Groundwater Management in the Near East Region
Synthesis Report

Food and Agriculture Organization of the United Nations

Rome, 2011
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**Foreword**

The Near East region is characterized by severe water scarcity with many countries having less than 500 CM/capita/yr of renewable water resources – a situation that is likely to get worse as populations grow, socio-economic demand for water increases, and climate change threatens to reduce annual rainfall and increase periods of drought.

Most countries in the Near East Region have come to rely heavily on groundwater to meet their growing water demand for domestic, industrial, and agricultural use. Indeed groundwater has always been seen as the reliable source of water particularly in times of drought when surface water is scarce. Some 50 years ago the modest demands placed upon groundwater and the traditional methods of abstracting it, such as shallow wells and Aflaj meant that abstraction rates were generally well within those of natural recharge. The balance between supply and demand was not an issue.

Over the past 30-40 years this situation has changed dramatically as countries in the region have grown both socially and economically. The demand for more food products, policies of food security and self sufficiency, the introduction of new deep well pumping technology, the ease of access to groundwater as a reliable source of good quality water for drinking and irrigation just below good agricultural land, and the constant worries about droughts have all led to an explosion of uncontrolled groundwater development.

Irrigated agriculture is the most significant cause of the growth in groundwater consumption. It has produced many positive benefits such underpinning significant socio-economic development in rural areas and lifted many thousands of families out of poverty. Environmentally there have also been benefits as traditional oases thrive and develop. But agriculture now consumes 80-90 percent of the water used in most Near East countries and the demand is starting to outstrip the natural aquifer recharge. There is now serious over-exploitation of many renewable and non-renewable aquifers across the region which in turn is causing irreparable damage to coastal aquifers from saline intrusion and groundwater pollution. Inadequate sewerage systems add to the problem of pollution in urban areas.

The demand for water in all sectors continues to grow and the options to exploit additional groundwater resources are limited as renewable shallow aquifers become exhausted and water levels in the non-renewable aquifers fall beyond the economic and physical levels of pumping equipment. If this ‘mining’ of groundwater continues at current rates of withdrawal then many countries will face serious water shortages in the not too distant future.

This report is not about the hydro-geology of this region – such technical issues are well reported. Rather it attempts to address the question of groundwater management – How can countries manage their groundwater resources to bring about an appropriate balance between supply and demand so that groundwater exploitation is sustainable, compatible with plans for economic growth, and environmentally sound?

To find out more about what is happening and what plans are being made for the future FAO commissioned country studies by national groundwater experts in Algeria, Iran, Libya, Morocco, Oman, Tunisia, Saudi Arabia, and Yemen. This report brings together these findings in an edited format – country by country – and includes additional information on groundwater from other countries in the region – Egypt, Kuwait, Lebanon, Syria, and Jordan – to provide a more complete picture.
Acknowledgments

This report and the country studies that constituted the main sources of information for its preparation have been commissioned by FAO, within the framework of its endeavour to support countries of the Near East region in addressing water scarcity issues. The process has been carried out under the leadership of Mr Mohamed Bazza, Senior Irrigation and Water Resources Officer, in collaboration with Mr Jacob Burke, Senior Water Policy Officer.

Special thanks are extended to the following national experts who prepared the country studies: Abdelmajid Demmak (Algeria); Mohammad Mahdavi (Iran); Philippe Palls (Libya); Mohamed Oubelkace and M’Hammed Belghiti (Morocco); Slim Zekri and Osman Abdulla (Oman); Elyes Gaubi (Tunisia); Abdulaziz Al-Bassam, Mohammed T. Hussein, Abdulrahman Al-Dakheel and Abdullah Al-Shebel (Saudi Arabia) and Abdullah A. Noman (Yemen).

Appreciation is expressed to Mr Melvyn Kay, RTCS Ltd (UK), for drafting the synthesis papers as well as to FAO support staff and all those who contributed one way or another to the process. M. Bazza, J. Burke and K. Frenken, Senior Officer, FAO. reviewed and finalized all documents.
Groundwater management in the Near East Region

1 Key issues

Most countries in the Near East Region have come to rely heavily on groundwater to meet their growing water demands for domestic and industrial use and agricultural consumption. Indeed groundwater has always been seen as the reliable source of water, particularly in times of drought when surface water is scarce. Some 50 years ago the modest demands placed upon groundwater and the traditional methods of abstraction, such as shallow wells and Aflaj, meant that abstraction rates were generally well within those of natural recharge. The balance between supply and demand was not an issue.

Over the past 30-40 years this situation has changed dramatically as countries in the region have grown both socially and economically. The demand for more food products, policies of food security and self sufficiency, the introduction of new deep well pumping technology, the ease of access to groundwater as a reliable source of good quality water for drinking and irrigation just below good agricultural land, and the constant worries about droughts have all led to an explosion of uncontrolled groundwater development.

Irrigated agriculture is the most significant cause of the growth in groundwater use. It consumes 80-90 percent of the groundwater pumped in most Near East countries. This has produced many positive benefits. It has underpinned significant socio-economic development in rural areas and has lifted many thousands of families out of poverty. Environmentally too there are benefits as traditional oases thrive and develop.

But there are costs too. The demand for water in all sectors continues to grow yet the options to exploit additional groundwater resources are limited as renewable shallow aquifers become exhausted and water levels in the non-renewable aquifers fall beyond the economic and physical levels of pumping equipment. There is now serious over-exploitation of many renewable and non-renewable aquifers across the region. Saline intrusion along the coasts, pollution from inadequate and leaking urban sewers, and excess use of agricultural chemicals are causing irreparable damage. If this ‘mining’ of groundwater continues at current rates of withdrawal then many countries will face serious water shortages in the near future.

This report is not about the hydro-geology of this region – such technical issues are regularly reported on by the scientific community. Rather it attempts to address the question of groundwater management – How are countries managing their groundwater resources to bring about an appropriate balance between supply and demand so that groundwater exploitation is sustainable, compatible with plans for economic growth, and environmentally sound?

This is a big and complex question and is one that most countries in the region are only now beginning to comprehensively address. To find out more about what is happening and what plans are being made for the future FAO, commissioned country studies by national groundwater experts in Algeria, Iran, Libya, Morocco, Oman, Tunisia, Saudi Arabia, and Yemen. This report brings together these findings in an edited format – country by country – and includes additional information on groundwater from other countries in the region – Egypt, Kuwait, Lebanon, Syria, and Jordan – to provide a more complete picture.

This paper is a synthesis of these country reports and focuses on the question of groundwater management. First there is a resume of the technical information available to managers about the supply of groundwater – both renewable and non-renewable resources – and current and future projections of the demand for groundwater, driven largely by socio-economic and environmental issues, that have led to over-exploitation. The paper then looks at the ways in which countries are managing this situation, the
various policies, strategies, and institutional structures that support groundwater management, and the plans being made by governments to bring supply and demand more into line for sustainable groundwater development.

2 Countries of the Near East

The Near East in the context of this document comprises Algeria, Egypt, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Tunisia, Saudi Arabia, Syria, and Yemen. It is a grouping of countries defined primarily by history and culture and comprises all the countries across Africa north of the Sahara desert, the Middle East, and the Persian Gulf. The region is characterised by aridity, with low unpredictable seasonal rainfall and extended periods of drought. In spite of the severe climate, socio-economic conditions are improving, and populations are growing, but so too is groundwater use on which this is increasingly dependent (Figure 1). In most countries it is now the main water supply.

![Figure 1 Country dependency on groundwater – renewable and fossil water](image)

3 Water resources and water use

Table 1 brings together available data on exploitable surface water and groundwater and how resources are used across the region to show the relative importance of groundwater. For consistency these data are taken from the FAO AQUASTAT database. Exploitable groundwater is what is exploitable from a technical and economic perspective and usually less than what is potentially renewable. However, some countries do not have data on exploitable groundwater and so potentially renewable data are shown.

These data do show that the countries listed, except for Iran, Iraq, and Syria, have renewable resources below 1,000 CM/capita/yr - the World Bank’s measure of water poverty (Figure 2). Syria and Iraq are special cases in as much as their water resource is surface water from the Tigris and Euphrates rivers which cross the boundaries of Turkey, Syria, and Iraq. Several countries including Jordan, Kuwait, Saudi Arabia, and Yemen are seriously below this figure. By 2050 the available water per capita is expected to fall by half. The data also show that agriculture is by far the main consumer of water. Agricultural water demand has escalated in all the countries over the past 30-40 years. It accounts for 80-90 percent of the water use in each country and this is expected to rise further as populations continue to expand and improve their socio-economic circumstances.
Although domestic and industrial water use is important, agricultural water consumption is much more of concern not just in terms of the volume consumed but also because crop water evaporates into the atmosphere and is lost until it returns as rainfall. Domestic and industrial water, which represents only 10-20 percent of water use, is not consumed in the same way. Rather it is used and then returned to the basin, and although it may be of poorer quality, in some circumstances it is possible to use it again. In the same way inefficient irrigation practices, which are common place across the region, may actually return water to the basin for potential re-use by recharging shallow aquifers, though it is not always easily accessed and again the quality of the water may be degraded with agricultural chemicals.

But it is not an exaggeration to say that if agricultural water consumption can be constrained by changing cropping or reducing the cropped area, concerns about domestic water availability would quickly disappear.

4 The state of groundwater use

4.1 Matching groundwater supply and demand

Table 2 brings together the technical information on groundwater that managers need such as data on economically and technically exploitable groundwater (rather than potentially renewable groundwater which may not be easily accessed) and groundwater withdrawals so as to produce estimates of national groundwater surpluses/deficits. Again for consistency groundwater data is taken from the FAO AQUASTAT database but this is complemented with data and summary comments from the Country Reports. Some Country Reports indicated predicted withdrawals for 2025 (or 2030 in some cases) and so these are also included. However, it is not always clear how these predictions are calculated. It is likely that current withdrawal rates are projected forward based on population and socio-economic growth without constraints to produce ‘a worst case scenario’. In practice however, the natural decline in yield as aquifers are over-exploited and the possible successful introduction of the various measures to reduce demand may all serve to attenuate future deficits.

Based on FAO AQUASTAT data all the countries listed, except Tunisia and Morocco, are shown as overdrawing on renewable groundwater, although figures for Morocco in the Country Report show that Morocco too has a groundwater deficit. Six countries, Algeria,
Egypt, Libya, Morocco, Tunisia, and Saudi Arabia are also using ‘fossil’ groundwater resources. Clearly there are no ‘sustainable’ yields for this water but the Country Reports offer an indication of what is technically and economically abstracted and the time periods over which this will be available. For this reason Table 2 shows current withdrawals as deficits.

Some countries appear to be at a more critical stage of over-exploitation than others. However, national figures can ‘hide’ more localised problems within countries as groundwater and populations are not evenly spread.
<table>
<thead>
<tr>
<th>Country</th>
<th>Population (x10³)</th>
<th>Exploitable water resources (MCM)</th>
<th>Withdrawals (MCM)</th>
<th>Surplus/deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S/water</td>
<td>g/water</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(MCM)</td>
<td>(MCM)</td>
<td>(MCM)</td>
</tr>
<tr>
<td>Algeria</td>
<td>35,000</td>
<td>6,000</td>
<td>1,900</td>
<td>7900</td>
</tr>
<tr>
<td>Egypt</td>
<td>74,000</td>
<td>49,000</td>
<td>700</td>
<td>49,700</td>
</tr>
<tr>
<td>Iran</td>
<td>69,500</td>
<td>106,315</td>
<td>49,300</td>
<td>137,515</td>
</tr>
<tr>
<td>Jordan</td>
<td>5,700</td>
<td>650</td>
<td>540</td>
<td>937</td>
</tr>
<tr>
<td>Kuwait</td>
<td>2,780</td>
<td>0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Lebanon</td>
<td>3,577</td>
<td>1,580</td>
<td>500</td>
<td>2,080</td>
</tr>
<tr>
<td>Libya</td>
<td>6,000</td>
<td>135</td>
<td>500</td>
<td>635</td>
</tr>
<tr>
<td>Morocco</td>
<td>31,000</td>
<td>16,000</td>
<td>4,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Oman</td>
<td>2,570</td>
<td>1,050</td>
<td>1,300</td>
<td>1,400</td>
</tr>
<tr>
<td>Tunisia</td>
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<td>2,475</td>
<td>1,150</td>
<td>3,625</td>
</tr>
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<td>Saudi Arabia</td>
<td>24,600</td>
<td>2,200</td>
<td>2,200</td>
<td>2,400</td>
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<tr>
<td>Syria</td>
<td>19,400</td>
<td>16,800</td>
<td>3,800</td>
<td>20,600</td>
</tr>
<tr>
<td>Yemen</td>
<td>21,000</td>
<td>2,000</td>
<td>1,500</td>
<td>2,100</td>
</tr>
</tbody>
</table>

Source: FAO AQUASTAT (2000). ¹ per capita figures based on FAO AQUASTAT renewable water resources rather than exploitable resources. Country Reports that form part of the report are marked ‘blue’. ² Exploitable data not available so Renewable water resources are shown.
<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>Exploitable groundwater</th>
<th>Withdrawals</th>
<th>Current deficit</th>
<th>Predicted deficit 2025-30</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(x 10^3)</td>
<td>(MCM)</td>
<td>(CM)</td>
<td>(MCM)</td>
<td>(MCM)</td>
<td></td>
</tr>
<tr>
<td>Algeria</td>
<td>35,000</td>
<td>1,900</td>
<td>54</td>
<td>2,400</td>
<td>-500</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>FAO data on g/w withdrawals shows 4,600 MCM. Country Report suggests this is split as shown between renewable and fossil water.</td>
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</tr>
<tr>
<td>Egypt</td>
<td>74,000</td>
<td>700</td>
<td>9.5</td>
<td>7,000</td>
<td>-6,300</td>
<td>Not available</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>FAO AQUASTAT survey 2005 suggests shallow g/w withdrawals of 6,000 MCM seepage from Nile Basin, 1,000 MCM from other shallow sources</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td>69,500</td>
<td>49,300</td>
<td>71</td>
<td>53,100</td>
<td>-3,800</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No fossil water. Main aquifers along coast and in central plain</td>
</tr>
<tr>
<td>Jordan</td>
<td>5,700</td>
<td>540</td>
<td>95</td>
<td>553</td>
<td>-13</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FAO report suggest that 6 of 12 main aquifers are over-exploited</td>
</tr>
<tr>
<td>Kuwait</td>
<td>2,780</td>
<td>20</td>
<td>7</td>
<td>415</td>
<td>-395</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Continuous deterioration of quantity and quality due to over pumping</td>
</tr>
<tr>
<td>Lebanon</td>
<td>3,577</td>
<td>500</td>
<td>83</td>
<td>1,320</td>
<td>-820</td>
<td>Not available</td>
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<td></td>
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<td></td>
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<td></td>
<td>FAO data on g/w withdrawals shows 4,270 MCM. Country Report suggests this is split as shown between renewable and fossil water. Country Report also suggests annual aquifer recharge approx 700 MCM.</td>
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<tr>
<td>Libya</td>
<td>6,000</td>
<td>500</td>
<td>83</td>
<td>1,320</td>
<td>-820</td>
<td>Not available</td>
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<td>FAO data on g/w withdrawals shows 4,270 MCM. Country Report suggests this is split as shown between renewable and fossil water. Country Report also suggests annual aquifer recharge approx 700 MCM.</td>
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</tr>
<tr>
<td>Morocco</td>
<td>31,000</td>
<td>4,000</td>
<td>129</td>
<td>2,670</td>
<td>1,330</td>
<td>-4,200</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>FAO data on g/w withdrawals shows 3,170 MCM. Country Report suggests this is split as shown between renewable and fossil water. Also Country Report estimates exploitable g/w as 2,575MCM and g/w use as 3,507 MCM use giving a deficit of 932MCM. Water table falling about 2m/yr.</td>
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<tr>
<td>Oman</td>
<td>2,570</td>
<td>1,300</td>
<td>505</td>
<td>1,180</td>
<td>120</td>
<td>Not available</td>
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<tr>
<td></td>
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<td></td>
<td>Country report suggests this deficit is an underestimate and reports exploitable g/w 1,267 MCM, withdrawals 1,645 MCM with deficit -378 MCM</td>
</tr>
<tr>
<td>Tunisia</td>
<td>10,000</td>
<td>1,150</td>
<td>115</td>
<td>810</td>
<td>340</td>
<td>-370</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>FAO data on g/w withdrawals shows 1,900 MCM. Country Report suggests this is split as shown between renewable and fossil water. Country Report also estimates exploitable renewable g/w as 750 MCM.</td>
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<tr>
<td>Tunisia</td>
<td>10,000</td>
<td>1,150</td>
<td>115</td>
<td>810</td>
<td>340</td>
<td>-370</td>
</tr>
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<td></td>
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</tr>
<tr>
<td>Fossil water</td>
<td>1,090</td>
<td>1,090</td>
<td>Not available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Country Report estimates 1,140 MCM/yr withdrawals from fossil g/w. Fossil water shared with Algeria and Libya</td>
</tr>
<tr>
<td>Country</td>
<td>Total G/W</td>
<td>Renewable G/W</td>
<td>Fossil G/W</td>
<td>Unavailable G/W</td>
<td>FAO Data</td>
<td>Country Report</td>
</tr>
<tr>
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</tr>
<tr>
<td>Saudi Arabia</td>
<td>24,600</td>
<td>2,200</td>
<td>89</td>
<td>2,200</td>
<td>unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FAO data on g/w withdrawals shows 22,400 MCM. Country Report suggests this is split as shown between renewable and fossil water. Country Report suggests that shallow renewable aquifers are over-exploited.</td>
</tr>
<tr>
<td>Fossil water</td>
<td>20,200</td>
<td>-19,200</td>
<td>Unknown but &lt;19,200</td>
<td>Not available</td>
<td>Large fossil water reserves. Country Report estimate of exploitable aquifer storage down to 300m is 923,600 MCM.</td>
<td></td>
</tr>
<tr>
<td>Syria</td>
<td>19,400</td>
<td>3,800</td>
<td>206</td>
<td>Not known</td>
<td>-</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No clear picture of withdrawals.</td>
</tr>
<tr>
<td>Yemen</td>
<td>21,000</td>
<td>1,500</td>
<td>71</td>
<td>2,400</td>
<td>-900</td>
<td>-1,270</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Country Report estimates available g/w storage of 10,270,000 MCM. 2030 estimate based on data from Sana’a studies.</td>
</tr>
</tbody>
</table>

Sources: For consistency the main data source is FAO AQUASTAT (2000) but this is complemented with information from the Country Reports. Country Reports that form part of the report are marked ‘blue’. Data on predicted groundwater deficits by 2025-30, where these are available, are taken from the Country Reports.
IN ALGERIA

There are substantial reserves of surface water, which also contribute to groundwater recharge, and so there is at present less reliance on groundwater than in other countries. However, the population is concentrated in the north and west where most of the renewable groundwater is available and where it is most vulnerable to over-exploitation from agricultural water demands. In the less populated south, fossil water from the substantial Terminal Complex and the Continental Interlayer aquifers are more reliable, at least in the short-medium term and meet most water needs in this region. These aquifers also underlie Libya and Tunisia and together they have formed a collaboration to share the available supply (see Managing shared groundwater).

IN IRAN

There are also extensive and underutilised surface water resources and dam storage. But because these resources are unevenly distributed across the country more than half of all water withdrawals are from groundwater. The main aquifers lie along the coasts and in the arid central plain. All these are now being over-exploited and water tables are falling – the overall average rate across the country is 0.5m/yr. The most severe over-exploitation is in the central plain where there is less surface water available. All the available groundwater is renewable and there are no reported fossil reserves. As in other countries in the region agriculture is the main user of groundwater.

IN MOROCCO

There are also extensive surface water resources but they are not easily accessible and so there is a preference for using groundwater. The result is an overdraft of about 30 percent of all withdrawals and this is predicted to get considerably worse by 2025. Groundwater is predominantly renewable, it is well distributed across the country, and is easily accessed in populated areas. Agricultural is the main consumer of groundwater. The seriousness of the groundwater situation varies across the country ranging from an overdraft of 5 MCM/yr in Loukkos to more than 296 MCM/yr in Souss where some 90 percent of groundwater is used for agriculture.

IN LIBYA

Renewable groundwater is heavily overdrawn in the most populated areas along the Mediterranean coast, mainly from excessive agricultural consumption. But the contribution of this resource, although important, is modest in comparison with Libya’s vast fossil water reserves underlying the more sparsely populated Saharan region. Water from the Kufrah aquifer alone – one of six major aquifers in Libya – is reported to be capable of yielding 2,400 BCM if the water table was lowered by 50m. This would supply current water demands in Libya for the next 600 years. Water is transported to the coast via the ‘Great Man-made river’ – a major water pipeline and pumping system. So the constraint on Libya’s future groundwater resources is not about the amount of water available per se, rather it is the technical and economic ability to transport enough water to the coast in line with increasing water demand. Some of the major aquifers are shared with Algeria and Tunisia (see Managing shared groundwater).

IN SAUDI ARABIA

Vast fossil groundwater reserves also exist in the centre and east where the climate is harsh desert with little or no rainfall. But the population is generally concentrated along the wetter mountainous Red Sea coast and relies on rechargeable groundwater from wadi fed aquifers – about 2,200 MCM/yr. There is a growing overdraft along the coast but it is still not clear just how serious this is. However, the focus of attention has turned away from groundwater and towards desalination to meet domestic water demands. As this is a more expensive option, price may provide the motivation for people to use water efficiently. In fact Saudi Arabia is now the world’s largest producer desalinated water.
Saudi Arabia’s renewable reserves are modest compared with fossil groundwater reserves. One estimate suggests there is more than 923,000 MCM in six main aquifers though estimates of what can be actually exploited are about half this amount. One of the largest aquifers, Saq-Disi, is shared with Jordan. But Saudi Arabia’s main concern is the excessive use of fossil water for agriculture – currently this is over 20,000 MCM/yr. Subsidies continue to encourage farmers to grow more food in order to meet government demands for self-sufficiency in food while exercising little or no control over well drilling and withdrawals. Abstraction is now coming down but progress is slow.

IN OMAN

The economy is dominated by oil. But water is important for both domestic and agricultural use. The country relies almost entirely on groundwater, which is renewable from rainfall in the mountain ranges in the north and south of the country. However, groundwater is being ‘mined’ as pumping exceeds recharge. Over-abstraction is particularly serious along the coastal aquifers where most of the population resides. The Batinah Plain in the north of the country is particularly over-drawn and saline water is intruding into the aquifers.

Oman annually uses 544 CM/capita and is the largest groundwater user per head of population in the region. Some 38 percent of groundwater is still abstracted using the traditional Aflaj systems which intercept natural springs and the water table to obtain gravity flows. But power driven pumps and the growing demand for water, driven mainly by agriculture, has created an annual deficit of 120 MCM. However, the Country Report suggests that FAO AQUASTAT under-estimates this and the actual deficit is 378 MCM. This is about 25 percent of the total withdrawal.

IN TUNISIA

Tunisia is the only country showing a small water surplus. But the Country Report suggests that groundwater is being over-exploited. National data also hides more localized groundwater shortages. Renewable groundwater occurs mainly in the north and centre of the country and it is unevenly exploited. About 145 shallow aquifers are reported to be still under-exploited whereas 25 are in optimal use and 56 are depleted. Steps are being taken to protect the most vulnerable from further exploitation. Water resources in the south of the country come from both deep and shallow aquifers with some recharge. Some 40 percent comes from the Terminal Complex and the Continental Interlayer fossil aquifers that Tunisia shares with Libya and Algeria (see Managing shared groundwater).

IN YEMEN

Yemen’s population of almost 21 million is mostly located in the west of the country were rainfall is more favourable. The country relies mostly on renewable groundwater and is running an annual deficit of 900 MCM. But as in other countries, demand is greatest in centres of population. The capital City, Sana’a, withdraws 248 MCM annually while recharge is only 46 MCM – a deficit of 202 MCM, which represents almost a third of the total deficit. Some 205 MCM is used for agriculture. Withdrawals are predicted to increase the annual groundwater deficit of 1,270 MCM/yr by 2025.

IN OTHER COUNTRIES

This study does not have Country Reports from Egypt, Jordan, Iraq, Kuwait, Lebanon, and Syria. Groundwater is less important in Egypt, Iraq, and Syria because of their reliance on shared surface waters. In Egypt local groundwater is reported in FAO AQUASTAT but this is seepage from the Nile which is pumped from the resulting localized water table. Egypt does have extensive fossil water reserves as the country overlies the largest aquifer in the world – the Nubian Sandstone Aquifer System (NSAS) – which it shares with Chad, Libya, and the Sudan. Pumping test undertaken by both Egypt and Libya suggest that neither country would interfere with groundwater levels beyond their political borders.
Jordan shares the Disi-Saq fossil aquifer with Saudi Arabia, although Saudi Arabia is the major user. Kuwait has serious groundwater problems but as an oil rich nation it has the ability to turn to other sources such as desalination. Lebanon also consumes groundwater but surface water is more in abundant.

4.2 Drivers for change

Groundwater has always been an important source of water across the region for many centuries and its use is well entrenched in both urban and rural societies. Traditional methods of abstraction, such as Aflaj and shallow wells with hand and animal lifting devices, maintained a balance between what could be withdrawn and natural recharge. So the use of groundwater was not usually a problem. But the rapid expansion in groundwater use over the past 30-40 years, particularly in agriculture and to a lesser extent in water supply and sanitation, is now in danger of creating more socio-economic problems than it has solved.

But significant changes are needed if supply and demand for groundwater is to be brought into line. But what changes are needed and what will drive the changes? Pressures come from various sources - population pressures, the need to improve water supply and sanitation, a desire for increased food security, and a clean and sustainable environment in which to live. But what drives users to change their attitudes and use less groundwater and are these currently strong enough to bring about the changes perceived by national governments and international agencies?

4.2.1 Population growth

One of the most significant drivers of change is population growth. This not only drives the need to secure water for drinking and industrial purposes but increases the demand for food and hence the water to grow it. The region is already home to some 400 million people, about 6 percent of the world's population. The population has almost quadrupled in the past 50 years and continues to grow in line with the countries' prosperity. In terms of water available per capita, water resources are already low (Figure 2) and this is expected to decline as populations expand. In 1950 the average water available per capita was about 4,000 CM/yr, today is about 1,100 CM/yr, and projections indicate that this will drop by half to 550CM/yr by 2050. This compares to a global average of 8,900CM/yr today and about 6,000CM/yr in 2050 when the world’s population will reach more than 9 billion (FAO AQUASTAT).

The extreme aridity over much of the region means that the population is not distributed evenly among countries and within them. So variations from the average are likely to produce areas of extreme water poverty. Climate change too will add to this challenge with predicted increases in temperature and shorter, less reliable rain seasons for recharging available water resources.

4.2.2 The need to improve water supply and sanitation

Over the past 50 years the exploitation of groundwater for household and industrial purposes and the advent of modern pumping technologies have enabled urban and rural centres to flourish in locations away from the more traditional perennial water sources.

Riyadh in Saudi Arabia is an example of major city development which relies almost entirely on groundwater. There are many other examples including villages in locations where they could not survive without groundwater. However, Riyadh is also an extreme example of over-exploitation. Average potable water use per person in the Kingdom is 200-400 l/day but in Riyadh it is reported to be as high as 800l/day. Libya too is a high domestic user. Tripoli uses 650 l/capita/day. Households in the region are generally not
metered and it is rare for graduated water use tariffs to be applied in an attempt to conserve water. These per capita rates of use are extremely high compared with international practice (in Europe average water use rates vary from 120-200 l/day).

There is clearly significant room for improvement in the efficiency of water use for domestic and industrial use. But are the pressures strong enough at present to bring about changes in attitude to domestic water wastage? Efficiency improvements in this sector will undoubtedly reduce water use but at present there seems to be few incentives to do this. A factor must be that water supply, albeit important in the minds of governments, households, and industry, only represents about 12 percent of water use (based on the countries listed in Table 1). So reducing this amount may not have such a high priority in people’s minds. It is also likely to be costly in terms of new infrastructure. Financial incentives also appear to have little effect on demand. The price of water is often set well below the true cost of supply and in some cases it is supplied free of charge. The case for supplying domestic and industrial water as an economic good to wealthier communities must be a strong one but it is not helped by weak administrations that fail to collect revenues or impose penalties for those who do not comply with the rules.

In some countries leakage from poorly engineered and/or poorly maintained water supply and sewerage systems has led to urban pollution and concerns about health risks. Some countries such as Algeria and Saudi Arabia have reported rising shallow water tables because of leakage and in some cases this has led to urban flooding. This may prove to be a much stronger driver for improvements in water supply infrastructure and water management. Flooding is now causing public health problems and is affecting living standards in many urban environments. Along the more heavily populated Algerian coast some 600 MCM of untreated wastewater is discharged annually into the natural environment and contributes to a worrying level of pollution in alluvial groundwater which is recharged from surface water.

4.2.3 The desire for food security

All the countries in the region attach great importance to food security and this means growing food locally rather than relying on imported food and the implications of dependency on others. So the discovery of groundwater provided the opportunity to reduce food imports by growing more food locally and at relatively low cost. Agriculture accounts for over 90 percent of water withdrawals – surface and groundwater combined. Based on the countries listed in Table 1 this amounts to some 150,000 MCM annually and serves an irrigated area of 14,800,000 ha. This figure excludes Egypt and Iraq as countries that predominantly rely on shared surface water rather than groundwater. Assuming that all domestic and industrial water use is met from groundwater this leaves about 70,000 MCM withdrawn annually from groundwater to service agriculture – about half the agricultural water demand. Future plans being set by various governments suggest that this area could increase but it is questionable if even the existing irrigated area is sustainable. (see FAO Global Map of Irrigation Areas (Siebert, 2007 et al)).

Private farmers found it relatively easy to access groundwater which was often conveniently located below good agricultural land. Exploitation was thought to have low environmental impact and there were few institutional constraints on farmers as the old order of local and tribal rules were fragmenting and being supplanted by modern adaptations of Islamic law.

There was scant knowledge of groundwater resources and what could be safely withdrawn. The emerging private agricultural sector in particular, drilled and pumped with little or no control from government regulators or regard for exploiting groundwater efficiently as long as it was profitable.
Rather than constraining farmers, governments positively encouraged them to grow more food locally as it enabled many people to step out of poverty. It stabilized rural communities, slowed down urban drift, and substantially improve rural livelihoods – a ‘win-win’ situation for governments and for the rural poor. Expansion was driven by finance, credit, and the technology to drill deep wells. Unfortunately this overwhelmed the capacity of government organizations to plan and control exploitation in a more sustainable manner.

The price of this ‘success’ is now being paid – serious over-exploitation of groundwater across the region to a point where it is beginning to threaten national food security and rural livelihoods – the very issues that it was meant to resolve in the first place. This is now impacting on national assets. In the short term it increased water based economic activities, but it is now having the opposite effect. Data available from five Near East countries (Figure 3) suggests that the value of national wealth consumed by over abstraction is as much as 2 percent of GDP (World Bank, 2007).

4.3 Improving irrigation water use efficiency

The reliance on irrigated agriculture and the desire for food security from local production must be a significant driver to ensure that water is used efficiently in agriculture. But so far this has proved not to be the case. The Country Papers confirm low levels of water use efficiency, often less than 50 percent, in most countries which means that about half the water pumped for agriculture goes to waste. This is a most damning indictment for a region so short of water.

Traditional flood irrigation methods, still widely used across the region, are often blamed for this. But even in areas where Modern Irrigation Systems (MIS) have been introduced there is little change in efficiency. It is now increasingly recognised that efficiency is as much a function of farmer irrigation management ability and their attitude to waste than technology per se. Saudi Arabia is a striking example. MIS was used to establish large private farms to produce wheat and milk with little prior investigation of water availability and no data on water use. In the late 1980s Saudi Arabia consumed fossil water reserves to become the world’s sixth largest exporter of wheat competing with rain-fed production. Overall water use efficiency of 45 percent was reported compared to more accepted

1This may be an overstatement as not all water is lost to the rural economy. Losses on the farm can seep into the ground and become a source for someone else by recharging shallow aquifers. This may be of poorer quality and not so easily accessible but nonetheless it may not be completely lost to the basin and to the economy.
efficiencies of 75 percent elsewhere in the world. This attitude to abstraction is prevalent across the entire region, although on a more modest scale.

Improving agricultural water use efficiency is cited by the Country Reports as the most important water conservation strategy for most countries in the region as governments seek to achieve a more sustainable groundwater supply-demand balance. Although various agricultural water sector organizations have attempted to do this, farmers have few incentives to improve efficiency they have not met with much success. Indeed, some governments fuelled development and profligate water consumption by providing perverse incentives to farmers such as barriers to imports, domestic price support, subsidies for MIS and energy for pumping (Figure 4). Such policies, rather than being drivers to use water wisely tended to have the opposite effect as farmers used the water to expand the irrigated area to supply fruit and vegetables to a growing urban population and lucrative export markets. The policies of price support for staple crops, subsidized credit for investment in irrigation, and low priced energy for pumping also encouraged subsistence agriculture by directly or indirectly providing incentives to use water for low value agriculture.

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- Figure 4 Perverse incentives for excess irrigation (World Bank, 2007)

Agriculture is also wasteful of capital investment. In some countries in dry years there is not enough water to service existing infrastructure and when water does reach farms it is often not put to the highest value use. Farmers using publicly funded irrigation schemes tend to grow low value crops, often with low yields, rather than grow crops with high market value such as fruits, vegetables, and nuts, in which they have a comparative advantage.

Based on this experience it is now increasingly recognised that the main drivers for change in agricultural water use do not lie in the water sector. Rather they lie beyond it. Indeed the World Bank (2007) suggest that rather than pressing farmers to improve their on-farm water use efficiency, the need is for major structural economic changes away from agriculture to other non-agricultural activities. This would substantially reduce agricultural water consumption and the scarce resources available could then be used for high value agriculture. Basic staple food crops would be imported. This is a major shift not only in the structure of a country’s economy but also a significant mind shift in terms of defining food security. Reliance of food imports, which in effect means importing water embedded in those crops, a concept known as virtual water, may prove to be anathema after earlier experiences which fuelled the drive for more local food production.
4.3.1 Water quality and environment

Water quality and the impact of over-abstraction on the environment are an increasing cause for concern in some countries, though the pursuit of water for economic development still seems to override concerns over health and environment.

Some groundwater sources already have naturally occurring quality problems. In Algeria the Terminal Complex aquifer is reported to be highly mineralized with salinity levels between 4 and 9g/l. High water temperatures in the Continental Interlayer – between 45 and 65°C mean that cooling or mixing with colder water from the Terminal Complex is needed before it is usable. All this adds to the cost of development.

But there are also quality issues that are the result of over-abstraction. In Oman, irreversible saline intrusion occurs along coastal aquifers and impacts on coastal communities. Similar problems occur in Algeria, Libya, Morocco, Saudi Arabia, and Tunisia. Contamination from sewage in urban areas and excessive use of agricultural chemicals is now showing up in a number of countries but due to poor monitoring services the full extent of the problems is not clear.

Algeria also reports problems of groundwater contamination from oil drilling. In Zaccar an oil well had to be converted to a water well when a perforated pipe passed through the Continental Interlayer. Land subsidence from over pumping is also reported in Iran.

Although groundwater development was thought to have minimal impact on the environment it is more often the profligate use of groundwater that is causing problems in some countries. In Algeria for example, there are reports of flooding in traditional agricultural depressions where there is no natural drainage outlet. Pressures on oases development have encouraged pumping from deep aquifers for irrigation and urban development. Excessive withdrawals have created high, local groundwater tables, flooding, and land salinization. Flooding is now causing public health problems and is affecting living standards.

Environmental concerns are growing in the region as they are in other countries and central to those concerns is usually water or water related issues. The Country Reports show that Departments of Environment are taking responsibly for preparing environmental protection policy and the laws, directives, and systems necessary for evaluating the impacts of social and economic development projects, particularly irrigation and hydropower projects, on the environment. They are also usually tasked with following up on any action required to preserve or enhance the environment.

However, there is as yet little evidence of water being allocated specifically for environmental purposes or of the control of groundwater to sustain vulnerable environmental sites even in sites with high environmental value.

5 The groundwater management response

“Hydrology is important but institutions and policies determine how well countries manage their water resources” – ‘Making the most of scarcity, Accountability for better water management results in the Middle East and North Africa’ (World Bank, 2007).

The World Bank (2007) argues that the drivers for change are strong and that the time is right to move beyond the focus on capturing more water resources to one that manages water resources in a flexible, equitable, and sustainable manner. To do this they suggest that there are three types of scarcity that must be tackled – scarcity of physical resources, scarcity of capacity within management organisations, and scarcity of accountability.
mechanisms – if water is to achieve its potential contribution to growth and employment. They report that governments in the region are well advanced in dealing with the physical resource issues, they are making progress with management capacity, but there is little progress with accountability mechanisms.

The country reports demonstrate that groundwater professionals in the region are indeed well aware of the needs for good science, engineering, and modern technologies to deal with groundwater development. They also show that professionals are increasingly recognise the importance of good management for effective and efficient use of groundwater and that strong institutions and policies provide the backbone for good management. But they also know that in many places the institutions are not working well and there is confusing overlap as more organisations become involved in groundwater development.

Tunisia typically demonstrates the evolutionary pathway of groundwater development that is prevalent in most countries in the region. First came infrastructure development and the drilling of deep boreholes to meet growing water demands. Then the disengagement of the state from economic activities to encourage the private sector to engage in irrigated agriculture, which in turn encouraged investment in modern technologies and pumping systems and fuelled the rural economy. This substantially increased the demand for water and planners then became concerned about the availability of groundwater resources, and the prospects of water scarcity and water shortages. Up to this point the focus had been on augmenting supplies as demand increased. But as supplies diminished attention turned to managing water demand – managing and reducing groundwater using economic instruments, educating farmers to irrigate more efficiently, and introducing new water legislation and institutional reforms to better regulate water supply.

Most countries are following this pathway and are reaching the stage when they can no longer secure additional supplies because of physical and financial limits and are switching towards better management of groundwater. This approach not only affects groundwater but surface water too. Indeed most countries include the entire water cycle in their planning rather than focusing on its separate components.

Several countries have now re-organised their institutional structures governing water by rationalizing and consolidating water responsibilities into one ministry. In some cases this is within the ministries of irrigation as in Jordan, Egypt, and Syria, ministries of energy as in Iran, Kuwait, Lebanon, and Saudi Arabia, or ministries of planning and environment as in Morocco, Oman, and Yemen. Algeria has a dedicated Ministry of Water. However, in many countries water supply and sanitation, and agriculture still tends to be dealt with elsewhere.

The reports also show that although countries in the region are highly centralized, some are now recognizing that water decision-making, inline with international experience, should take place at the lowest appropriate administrative level and that river basins are a good unit for integrated water resource management. They include Morocco, Algeria, Tunisia, Lebanon, and Yemen.

The has also been progress in developing new, modern water policies and enabling legislation – Morocco, Yemen, West Bank and Gaza – and most have now published official water resource management strategies that recognise the need to manage both water resources and demand. Indeed the World Bank (2007) recognises that the organizational changes that have taken place put countries in the region ahead of those in many other developing countries. Additionally several international treaties have been established to govern shared groundwater resources (FAO, 2005).

Nevertheless, the country reports suggest that they are all, without exception, experiencing considerable difficulties in implementing changes in water management. This
is not something that is peculiar to this region, most other countries in the world share this problem. Some of the reported country experiences include:

**In Algeria**

Although Algeria now has a Ministry of Water the Country Report highlights the confusion that exists in many countries where more than one government organisation has responsibilities for groundwater development and management. In this case three government organizations had overlapping responsibilities. In addition five watershed agencies were established under the new water policy and they also influence groundwater use as part of the integrated approach at catchment level.

Groundwater knows no national boundaries and so Algeria also seeks to manage and share its deep fossil groundwater with Libya and Tunisia as a member of the recently formed Systhème Aquifère du Sahara Septentrional (SASS).

**In Libya**

There are several organisations with groundwater management responsibilities. A separate organisation – The Great Manmade River Authority (GMRA) – has specific responsibility for fossil groundwater and its transportation from the southern well fields to the coast. But overlaps occur between those responsible for developing the resource and those who wish to make use of it. For example, there are concerns about the lack of coordination between the GMRA and the Secretariat for Agriculture as both are planning parallel developments using the same water source in the same area. Libya also shares aquifers with Algeria, Tunisia (Systhème Aquifère du Sahara Septentrional (SASS)), and to the east with Chad, Egypt and the Sudan (Nubian Sandstone Aquifer System (NSAS)).

**In Morocco**

Morocco has the longest experience of decentralizing water management based on river basins. Responsibility for water management is shared between government, that sets the National Policy for Water through the National Water Plan, and regional and local organisations responsible for exploitation including seven Water Basin Agencies, Regional Agricultural Development Office (ORMVA), and Water User Associations.

Water Basin Agencies are funded from water charges which are also designed to persuade people to reduce consumption and pollution, and provide funds for further investment in the preservation of water resources.

But the pace of groundwater development has meant that planning lags behind what is actually happening on the ground and the focus at present has shifted from increasing regulation to mitigating the damage being done to aquifers.

**In Oman**

Water responsibilities are now combined under one ministry – the Ministry of Regional Municipality, Environment, and Water Resources – to avoid overlapping responsibilities. At the same time laws were introduced to protect groundwater as a national resource and to safeguard traditional water rights and customs.

**In Saudi Arabia**

A Ministry of Water and Electricity (MOWE) was created to supervise the water sector, develop water-related policies and set up mechanisms and instruments aimed at managing water resources and water services delivery in an efficient and sustainable way. But these functions still overlap with those of the Ministry of Agriculture which has responsibility for administering over 90 percent of groundwater use. The ministries also lack a critical mass of technical experience for effective groundwater management and other important related functions such as pollution control, legislation, economics, social science, and
management. However, the establishment of the MOWE is a step towards streamlining water resources management in the country. But despite the existence of regulations and decrees, the government has had limited success in controlling excessive groundwater use.

**IN TUNISIA**

Responsibility for water resources lie predominantly with the Ministry of Agriculture and so the state continues to play a central role in water resources management. The country’s Water Code sets out measures to protect groundwater over-exploitation and degradation but this is only enforced for deep groundwater over which the government has control.

Shallow groundwater is largely in the hands of private farmers, regulation is scant and it lacks policing and sanctions because of a lack of resources to do the work. Also public authorities seem unwilling to apply the law. This uncertainty is exploited mainly by private farmers and it has led to a proliferation of well drilling and over-exploitation.

Institutionally water is managed at three levels – national, regional, and local but there are concerns about just how much cooperation there is between the different levels. Water User Associations working at the local level sets fees and users’ contributions to cover all the Association’s running costs. This kind of regulatory structure at the user level has seen improvements in water management and environmental water protection.

**IN YEMEN**

In 1995 the government moved to consolidate various water management functions within one organisation – the National Water Resources Authority (NWRA) – with the result that the water sector gained representation at cabinet level. However, the responsibility of irrigation which consumes 90 percent of the groundwater remains with the Ministry of Agriculture and Irrigation.

In 2002 Yemen enacted new water legislation to provide a legal basis for controlling groundwater abstraction. The Water Law also supports decentralization by encouraging Basin Committees to form and manage water resources locally. ‘Basin co-management’, whereby stakeholders and state institutions forge a partnership for managing water resources at catchment level is seen as the way forward but as yet only the Basin Committee in Sana’a has been formed. Further developments are constrained by the limited local presence of the NWRA.

### 5.1 Progress towards better management

> “The region has seen some major advances, but on the whole, progress toward better management has been slow. Sluggish water reforms are not unique to the MENA region. Indeed, most countries in the world share the problem. However, given the resource challenge, the cost of inaction is likely to be higher in this region than elsewhere. The urgency of accelerating the progress seen to date is absolute. ‘Making the most of scarcity, Accounting for better water management results in the Middle East and North Africa’ (World Bank, 2007).

Although progress is being made, the new policies and organizations are in many cases not fully achieving their intended goals. The reasons put forward for this include subsidy regimes which encourages dependency, the status quo, and resistance to change; legislation which lacks implementing rules and regulations; and weak enforcement of the regulations.

Farmers too are reluctant to change. They were encouraged to get on with the job – drilling wells, pumping water, and growing crops – rather than filling in forms and seeking permission. They have not been subject to control in the past and have not paid for water beyond the immediate costs of installing their own wells and energy for pumping.
Changing this mindset will be difficult. But more serious is the apparent reluctance among governments to curb private sector agricultural development because of the major impact this would have on rural communities.

The messages to farmers from government are mixed. There is the desire by government to control and regulate groundwater abstraction. But at the same time some government departments are encouraging private farmers to use more groundwater by providing subsidies for MIS and for the energy used to pump water.

Authorized withdrawals of water represent only a fraction of the actual withdrawals. The task of regulating groundwater is immense considering the extent of the territory involved, the complexity of proposed licencing systems, and the lack of materials and resources to police them. These are some of the reasons why water charging as a mechanism to control groundwater is largely ineffective.

Another major concern raised in some of the country papers is the age of professionals within the various government organizations. Most were recruited in the 1970s and 80s and are coming up for retirement. This will leave a serious human capacity gap that cannot easily be filled without serious long term capacity development plans.

The urgency to make new organisations work as intended is increasing yet the issues raised in the Country Reports show that transforming government water organisations that have traditionally focused on increasing water supply to ones that manage resources and services is not going to be easy.

But over shadowing all these concerns is the growing realization, particularly among water sector professionals, that the management of groundwater is highly political and so cannot be dealt with by the water sector alone. Rather it is a shared development challenge and one that requires attention from a range of perspectives. This is where the third type of scarcity raised by the World Bank (2007) – accountability mechanisms – comes in. On this subject the Country Reports are ominously silent. The World Bank argues that reforming and creating new institutional structures and water laws is not enough. Water is now a highly political issue and the most important changes must come from outside the water sector if water is to fully contribute to economic growth. This requires sound institutions working within an environment of accountability and inclusiveness. In simple terms it means reducing the region's dependency on irrigated agriculture and switching to non-agricultural economic activities. This would take the pressure of scarce water resources and what was available would then be more than adequate for households, industry, some high value agriculture, and the environment. Basic staple foods would be imported, mainly from rain-fed areas where the monetary and environmental costs of production are lower. This really is a major issue that goes well beyond the scope of this paper and the Country Reports. But clearly it cannot be ignored and has massive implications for groundwater development and management and falls largely outside the influence of those working in the water sector. It is not therefore surprising that the Country Reports have not ventured into this highly political territory.

5.2 Managing shared groundwater

The major aquifers in the region straddle national borders. This is particularly the case for the Système Aquifère du Sahara Septentrional (SASS) and Nubian Sandstone Aquifer System (NSAS) in North Africa. While direct hydraulic dependence on cross border groundwater flows or diffusion processes is not detectable, the possibilities of long term pumping of fossil groundwater from the same aquifer impacting neighbouring countries is a concern and has led to specific international groundwater agreements (FAO, 2005; UNESCO, 2004).
The Système Aquifère du Sahara Septentrional (SASS) involves the sharing of two major confined fossil aquifers – the Continental Interlayer sandstone aquifer and the shallower sandstone aquifer known as the Terminal Complex – that lie under Algeria, Libya, and Tunisia. These aquifers are now the subject of an international cooperation set up in 2008 between the three countries to sustainably manage the groundwater resource. Libya has already carried out simulated pumping tests in the Continental Interlayer on the border between Libya, Algeria, and Tunisia. They concluded that pumping 90 MCM/yr (predicted demand in 2050) indicated that a drawdown of 90-100m could be expected at the well field and the cone of influence would extend some 150 km into Algeria and 200 km into Tunisia. Although this would not affect existing development plans in these adjacent countries there is always the risk that it may interfere with future developments.

A coordination unit has now been established and is hosted by the Office of the Sahara Sahel Observatory (OSS) based in Tunisia.

The Nubian Sandstone Aquifer System (NSAS) is the world’s largest fossil water aquifer covering some 2 million km$^2$ with reserves estimated to be 375,000,000 MCM. It lies beneath Chad, Egypt, Libya, and Sudan. All four countries plan to place greater emphasis on groundwater resources to meet their future needs, although in different ways. In Chad little is known about the NSAS resources but the government’s water strategy is to secure more water for nomadic people in this sparsely populated area. In Egypt the NSAS is the only source of freshwater in the Western Desert, which covers about 68 percent of the country. Egyptian national policy stresses population redistribution and NSAS is a strategic resource in developing this policy. In Libya the policy is to transport NSAS water to the coastal urban areas where the majority of people live. Sudan, like Egypt relies heavily on the Nile, an already strained resource. NSAS offers an alternative to support future development plans.

The four NSAS countries have formed the Joint Authority for the Management of NSAS with the objectives of overseeing strategic planning, developing a monitoring programme and exchanging data on water resources and abstractions. The Authority is still in an embryonic stage with plans to expand aquifer monitoring to fill in important data gaps. The next steps are to strengthen legal, institutional, and management framework of the Joint Authority.

UNESCO (2004) reported on shared aquifers and pointed out that more scientific data and analysis of shared aquifers are needed to form the basis for national and/or joint decisions on the development, conservation, and protection of groundwater resources and of the interdependent land-based resources. In the case of SASS and NSAS the foundations
have been set but institutional and managerial arrangements are still in the early stages of development and water is still in plentiful supply. It remains to be seen how they will stand up when together they have to deal with water shortages.

6 Future perspectives

As countries in the region look to the future, groundwater will undoubtedly continue to play a dominant role in supplying water for domestic and industrial use, and agricultural consumption. But what is also clear is that current rates of groundwater withdrawals are far from sustainable. Yet in most countries there are plans for economic expansion, particularly in agriculture, which will place greater demands on groundwater resources not fewer. Although there are variations from country to country the common challenge is how curb agricultural water consumption. How can countries sustain agricultural growth to secure food supplies and improve socio-economic conditions, particularly in rural communities, while curbing the use of groundwater to bring supply and demand into a more sustainable balance?

The Country Reports address this big question by showing that each country is developing policies, strategies and regulatory systems which broadly include developing new resources where these are available; but more importantly making much better use of existing groundwater through improvements in water efficiency and new approaches to demand management; improving aquifer recharge through investment in surface water storage; and seeking alternative water sources which include further development of surface water resources, re-use of wastewater, and desalination.

- In Algeria groundwater planning and development is more advanced than it is in most other countries. Groundwater is likely to be fully exploited by 2025 but there are plans in hand for surface water development and water transfer schemes. These include an ambitious new land and water use strategy that will facilitate a more balanced distribution of population and economic activities from north to south and bring about a more balanced us of groundwater resources.

- Libya faces a problem of delivery rather than groundwater resource availability per se. There are immense fossil groundwater reserves. Yet the groundwater demand to achieve self-sufficiency by 2025 is much greater than the amount planned to be transported by that date.

- Saudi Arabia also has immense fossil reserves but groundwater consumption is exceptionally high and has been profligate in pursuit of food security. It has one of the highest per capita domestic use rates in the world.

- Morroco has a predicted groundwater deficit of 4,200 MCM/yr by 2030 and this does not include growth in private sector irrigation which is largely outside state control.

- Oman also has a growing groundwater deficit but plans to meet this by exploiting additional groundwater resources and the use of desalinated water for domestic and industrial use – a potentially viable strategy for an oil-rich country.

- Tunisia expects its existing water resources to be fully utilized by 2010 and beyond this the imbalance will grow. Alternative resources are expected to be used up by 2030.

- Yemen continues to pursue a growth oriented strategy while also decentralizing and empowering communities to take responsibility for their own future livelihoods. Future success of sustainable groundwater management will depend a great deal on the success of these institutional changes.

As the Country Reports show, all the countries are addressing the need for technical and organisational capacity, they have legislation in place, and are taking steps to avoid
confusing overlaps in minsterial responsibilities for groundwater management. They are dealing with the first two types of scarcity outlined by the World Bank (2007), albeit with varying degrees of success.

There is clearly a shift taking place from the focus on the technological aspects of groundwater development – the ‘planning’ approaches apparent in the late 1980s (RIGW/IWACO, 1991) – towards addressing the scarcity in capacity to manage groundwater (World Bank, 2007). There is evidence in the Country Reports that regulatory agencies are becoming more attuned to the entrenched socio-economic dependency on groundwater but they have yet to find new ways to regulate groundwater development and to influence groundwater users to consume less. Some countries are pursuing policies of decentralisation to place groundwater management decisions at the lowest administrative levels as a means of bringing users into the decision making process. Morocco has the longest experience of this approach and others, such as Algeria, Tunisia, and Yemen, are following this lead. But progress is slow and it is a challenging process in countries that have highly centralised management systems.

However, even if all the efficiency gains that are planned do become a reality, and it is a big ‘if’, there must still be considerable doubt about this achieving a sustainable balance between groundwater supply and demand in the long term. ‘Business as usual’, even with efficiency gains, may not be enough and so this brings us back to the World Bank’s argument – that the only way that countries can realistically move towards a more acceptable and sustainable use of water and continue to grow economically is to address the third type of scarcity. This means recognising that the problems facing water management are highly political and that the solutions may well lie outside the more immediate influence of the water sector.

Economic diversification is a policy that has been very successful in many other countries with consequent benefits for agriculture and water resources. But large, often inefficient, government departments often discourage entrepreneurism with their costly employment rules, red tape, and poor logistical support. At present farmers have few options other than staying in agriculture on small land holdings and adopting risk averse strategies such as growing low value and water inefficient crops. A shift towards a non-agricultural economy would encourage the less efficient to take up employment outside of agriculture. This is a ‘win win’ situation – it benefits those who leave agriculture and take up employment elsewhere and it benefits agriculture by reducing water demand and enabling scarce groundwater to move to higher value production.

The World Bank does not offer any ‘blueprint’ for this because solutions will be specific to each country. Some countries are well endowed with natural resources despite the harsh climate and limited water resources. For example some two thirds of the world’s crude oil reserves lie under the region, with one quarter located in Saudi Arabia. Iran has some 15 percent of the world’s natural gas reserves, and Morocco alone has more than 30 percent of the world’s phosphorous reserves (Khader, 2003). Some counties are already taking step to approach water management in this way. In Morocco for example, the King, the Prime Minister, and the Ministry of Finance have all become champions of water reform. This highlights the importance of strong advocacy at the highest levels in society for achieving change. Several other countries including Algeria, Egypt, and Yemen have begun explicitly addressing non-sector audiences with analyses that demonstrate the impact of poor water management across the economy.

The steps recommended by the World Bank include promoting education about multi-sectoral aspects of water management, and also investing in data collection on groundwater availability and quality and tailoring this to meet the needs of policy makers outside the immediate water sector. Good sound data is essential for accurate policy making and it must be presentable in a format that can be easily understood by non-water professionals.
Such is the challenge facing groundwater development in the region. No one said it would be easy.

References

World Bank (2007) Making the most of scarcity, Accountability for better water management results in the Middle East and North Africa.


