4 Rural Economic Transitions: Groundwater Use in the Middle East and Its Environmental Consequences

J.A. Tony Allan

King's College London & SOAS University of London, SOAS, Thornhaugh Street, London, WC1H 0XG, UK

Renewable groundwater is a fatally attractive source of water, especially in political economies that have not yet devoted substantial political energy to developing norms and laws to establish ownership, or to regulating water use to achieve efficiency and environmental consideration.

Farm lobbies are the oldest of all lobbies. They are incredibly strong in a young economy such as that of the USA. They are even stronger in societies that have been coping with periodic 'lean years' for four or more millennia.

Introduction: Groundwater in Its MENA Context

The first purpose of this chapter is to identify and explain the importance of groundwater in the Middle East and North Africa (MENA) region in the second half of the 20th century. The second is to demonstrate that one of the most important roles of the MENA region's very limited groundwater (Table 4.1) has been as an enabler of an important rural socio-economic transition. Groundwater played this important transitional role by strengthening individual family economic circumstances in rural areas. These stronger family economies were able to provide a stable pattern of expenditure, which enabled the acquisition of skills by the younger family members. Thus equipped, significant proportions of whole generations have moved to urban centres. Many rural communities in the region experienced relatively high rural incomes for about three decades on the basis of groundwater use.

At the same time, there is no question that those running the MENA political economies presided passively over a water-managing system that overused environmental capital – groundwater – that underpinned the process. This socio-economic groundwater-related phenomenon has also been identified in South Asia where numerous strategies have enabled similar transitions (see Tushaar, Chapter 2, this volume; Burke and Moench, 2000). Llamas and Custodio

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Table 4.1. A typology of MENA economies useful in analysing the management of groundwater in the MENA region. (From the author.)

Low-income economies	Yemen
Partially industrialized economies	Lebanon, Syria, Jordan, Palestine, Egypt, Tunisia, Morocco
Oil-enriched economies with different groundwater endowments:	
• With modest renewable groundwater	Algeria, Iraq
• Mainly with non-renewable (fossil) groundwater	Saudi Arabia, Libya
• Very poor groundwater endowment	Kuwait, UAE, Oman, Qatar
Industrialized diverse economies with poor water endowment	Israel

For the purposes of this overview Turkey and Iran in relatively hydrologically favoured parts of the region have not been included.

(2003a,b, pp. 13–26) have drawn the attention of water professionals and water policymakers to the importance of taking a balanced view of the drawdown of groundwater aquifers. They show that lowering aquifer levels for productive economic purposes can bring economic and environmental benefits. Using the water stored in aquifers leaves space for the recharge following major rainfall events. The MENA region is particularly subject to such erratic rainfall patterns. Lowering groundwater levels where they have been at, or close to, the surface reduces evaporation and also transpiration where vegetation has been supported by groundwater (Llamas and Custodio, 2003b, pp. 18–19). It will be shown that there have been remarkable experiments in managing groundwater storage in the MENA region. However, the most significant feature of MENA groundwater management has been the revelation that groundwater resources are never sufficient to underpin food self-sufficiency. At best they can be an element in a complex of resource management strategies that achieve overall water security. Economic instruments and processes beyond hydrology and hydrogeology are the locus of water security.

Background

The MENA region's farmers and governments are very aware of water and the potential constraints of encountering seasonal and systemic water shortages. Irrigated farming is a deeply entrenched social phenomenon because it is the sole livelihood provider for many communities. Irrigated farming, as a result, is disproportionately prominent in national water allocation policy discourse. In the non-oil economies of the region, irrigated farming is still the basis of the livelihood of the largest employed sector. Secure livelihood is pivotal for rural societies. Traditional irrigated livelihood is integral to a range of powerful ideas that tend to reinforce the notion that irrigated farming is worthy, essential and even holy. Farmers do Allah's and God's work. Unfortunately irrigated farming brings the lowest economic returns to water of any productive combination of factor inputs.

The water predicament of the MENA economies is globally significant. Their experience in coping with progressively more serious water scarcity – demographically driven – in the second half of the 20th century provides an important parable. The experience is especially relevant to economies in arid regions where communities depend on irrigated farming. Water scarcity across the MENA region has been exceptional by global standards. The challenges facing some of the MENA economies are unprecedented at least in modern history.

In order to develop a comparative analysis – within the region and with other regions facing similar problems – it is tempting to identify a typology of the economies of the MENA region based on endowments:

1. Environmental endowments:
   - rich renewable groundwater endowments vs. poor renewable groundwater endowments in general (with the exception of Morocco there are only poor groundwater-endowed economies in relation to demographic circumstances in the region);
   - rich fossil water endowments vs. little or no fossil water endowments (Libya and Saudi Arabia vs the other economies);
   - other renewable water endowments (at the surface and in soil profiles) vs. very limited other water endowments (Egypt, Iraq, Syria and Lebanon vs. the other economies).

2. Non-water endowments and circumstances:
   - economies with large numbers of water-challenged water users living at high elevations – all dependent on scarce groundwater – vs. economies with water users living at low elevations (part of Syria, Jordan and Yemen vs. the other economies);
   - rich economies with poor water resources (e.g. oil-enriched), diversified economies and responsive political systems vs. poor natural resources, non-reforming political systems and limited economic developmental capacity (Algeria, Libya, Iraq, Saudi Arabia, Kuwait, Qatar, UAE and Oman vs. the other economies; Syria, Egypt and Yemen have limited – but important in the short term – oil resources).

The economies of the region do not fit neatly into two or three categories according to groundwater endowments. A typology based on political economy outcomes rather than groundwater endowments provides much greater analytical insights, i.e. a typology based on what political economies have done with their water endowment rather than how they are endowed. Environmental determinism has everywhere been discredited. Recent MENA groundwater management experience confirms that analyses based on water resource determinism must be avoided.

There is very strong evidence in the region that poor water endowments, especially poor groundwater endowments, do not determine approaches to utilizing and managing them. Israel is worse off in its water endowment than a number of its neighbours (see Table 4.2). It has no oil resources either. But it has

Table 4.2. Data on the Nubian sandstone aquifer systems (NSAS) of northern Africa. (From CEDARE/IFAD Programme for the development of a regional strategy for the utilization of the Nubian sandstone aquifer. Cited in Bakhbakhi, 2002.)

	Nubian system Palaeozoic and Mesozoic sandstone aquifers		Post-Nubian Miocene aquifers		Total freshwater in storage	Recoverable groundwater	Present extraction from NSAS		
							Post-Nubian	Nubian system	Total from NSAS
	Area ('000 km^2)	Volume ('000 km^3)	Area ('000 km^2)	Volume ('000 km^3)	('000 km^3)[a]	(km^3)[b]	(km^3)	(km^3)	(km^3)
Egypt	815	155	426	97	252	5,180	0.306	0.200	0.506
Libya	754	137	494	72	208	5,920	0.264	0.567	0.831
Chad	233	48	NA	NA	48	1,630	NA	0.000	0.000
Sudan	373	34	NA	NA	34	2,610	NA	0.840	0.833
Total	2,176	373	921	169	542	15,340	0.570	1.607	2.170

[a]Assuming a storability of 10^4 for the confined part of the aquifers and 7% effective porosity for the unconfined part.
[b]Assuming a maximum allowed water level decline of 100 m in the unconfined aquifer areas and 200 m in the confined aquifer areas.

combined scarce renewable groundwater and some other renewable waters with its other endowments to develop a diverse and effective economy – albeit in very controversial asymmetric local power relations. (Allan, 2001; Selby, 2005).

The MENA region is also a very useful groundwater management laboratory, which confirms that water problems are only partly solved. It is evident from the levels of food imports of all the economies of the region that in almost all cases the region's problems are not even basically solved in the water sector. There are two ways of approaching the need for more water. Both encounter thresholds where they can contribute no further. The first threshold of water insufficiency is reached when supply management measures cannot deliver more solutions. The second threshold is reached when the increased efficiency associated with demand management proves to be insufficient to achieve or maintain self-sufficiency. At this point, the deficit has to be addressed in the political economy rather than in the water sector.

All the economies of the MENA region are solving their current water shortage problems outside the water sector. Table 4.1 indicates the extent to which the individual economies were solving their water deficit problems and avoiding international conflict over water by resorting to imports of water-intensive commodities (Allan, 2002, 2003). Their future water problems will also be solved outside the water sector in international trade. The MENA economies can pay for imports through the development of their own political economies. The capacity to pay for imports is politically determined. Politics determines whether an economy diversifies and strengthens. Groundwater endowment is a minor factor in relation to the bigger water picture. But in some economies in the region groundwater has provided a crucial and timely resource to support rural economies as families move to earn their livelihood in the cities.

With this evidence that a version of water security can be achieved despite poor groundwater endowments, a political economy analysis will be adopted. The strength or weakness of the individual MENA economies are expressions of their political, including institutional, capacity to combine water endowments effectively with other environmental capital, and with human, social and financial capitals.

On the basis of the current political economy outcomes – reflecting the ability of water users and governments to manage scarce groundwater endowments with different levels of effectiveness – we can identify the following typology.

MENA Groundwater Resources

Before analysing the MENA region's experience in managing its water in the different types of political economy, a brief quantification of the region's water will be provided. Its other freshwater resources – surface waters – will also be shown to provide a context. The very limited soil water resources[1] have not been estimated for the individual economies; however, a rough estimate for this chapter is provided. This number is necessary to make it possible to provide an estimated water budget for the region that approximates to its water needs. Surface and soil water will not be analysed in detail. They will be referred to when they are the most important or very significant elements in an economy's water use.

Renewable groundwater

The majority of the MENA region's accessible renewable groundwater aquifers are located in the region's extensive coastal plains. Human settlement has been supported by coastal aquifers for millennia along the coasts of northern Africa and the eastern Mediterranean as well as in the Gulf. As populations rose and groundwater levels fell, through excessive use, all these coastal aquifers have been subject to sea water intrusion. The second half of the 20th century witnessed progressive subsurface seawater intrusions of more than 20 km, e.g. in Libya, and of even greater distances under the delta of the Nile. A feature of the groundwater management of delta Egypt is the cultivation of rice associated with high inputs of water. High levels of water use prevent or at least slow the advance of the saltwater–freshwater interface. There is evidence from Israel that coastal aquifers can be managed to avoid serious degradation by means of technology and regulation, but at present such technology and regulation have not been deployed elsewhere.

Alluvial aquifers and other aquifers exist in inland basins and in the uplands of the region – for example, east of Damascus in Syria, in the highlands of Jordan and Palestine and in the highland basins of Yemen in Sana'a, Tai'iz and Sa'adah. These renewable aquifers are without exception being used beyond their rates of recharge.

Fossil groundwater

The deserts of northern Africa and the Arabian peninsula have been extensively explored for oil in the second half of the 20th century. Oil exploration companies are contracted to record and report on the hydrogeology, especially the non-renewable fossil waters. These groundwater data have been systematically collated by the national governments of the region.

Past rainfall regimes over the Sahara and the Arabian peninsula have left in place substantial reserves of groundwater with estimates of their age of between 12,000 and 30,000 years (Wright and Edmunds, 1971; Wright, 1986). Much of the ancient water is of usable quality (Edmunds and Wright, 1979). This water is often at accessible depths in terms of pumping costs, but it is located hundreds of kilometres away from potential users. An exception is the rapidly expanding capital city of Saudi Arabia, Riyadh. It lies close to 'fossil' groundwater but perversely the national government decided to devote almost all the 'fossil' water to agriculture rather than to supplying the city. In 2005 the city was mainly supplied by desalinated water pumped 450 km from the Gulf and lifted 600 m, costing \$1.4/m^3, to deliver to Riyadh. In the first few years of the new millennium the city used only 145 million cubic metres of local deep groundwater at a cost of about \$0.44/m^3 and 261 million cubic metres of desalinated water at a higher cost (E. Elhadj, London, 2005, unpublished data).

The volumes of water listed in Table 4.3 are more interesting to water scientists than of relevance to water managers and policymakers. The estimates are in many cases preliminary although helpful in so far as they narrow the levels of uncertainty associated with such 'fossil' water resources. For water managers the estimates are not useful. The high estimates of supposedly recoverable volumes of fossil water beneath the Libyan Sahara would secure the Libyan economy and its future estimated populations for 500 years at current rates of use. The low estimates would underpin all the water needs of the 2005 Libyan population for 100 years if they could be technically mobilized. On the basis of these estimates it is possible for Libyan water planners to claim in some international dialogues that Libya is very water-secure. Nevertheless, Libya accesses net annual volumes of virtual water of about 1.3 km^3 (Hoekstra and Hung, 2002; Chapagain and Hoekstra, 2003) in food imports rather than mobilizing sufficient fossil water to meet all its water needs. Egypt is also rich in fossil water but its net imports of virtual water at more than 18 km^3 annually reflect a national water self-sufficiency of 78%. There is no attempt to bring the fossil water into the national water budget. Nor in the case of Egypt is there significant development of the 'fossil' water to address Egypt's current water deficit. Present technologies are inadequate. International market circumstances are such that it is impossible to get the 'fossil' water into MENA economies cost-effectively for agricultural use, especially in Egypt. The oil-rich economies can meanwhile indulge their inclination to be self-sufficient in food via big infrastructures. The Great Man-made River project in Libya is an experiment of global significance testing technologies and the institutional capacity of a political economy of the region to develop MENA fossil waters.

Table 4.3. An estimate of the MENA region's annual water budget in 2005 showing the limited role of groundwater. (From FAO AQUASTAT 2003; Chapagain and Hoekstra, 2003, pp. 68–73; authors' estimates.)

	Groundwater (km^3/year)	Percentage	Required for food self-sufficiency (km^3/year)
Freshwater sector provides limited and partial solutions			
Surface water	154	49	Overused in many basins
Renewable groundwater	28	9	Generally severely overused
Fossil water contribution	3	1	Expensive option in agriculture in MENA
Total	185	50	Used at rates that severely impair environmental water services
Soil water	40	13	Very approximate estimate by author
Non-water sector provides solutions with substantial future potential			
Net virtual water 'imports'	77	25	Rising; very attractive economically
Manufactured water	3	1	Rising; too expensive for most agriculture
Total	80	26	Easily expandable, economically acceptable, no regional impairment of environmental services of water
Total	305	100	272 needed, assuming 1100 m^3/person/year for 247 million population

A feature of the fossil groundwater hydropolitics in the Middle East is that economies that have to share their surface and groundwaters with other countries do not want to draw attention to the fossil water endowment. Presumably it would be a complication in any attempt to resort to the principle of *equitable utilization* in any legal or quasi-legal process to settle an international water dispute. For example, Egypt and Israel are very reluctant to discuss their fossil water endowments.

MENA groundwater in relation to the total water resources of the region's economies

Renewable groundwater is an important resource but a minor one in relation to the surface waters enjoyed by a few of the region's economies – Syria, Iraq, Lebanon and Egypt. The fossil water resources of three of the region's economies – Libya, Egypt and Saudi Arabia – are vast but not able to be used to meet water needs in all sectors in current technological and economic circumstances.

Table 4.1 provides estimates of the water resources of the economies of the region. It gives basic information on current estimates of the water resource status of the 18 economies of the MENA region that endure water resource problems. The general impression provided by the data-set is that the Tigris–Euphrates economies are still relatively well endowed with water resources. Lebanon is also relatively secure with respect to water. All the other economies are enduring serious water deficits with respect to their capacity to produce enough food for self-sufficiency. And the situation is worsening as a result of rising populations. Future demographic trends will be very significant vis-à-vis water resources in the MENA region during the 21st century. The population of the MENA region will probably double before the mid century. This rate of increase is higher than most economies in Asia and South America and similar to those in Africa. The MENA region has indirectly benefited greatly from the population policies of Asia's major economy, China. China has lifted out about 300 million of its population from poverty in the last three decades. The population of the 18 economies of the MENA region considered here is only 280 million at the beginning of the millennium. In this type of calculus the role of water can be seen to be minor compared with the scale of the global demographic shifts and in population policies in other regions.

Table 4.1 provides estimates of the very limited volume of renewable groundwater in the MENA region. The 18 economies listed have in total only about 28 km^3 of renewable groundwater annually – 15% of the total freshwater used and 9% of the total water needed for food self-sufficiency. Most of this renewable groundwater has been used without giving attention to the institutions, regulations and technologies that would match water withdrawal with regional hydrological regimes for over four decades. This volume is sufficient for the *domestic* and *industrial* water needs of about 250 million people – a number close to the total population of the 18 economies. Domestic and industrial water use is about 10% of the total water that an individual or an economy needs. The remaining 90% of water needs is covered partially by renewable surface and soil water, with the deficit remedied by virtual water.

These macro-level estimates of the elements of water availability and use are subject to poor precision, with estimates of soil water being the least precise. However, it is interesting that the author's estimated figure of 40 km^3 of annual regional soil water was entered before the numbers for virtual, surface and groundwaters and before all sources were added together. Apart from the estimates for soil water all the others are based on best practice in respected agencies such as the Food and Agricultural Organization (FAO) for surface and groundwaters, or in a research institute such as the Institute for Water Education (IHE) for the virtual water data. The estimates used are: 154 km^3/year for annual surface water use; 28 km^3/year for renewable groundwater and fossil water use; and 80 km^3/year for virtual water and desalinated water. The very approximate estimate of 40 km^3/ of annual soil water use for rain-fed crop production brings the numbers for use and for estimated total regional water needs to a reasonable convergence with the estimate of water needed to secure the food and job needs of the region's population. If the absence of a more reliable estimate for soil water troubles hydrologists and soil scientists, they are invited to provide it. Meanwhile water users, managers and policymakers will remain comfortably unaware of the role of soil water. Ignoring soil water in a national water budget is part of normal political behaviour. Politicians, and political processes more generally, have to deal with all sorts of uncertainties including the absence of knowledge on most issues of importance. Water scientists could help if they can provide (accurate) evidence on soil water and offer such data to political processes in a friendly language register.

A very approximate water balance for the 18 economies of the MENA region considered in this discussion is shown in Table 4.1.

Table 4.1 and Fig. 4.1 are helpful in putting the MENA region's finite groundwater into perspective. The volumes of groundwater available are small. Renewable and fossil water at the beginning of the millennium amounted to only:

18% of all freshwater use in the region;
11% of the total water needed by the region's peoples and economies;
35% of the unconventional water use – virtual and manufactured water.

In addition, the MENA history of intense groundwater use is very short, i.e. about four decades. The era spans from the initiation of intensive use in the 1960s to the end of the millennium, by which time most renewable groundwater users were reducing pumping because the aquifers were damaged.

There are several strategic implications of these circumstances for water policymakers in the MENA region:

- The spectacular contribution of renewable groundwater to the very important urbanization transition in the MENA region in the past four decades was an important, but brief and unsustainable, moment in the region's economic history. Renewable groundwaters were too easy to develop in a cultural setting that rejected any regulatory regime. Renewable groundwaters have been dangerously impaired in some economies.
- As the region's renewable waters, including groundwaters, have been severely mismanaged, the priority should be to remedy their poor water quality and to initiate measures that restore some of the essential environmental services of renewable surface and groundwaters. The priorities should be, first, to put water back into the environment and, second, to reduce pollution. Experience in the region indicates that reforms will only be possible when the economies are diversified and strong.
- The future water security of the region's much higher population will be mainly addressed by measures outside the region's water sector. These measures enable the import of water-intensive commodities from global production and trading systems. In the region itself these non-water-sector processes are socio-economic development and especially economic diversification. The manufacture of desalinated water will also be a very important remedy for those economies that do not have sufficient water to meet domestic and industrial needs as most of the region's population lives either near the coast or on major river systems.

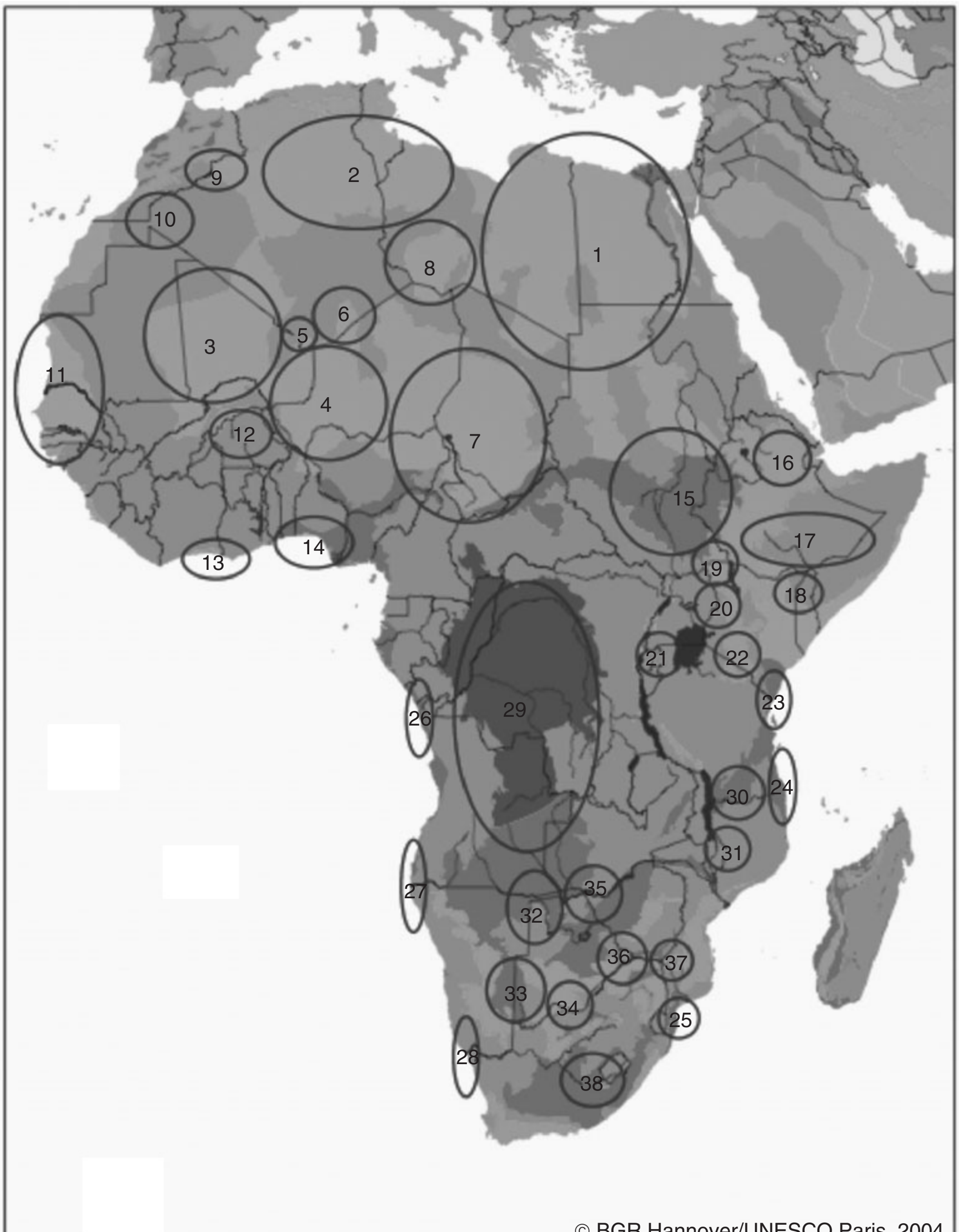

Fig. 4.1. Map of trans-boundary aquifers in Africa.

The rest of the discussion will examine the short history of intensive renewable groundwater use. It will show how a brief phase of intensive groundwater utilization has played a very important positive role because groundwater has a number of qualities for those facing immediate water scarcity. These qualities make renewable groundwater a fatally attractive source of water, especially in political economies that have not yet devoted substantial political energy to developing norms and laws to establish ownership, or to regulating water use to achieve efficiency and environmental consideration. The qualities of groundwater that make it fatally attractive are:

- Groundwaters can be beneath, or extremely close to, the projects and needs of water users.
- Groundwaters are often very close to the surface, at least when they are first developed, and can be developed at low cost.
- Groundwaters can be accessed by individual farmers and other individual users without the constraints of a regulated and bureaucratized water distribution infrastructure.
- Users can use water at will – provided only that they have the resources to acquire, operate and maintain the equipment and fuel it. This flexibility makes groundwater a very useful primary source of water for irrigation and an especially useful supplementary source in the extensive marginal rainfall tracts in the MENA region. A very important feature of the control that individual users have over groundwater is the capacity to address water scarcity in more than one annual cycle. The economic significance of this capacity to withstand droughts for more than 1 year is of immeasurable importance to those who have risked raising cash crops.

The qualities of groundwater that make it hard to monitor are technical, social and political:

- Users have little awareness of the impact of individual groundwater users on regional levels of use, especially in the early phases. The absence of awareness of the need for collective action is the norm.
- Renewable groundwater is regarded as a common pool resource – anyone who can access it is entitled to use it. This approach exists in all the economies of the region except Israel. Attempts to license wells and to limit groundwater use have generally failed.
- The impact of overuse is gradual and in the common pool circumstances of the MENA region a 'tragedy of the commons' has been accelerated (Handley, 2001; Lichtenthaler, 2003).

Mindsets and Sanctioned Discourse: Managing Groundwater in the MENA Region

More important than knowledge of the volumes and rates of use of renewable groundwater and fossil groundwater is the knowledge constructed by political classes and by the major users of water in the region – namely the irrigation communities. There are two main lessons to be learned from the MENA region about the unquestioning determination of such interests when in coalition to damage scarce renewable groundwater.

The first lesson is, as already mentioned, that the flexible accessibility of groundwater makes it a very easy and often cheap resource to mobilize. At the same time renewable groundwater has the capacity to enable rural communities to achieve higher incomes. Average yields of staple grains can be much more than doubled with supplementary irrigation, and more valuable crops, with higher returns to water, can also be raised.

The second lesson is that new users of renewable groundwater believe in their entitlement to the groundwater and will only stop using it when it runs out. No collective measures have been put in place to regulate groundwater use for the collective good – except in Isarel – at least certainly not in the last 40 years during which the MENA region's renewable groundwaters have been utilized at unprecedented rates.

Groundwater has nevertheless played a very important role in the economies of MENA since the mid 20th century. It will be shown in the following discussion that the mindset that has driven the development of groundwater at the level of government as well as at that of the individual farmer has been fixed on increasing agricultural production to meet national food needs and improve irrigators' incomes.

Supply management approaches, such as pumping more water, have dominated the water management of the last 50 years. A second goal has been productive efficiency, which means achieving more crop per drop via technological interventions. Renewable groundwater has been mobilized at progressively higher levels for irrigation use. Notions of economic efficiency and of the importance of economic returns to water have been evident only by the 1990s, and only in a minority of the economies – in Tunisia, Morocco and Jordan. Israel had embarked on the demand-managing measures of allocative efficiency a decade before in the early 1980s (Arlosoroff, 1996). Demand management requires that the allocation of water in an economy be informed by hydrological, hydraulic and economic science.

Knowledge-based groundwater policy has been rare in the MENA region. The norm is that users of groundwater pump water at rates that contradict the advice of groundwater scientists until the resource is exhausted. These practices reflect the assumptions of the region's water users and governments. These assumptions include a preference for water to be treated as a public good, even as an entitlement. Water should be provided freely and without restriction if possible or with little restriction otherwise. Where water is assumed to be privately owned, which is the case for most renewable groundwaters, the owner of the land assumes that he or she is entitled to use it without constraint other than the cost of drilling and pumping. Long-established uses of water in agriculture are also thought to be more important than uses for recently established activities such as industry and services. The environmental services of water resources are not significant in the minds of water users and governments.

The assumption that food self-sufficiency is a proper goal chimes with the immediate livelihood interests of the large rural populations of the region. The alignment of these interests with the mindset of the leaderships of the region has led to the overuse of the renewable aquifers in every MENA economy. The alignment of farmers' interests and those of the political class is the international norm. It is evident across the economies of the world including those of the USA and Europe. Farm lobbies have disproportionate influence in northern economies. Production and export subsidies are issues that are becoming increasingly politicized internationally. It should not be surprising that the realities of economic life and the imperatives of sustaining farmers' livelihoods in the south are elemental in the economies of the MENA region. The farm lobbies are the oldest of all lobbies. They are incredibly strong in a young economy such as that of the USA and in the recently established European Union (EU). That they are even stronger in societies that have been coping with periodic 'lean years' for four or more millennia should not be surprising.

It is argued next that it would have been strange if groundwater had been managed otherwise in the circumstances of the MENA region in the late 20th century. Even in economies that had the political and economic space to pursue knowledge-based groundwater management policies, both renewable and non-renewable aquifers have been seriously depleted. Overuse of the aquifers of the High Plains of Texas is a sorry tale (Rainwater *et al*., 2005a). The political pressures are captured (Rainwater *et al*., 2005b) in the following paragraph:

> The resistance [to reform] is not purely interest-based, but is generated in some measure by considerations of identity: we are not people who treat the sacred as something to be bought and sold. Similarly, for families who have worked the land for generations, even if only at the level of subsistence agriculture, telling them that it is irrational to farm in their location because climate change is producing extended drought conditions, or that it would be wiser for the government to import virtual water in the form of grain, rather than supporting irrigation projects, is not likely to be well received.
>
> The examples are not limited to the developing world. Consider the worldwide industry that is golf. Why is it so hard to convince people that planting golf courses in Arizona and Dubai is not rational or environmentally sustainable? The wealthy are by no means immune to constructed identities: we are people of leisure who have worked hard and deserve both sun and golf. The purely rational often succumbs to the powerfully normative or the radically political.

MENA farmers and municipalities benefited from advances in technology in accessing and distributing groundwater from the 1950s. In addition, by the 1960s half of the MENA population was oil-enriched. They were able to combine oil-rent-derived financial resources to develop accessible groundwater rapidly and more intensively – especially fossil water in a few economies. MENA groundwater users, like all others in water-scarce regions, found renewable groundwater to be a particularly useful and flexible resource since its use did not require major infrastructures to get the water to the points needed by irrigators. At least this is true for unregulated use, which has been the norm in the region. The development of non-renewable aquifers beneath the deserts of the region after 1980 has in the case of Libya required major pipelines, but this has been the exception.

Concluding Comments

This chapter has shown how MENA groundwater users, water professionals and politicians have managed renewable and fossil groundwater resources during three decades. The potential demand for water doubled during this period with the doubling of the region's population. There are four main conclusions. First, renewable groundwater aquifers are too easy to utilize and to damage in the absence of a regulatory culture. The ease with which they can be turned on and off to comply with the users' needs makes renewable groundwater very popular indeed. But nowhere is there a balanced approach to achieving collective interests.

Second, fossil water resources, of which the region has a significant volume both in northern Africa and in the Arabian peninsula, are expensive to develop, and the pumping and delivery infrastructures are also expensive to maintain. The oil-rich economies that have developed them have been expensively addressing a fantasy of self-sufficient food security without recognizing a much more hazardous technological dependency.

Third, the region has not developed the institutions and the political culture to install regulatory measures that would address the collective interests of the populations of an individual state. At the interstate level international customary law is very poorly developed with regard to groundwater shared by more than one state. With only minor exceptions, there have been no formal negotiations over trans-boundary groundwater despite the urgency of the problems facing managers. The issues have been discussed at scientific conferences on water resources, focusing on the shared North African aquifers. Data are beginning to be shared and published by agencies such as United Nations Educational, Scientific and Cultural Organization (UNESCO) and Centre for Environment and Development for the Arab Region and Europe (CEDARE), but as the issues are not urgent it is understandable that progress over cooperation is slow.

This chapter has emphasized that institutional development is slow as a result of the lack of diversity and strength of the MENA economies. This lack of diversity and strength is in turn the result of the patrimonial political and governance regimes that characterize the region. Israel, a non-patrimonial state, has demonstrated that water problems are easily manageable within a diverse and strong economy. Diversity and strength come when the political circumstances enable the productive combination of the factors of production. Sound water management is associated with economic strength and especially economic diversity. These socio-economic virtues are a consequence of political processes that combine and manage resources effectively.

The MENA region has too many examples of the social and cultural conditions that determine short-term water-using practices. Renewable groundwater is too easily developed. Regulation cannot be installed. Everywhere water policy is made by officials, politicians and water users with mindsets established in the demographic and water-using practices of the past. Water-managing policies evolve that molest as little as possible the users of big volumes of water in irrigation. This is especially the case in the use of groundwater, which has indeed proved to be a very popular water resource with farmers.

As a result of the easily initiated and impossible-to-stop forms of renewable groundwater use, individual MENA economies have experienced the comfort of renewable groundwaters in rural areas for periods of 20–40 years. Renewable groundwaters has supported very important and timely rural transitions. Irrigation, as well as supplementary irrigation, has enabled rural families to enjoy a period of higher income than in the past. The period of greater prosperity has come about in combination with improved public services. Together these factors have enabled a couple of generations of young people to gain education and skills that have eased their transfer from rural areas with poor long-term prospects to the cities of the region.

Notes

1 Soil water here is defined as the water intercepted by the root systems of plants and crops. It is the water that exists in soil profiles after a period of rainfall. It is not the water provided by an irrigation system from surface or groundwater resources. This rain-fed soil water is extremely difficult to quantify. Soil water is, however, very important globally as most of the agricultural production of the world, and almost all the forest products, are raised with soil water. Engineers are not comfortable with the concept as soil water cannot be pumped. They are also unhappy with attempts to quantify soil water as it normally moves downwards in response to gravity. The significant soil water is that intercepted by plants and crops. Economists are disposed to ignore soil water as it is even more difficult to value than to quantify. For this chapter it has been estimated that soil water available annually in the 18 economies considered averages to about 40 billion cubic metre. This volume is about 30% bigger than the renewable groundwater available (28 billion cubic metre) in these economies.

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