution of water is also forbidden, with reference being made to the purity of water sent down from the sky 'pure', 'to cleanse you with it' (25:47 and 8;11). In Islamic law it is forbidden to impair the quality of water, and the quotation at the beginning of this section establishes the very long standing credentials in the Islamic tradition of the currently very prominent concepts of 'environmentalism'. The quotation also proves that the concept of sustainability was also coined by the Prophet over 1300 years ago in a particularly succinct and elegant form - 'Cultivate your world as if you would live forever'. In the second part of the quotation - 'and prepare for your hereafter as if you would die tomorrow' there is a clear exhortation that individuals and institutions should be accountable to a higher entity for the outcomes of the use and management of renewable natural resources.

Culture and water in Arab countries

The foregoing discussion cannot be taken to prove that there is some determining element in the cultural background of those who observe Islam and keep its laws. The purpose of drawing attention to the strong and symbolic place which water has in the religious tradition of the majority culture of the region is to heighten awareness that the economic notions and principles emphasised and even advocated elsewhere in the analysis are heard by Arab individuals and Arab communities through a culture with a value system which places economic arguments below familiar (familial?) arrangements and relationships validated by religious convention.

Some important features of the political economy of water - a persuasive explanation of current policy and practice vis-à-vis water in the region - a conclusion

By way of conclusion, consideration will be given briefly to the most important context of all for understanding the allocation and management of water in the Middle East and North Africa. Its approach provides a persuasive explanation of why current policy and practice on water are as they are in the region. The analysis is especially useful in explaining why the agendas addressed by leaders and officials in Arab countries are partial and avoid consideration of issues of crucial importance if strategies are to be adopted which are economically and ecologically sustainable.

The approach requires that the major problems of allocating and managing water be identified, and then be analysed in terms of the sectoral and institutional contexts to which the problems are relevant. Especially, the interests of users and beneficiaries of water must receive attention. The final feature of the analysis, which is of particular importance to understanding why there are preferred as well as unpopular policies on water, is to review the level of divisiveness engendered by some of the policy options. Table 9 is a first attempt to gain insights concerning why there are filters which prevent the consideration and development of comprehensive and sound policies.

Table 9 Types of activity associated with the allocation and management of scarce water, and some political and institutional consequences in the Middle East and Northern Africa

Problem	Arena & institutions affected by the problem	Politically divisive or not - in current information circumstances
Issues addressed by political elites, government institutions and international agencies		
1 International 'share'	International relations	Non-divisive nationally (conflictual abroad)
2 Finding new water	National - public bodies involved in search also international agencies	Non-divisive
3 Developing new water	Public and private bodies & international agencies	Possibly divisive because of competition for benefits
4 Using existing and new water as efficiently as possible (Productive efficiency)	Public and private bodies & international agencies	Non-divisive
Issues not addressed by political elites and government institutions although international agencies may show concern		
5 Efficient inter-sectoral water allocation (Allocative efficiency)	Private interests, the political elite & government institutions; also international agencies	Extremely divisive because there would be losers and these losers power are powerful
6 Introduction of engineering and institut- (economic) instruments to improve the efficiency of water use according to sound principles of demand management	Private interests, the political elite & government institutions; also international agencies	Extremely divisive because major changes in ional user's behaviour would be required

Table 9 groups the problems needing attention according to whether they have or have not been addressed by the leaderships and political elites of Arab countries. The first four problems have been addressed, sometimes for many thousands of years, and generally speaking have generated little controversy and little political heat. Where the promotion of these policies requires that investment budgets be allocated to one project or another then there could be conflict at whatever level in the political process the competition for resources was expressed. But the overall inspiration and direction of policy in addressing the first four problems is clear and generally perceived to be for the general good.

The last two problems are, however, very differently viewed by policy makers because they require solutions which if advocated would generate conflict amongst users. Antagonism would be turned on policy makers and on the implementers of policy. A very important factor in the political economy of water allocation and management in Arab countries is that there are only very rudimentary and by no means comprehensive market mechanisms to help users, not to speak of leaders, legislators, officials and engineers, to understand the value of water. As a result any changes in policy have to be based solely on political arguments and political processes without the reinforcement of preferences expressed by well informed users in market places or through democratic institutions. Meanwhile the leaders and governments of Arab countries have been able to meet food (and water) gaps by importing food and as a result these leaders and their legislators have been able to avoid addressing the two most important approaches needed to deal effectively with the urgent and increasingly important problems of achieving sound water allocation and management. If one were to re-order the issues listed in Table 9 in terms of their relative importance for the future economic and ecological security of Arab countries problems five and six would be the first in rank.

In the introduction to this review it was suggested that remedies to the economic distortions and to the destabilisation of the economies and ecologies of Arab countries caused by the mis-allocation and mis-use of water would be addressed during the coming decade. The period will be a transitional one in which water allocation and management policies will be re-oriented. It has been the purpose of the discussion to promote and accelerate this essential process.

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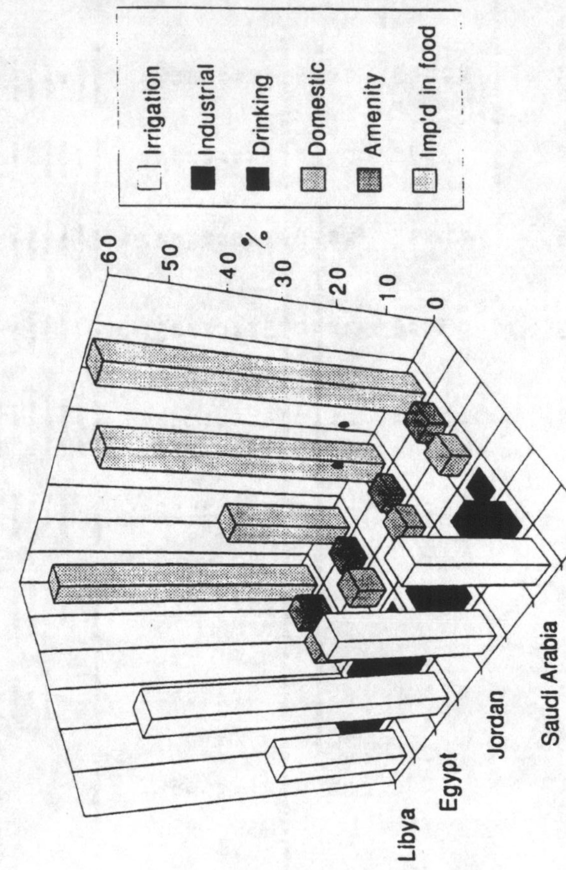
Figure 1



Water sources of some Arab countries indicating the dependence on water imported in imported products especially in food

Table 1 Goals and principles for water allocation and management and a framework for the analysis and development of policy and

Goals of water using activity	principles	Guiding	Policies Institutional	Instruments Engineering
Facilitation of political circumstances to enable optimum resource use	*Minimisation of conflict; promotion of co-operation in the areas of water use at all levels*	*Conflict resolution; identification of **reciprocal arrangements** to proote economically and socially beneficial water use and the installation of such arrangements*	*Water sharing arrangements - traditional and new; recognition of water rights & of the ownership of water; consultation between legislators, officials (local, national and international) - ('**democratic**' institutions); introduction of **new economic and legal instruments** to shift access to water to the most beneficial users and uses*	*Earth observation (remote sensing); in situ monitoring & information systems*
Productivity *('Development')* **Allocative efficiency** **Productive efficiency**	Returns to water, sustainablity of water supplies.	Investment in sectors, activities and crops which bring optimum returns. **Demand management**	Water pricing, agricultural subsidies, crop pricing and other intervention. Advanced pricing systems imply water metering. Agreements both local & international. Subsidies and pricing imply water metering.	Large and small civil works for water abstraction, treatment, delivery and distribution, recycling, water metering. Water efficiency studies and water management programmes.
Equitable use	Social benefits	Identification of the social benefits and disbenefits of water use and the promotion of beneficial uses.	Land reform, water regulation, new legislation, reduction of illegal water use, changes to traditional rights	Water control systems, irrigation management.
Safe use	Provision of adequate volumes & quality of water	Identification of appropriate systems - traditional and new - promoting the safe provision of water use, re-use and disposal	Monitoring, legislation, regulating institutions (traditional and new)	Planning for future demands, water control systems, water treatment, mainteneance for reliability.
Environmentally sound use *('Conservation' Cultivating the* sound *as if you would live forever.)*	Sustainable use of landscape and amenity including intangibles	Identification of appropriate systems - traditional and new - for sustainable water use	Monitoring, legislation, regulating institutions (traditional and new)	Quality monitoring, water treatment, wastewater treatment, waste disposal

Table 2

Table 2 Water resources in Middle Eastern and North African countries:some data provisional and it is assumed that participants will improve the estimates

	Surface water				Groundwater (Note: the vexed question of subsurface international flow not addressed.)		Rainfall		Desalination capacity 1990	Approximate volume of accessible fossil groundwater reserves 1990	Proportion of total available water allocated to agriculture 1988-90	Annual requirements for full self-sufficiency including agriculture 1990.0
	Average surface inflow to country	Average internally derived surface flow	Average surface outflow to another country or sea	Average available surface water	Average groundwater abstraction rate-1990 (including falaj)	Average total water available	Average national rainfall volume	Available for agriculture etc.				
	km3/annum	km3/annum	km3/annum	km3/annum	km3/annum	km3/annum	km3/annum	km3/annum	km3/annum	km3/annum	%	km3/annum
Middle East												
Bahrein	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	?	0	20	1.0
Iraq-1980s & 90s	16+25+10	3.0	9.0	43.0	2.0	45.0	60.0	4.0	?	?	85	4.0
Occupied Territories	0.0	0.0	0.0	0.0	0.3	0.3	150.0	1.5	0.0	0	50	1.0
Jordan	0.2	0.1	0.03	0.5	0.4	0.1	50.0	2.0	?	5000	90	3.5
Kuwait	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	?	?	2	0.7
Lebanon	0.0	3.8	0.5	3.3	0.5	3.8	1000.0	10.0	0.0	?	?	3.0
Oman	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.1	cc	?	65	0.4
Saudi Arabia	0.0	0.0	0.0	0.0	3.5	3.5	4.5	3.5	cc	?	80	7.0
The Sudan	103.0	10.0	55.5	18.5	0.5	0.5	20.0				95	20.0
	Sudan loses half the White Nile flow - loses19 km3 annually - and most of the internally derived surface flow thro' evaporation in the Sudd. Also about 10km3 lost annually at Lake Nasser/Nubia.											
Syria	17.0	0.5	12.0	5.5	1.5	7.0	7.0	6.0	?	?	75	10.0
	The natural flow of the Euphrates would bring Syria c29km3 annually. By 1990 the avereage flow was c17km3 thro' the hydraulic works of Turkey											
UAE	0.0	0.2	0.0	0.4	0.4	0.8	0.5	0.0	0.3	?	50	1.0
Yemen	0.0	6.5	1.0	5.5	2.5	8	48.5	4.0	0.0	?	90	?
North and North-East Africa												
Egypt	55.5	0.0	12.0	43.5	3.0	55.5	2.0	0.4	0.2	30	88	60.0
Algeria	0.0	18.0	6.0	8.0	2.0	10	35.0	5.0	?	60000	72	30.0
Libya	0.0	0.1	0.1	0.0	1.8	1.8	8.0	0.5	?	2500	90	7.0
Morocco	0.0	25.0	5.0	20.0	5.0	25.0	126.0	15.0	?	?	91	30.0
Tunisia	0.0	2.5	1.0	1.5	1.8	3.3	12.0	0.8	?	10	90	?
Other relevant data - do we want to include these data?												
Ethiopia												
Iran	0.0											
Turkey												
Israel	0.6+0.2+0.1	0.0	0.05	0.9	0.6		400.0	4.0		5000	65	4.0

Table 3 The status of the water economies of the region with respect to the economic strength of the respective countries

Economies in water surplus	**Economies in immediate or long-term water deficit**
Oil economy	***Oil economies***
Iraq	Saudi Arabia
	Kuwait
	UAE
	Qatar
	Oman
	Libya
	Partial oil economies
	Egypt
	Yemen
	Syria
	Tunisia
	Algeria
Non-oil economies	***Non-oil economies***
Lebanon	Jordan
The Sudan	
[Turkey{	Morocco

Table 4 Estimated proportions of potential treated urban and industrial waste water of estimated future water in Egypt and Jordan

Existing water				**Total**	**New water**					**Total**
Water available	In agriculture Single use	With-re-use			From improved systems & irrigation efficiency	From Jonglei I (unlikely to be completed)		From urban waste-water treatment		of all water including all re-used water
Country	**km3 A**	**km3**	**km3**	**km3**	**km3**	**km3**	**%** (of Z)	**km3**	**%** (of Z)	**km3 Z**
Egypt										
Usual estimates	55.5	38	-	55.5	*Scenario* *Low* 5	2	**3.2%**	2	**3.2%**	62.5
					High 10	2	**3.2%**	4	**6.4%**	64.5
Accounting for agricultural re-use	55.5	38	Scenario Low 22	77.5	*Scenario* *Low* 5	2	**2.5%**	2	**3.2%**	79.5
			High 42	97.5	*High* 10	2	**2.0%**	4	**4.0%**	99.5
Jordan						**From fossil resources**				
Usual estimates	0.8	0.6		0.8	0.1	*Scenarios* 0.1	**8.3%**	*Scenarios* *L* 0.2	**16.7%**	1.2
						0.2	**14.3%**	*H* 0.4	**28.6%**	1.4

Sources: Column A offieial data from the Ministry of Public Works and Water Resources of Egypt and the Jordanian Water Authority. Other figures are author's estimates.

Table 5 An analysis of types of water availability - water supply - with respect to their cost of delivery and reliability of water supplies in Arab countries and showing relevant uses vis-à-vis water delivery costs

	Volume	Reliability - environmental & technical	Reliability - political	Quality	Cost of delivery	Water type
Free or low cost water suitable for all types of use including irrigated farming						
Rainfall	*	*	***	****	*****	
Indigenous surface flows	*	**	*****	****	****	
Cross-border surface flows						
• no control	* to ****	*	*	****	****	
• engineered	* to ****	*****	*	****	****	A1
Cross-border sub-surface flows	* to **	***	****	*****	*****	A2
Groundwater - renewable • from less than 100 m depth	* to ***	(short term) **** (long term) *	****	** to ****	****	A3
Groundwater - non-renewable • from less than 100 m depth	* to ***	(short term **** (long term) *	****	** to ****	****	A4
Expensive water suitable for water uses able to bear high water charges						
Groundwater - renewable • from over 100 m depth	* to ***	(no long-term role) (short term) **** (long term) *	****	** to ****	*	B1
Groundwater - non-renewable • from over 100 m depth	* to ***	(no long-term role) (short term) **** (long term) *	****	** to ****	*	B2
Re-used water	*	*****	*****	****	*	B3
De-salinised water	*	*****	*****	****	*	B4
Imported water as water	*	*****	**	****	*	B5
A very flexible, reliable but expensive source of water						
Imported water in other imported products	****	*****	***	*****	-	B6

*	very unfavourable	****	favourable
**	unfavourable	*****	very favourable
***	appropriate		

[boxed] Operationally usable

Table 6 An analysis of types of water demand in Arab countries and the nature of the water required to meet such demands

	Volume	Reliability - Environmental & technical	Reliability - Political	Quality	Cost of delivery	Water type
Free or low cost water required - *$US 0.0 to $US 0.01 per cubic metre*						
Irrigation	*****	****	****	***	*	A1,A2, A3, A4
Medium to high cost water can be used - *$US 0.2 to $US 1.0 per cubic metre*						
Industry	*	*****	*****	**	****	B1-B5
High cost water can be used - *$US 1.0 or more per cubic metre*						
Municipal use						
• for green amenity						
• in weak economies	*	****	****	**	(*****)	B1
• in strong economies	*	****	****	**	*****	B1-B5
• for domestic consumption						
• in weak economies	*	****	****	**	(*****)	B1-B5
• in strong economies	*	****	****	**	*****	B1-B5

*	Very low	****	High
**	Low	*****	Very High
***	Medium	(*****)	Very High but too expensive to deploy

Table 7 Past water resource allocation and management practice in the Middle East and Northern Africa and future options

	Natural water	Natural water	Natural water	Natural water	New water	New water
	Surface storage & & withdrawals from groundwater	Distribution & drainage - agriculture	Distribution - domestic & industrial	Quality assurance	Waste disposal & water re-use	Desalination
Limited management of water supplies						
Pre-19th century	No control - some natural surface storage	Minor canalisation. Natural re-use of Nile in agriculture	None	None	Limited - some careful management at some periods in Cairo	None
	Traditional groundwater use	Traditional systems - qanat and falaj				
Limited supply management - significant advances in distribution and drainage						
19th century	Minor control works on surface water	**Major canalisation in late 19th century**	Limited piped supplies in late part of century	None	Limited	None
Increasing supply management of surface water - beginnings of major groundwater use						
1900-1950	**Major dams on Nile constructed.** Groundwater development	**Major canals & drainage**	Major cities provided	Limited	Limited	None
Control of surface water supplies and heavy use of groundwater						
1950-2000	**Aswan Dam** & other major dams on **Tigris-Euphrates** Widespread construction of **minor storage works. Major groundwater use**	**Water carriers** Libya - (also in Turkey)	Urban provision - **including system improvement;** reduction of system waste. Beginning **of water charging. Efficient systems in agriculture.**	Improving	Initiated in most cities eg Egypt. Some rural provision.	In strong economies (Gulf)
Demand management to adjust demand to scarce surface water and scarce and expensive groundwater						
2000-2050	Major dams in upper Niles. **Total control.**	**Additional water carriers**	**Urban and rural piped supplies**	**Widespread**	**Widespread water re-use of urban water for use in agriculture & other sectors**	In strong economies

Table 8 The major shifts in approach in the policies and practices of managing and allocating water in the Middle East and North Africa

From the management of supply *Old solutions* Increasing the volume and timeliness of water availability: - dams, water storage, canals, pipelines - enhancing natural re-use in agriculture	**To the management of demand** *New solutions* Reducing waste: - reducing evaporation from surface storages - reducing water leakage in systems - increasing water treatment and the re-use of water
From ignoring the economics of water use in water allocation and management policies *Old and current practices* Assumption that water is a free good	**To the incorporation of economic principles in water allocation and management policies** *New practices* Attempts to charge for water in all sectors. Recognition of principles of environmental economics.
From traditional inequitable practices *Old and current practices* Some traditional practices were devised according to principles of equity especially at the local level of allocating and managing irrigation water. The international division of water has generally been inequitable.	**To the recognition of principles of equity** *New practices* The adoption of concepts of entitlement to secure supplies of domestic water. The recognition of the value of water and the need to allocate water to sound economic uses. At the international level the adoption of Helsinki and ILC Rules.
From ignoring ecological impacts and the sustainability of water using practices *Old and current practices* Little recognition of the consequences of water and soil mismanagement	**To the recognition of principles of ecological sustainability** *New practices* The adoption of methods of Environmental Impact Assessment

Table 9 Types of activity associated with the allocation and management of scarce water and some political and institutional consequences in the Middle East and Northern Africa

Problem	Arena & institutions affected by the problem	Politically divisive or not - in current information circumstances
Issues addressed by political elites, government institutions and international agencies		
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4 Using existing and new water as efficiently as possible (Productive efficiency)	Public and private bodies & international agencies	Non-divisive
Issues not addressed by political elites and government institutions although international agencies may show concern		
5 Efficient inter-sectoral water allocation (Allocative efficiency)	Private interests, the political elite & government institutions; also international agencies	**Extremely divisive** because there would be losers and these losers power are powerful
6 Introduction of engineering and institutional (economic) instruments to improve the efficiency of water use according to sound principles of demand management	Private interests, the political elite & government institutions; also international agencies	**Extremely divisive** because major changes in user's behaviour would be required