Chapter 26

Governing groundwater in the Middle East and North Africa Region

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ABSTRACT

Groundwater is a key resource in the Middle East and Northern Africa region for both water supply and agriculture. While farmers in irrigated areas have tapped aquifers as a response to dwindling and uncertain surface water supply, investors have drilled wells and expanded agriculture into arid or desert areas. Most countries in the region have adopted standard water regulations, with emphasis on zoning (of stressed areas), licensing, metering and sometimes pricing, but enforcement has been problematic, and results on the ground modest to non-existent. This reflects a lack of material and financial means to handle tens and sometimes hundreds of thousands of dispersed wells but also a lack of political will. This can be explained by the state's lack of appetite for curtailing access to a resource that substantially contributes to the rural economy, a drop in state authority after the Arab Spring, inter-sectoral policy contradictions, the interest of politically well-connected investors, and sometimes the complexity of tribal politics. While state-centred governance has been largely ineffective, attempts at co-management or instilling a degree of participation from users have also been limited and unconvincing, reflecting wider governance systems in the region. The worrying depletion of many vital aquifers in the region is increasing the cost of abstraction, heightening social differentiation, as smaller farmers are pumped out and foreshadows a gradual collapse of the groundwater economy.

26.1 INTRODUCTION

Poor surface water endowment and rapid population growth rates since the 1970s (the region's population doubled between 1980 and 2011 from 170 million to over 350 million) have reduced the Middle East and North Africa (MENA) region's[1] per-capita freshwater share – from around 3,500 m^3 per year in 1960 to 700 m^3 per year in 2011 (Al-Zubari, 2012). Groundwater is the region's second conventional water resource after surface water, and in countries such as Jordan, Oman, Saudi Arabia and

[1]Includes Morocco, Algeria, Tunisia, Libya, Egypt, Jordan, Palestine, Israel, Lebanon, Syria, Iraq and the Arabian Peninsula.

Yemen, it accounts for half the total water withdrawals (UNDP, 2013; Wada *et al.,* 2012). Worryingly, most groundwater-based agriculture and domestic and urban use are unsustainable. It has been estimated that the value of national GDP contributed by groundwater over-abstraction could be equivalent to 2 percent in the case of Jordan and around 1.5 percent in Yemen (World Bank, 2007). Yet these figures do not convey the strategic importance of the resource for rural livelihoods, food production or supply for cities. Neither do they reflect the associated environmental impact.

Groundwater quality also presents challenges for the region. With many large urban areas located near the coast, untreated sewage from these centres, refuse sites or septic tanks leak into and pollute coastal aquifers (often used for drinking-water supply) (e.g. in Lebanon, the West Bank and Egypt) (El-Fadel *et al.,* 2002). Industrial effluents and pollution from agricultural sources (fertilisers and pesticides) are also a cause for concern, especially in shallow aquifers (e.g. Ras al Jabal region in Tunisia and the Nile Delta in Egypt) (UNDP, 2013).

As a semi-arid to arid region, MENA has long depended on its groundwater resources. Historically, groundwater was accessed through shallow dug wells (mostly in alluvial formations) and natural springs, as well as 'horizontal wells' called *qanats* (or various other names across the region: e.g. *khettaras*, *fogara*, *aflaj*). Groundwater sourced from springs and *qanats* has been managed through customary rights and rules, generally articulated around private property rights associated with land access and the initial investment of capital and labour by shareholders. Many such common property resources have been successfully managed for centuries (and some are still in place in countries such as Algeria and Oman), indicating substantial, but dwindling, social capital around the collective management of groundwater resources.

As in many other countries in the world, tube wells (often deep), new drilling techniques, submersible pumps and electrification have contributed to an unsettling of the historic balance between the available resource and its use, quickly leading to an overall situation of overexploitation in many aquifers. What is special, therefore, with the MENA region regarding groundwater? First, MENA is facing acute water scarcity, and the overall reliance on groundwater is higher than in most regions. Second, and perhaps correspondingly, many aquifers are barely- or non-renewable. Third, the region displays a contrast between the age-tested, community-based management of springs, wells or *qanats* and the current, state-centred modes of governance, which are proving to be largely ineffective. Fourth, large-scale agribusiness companies are increasingly prominent in the expansion of groundwater-based agriculture.

This chapter first describes the unprecedented boom in groundwater use in the MENA region and then investigates in more detail the responses of the states and users. The last section analyses the major causes of those dynamics and the implications for groundwater governance. We focus on water depletion issues and allude to the contamination of aquifers only in passing, since this – locally serious – problem is not well documented and is still largely unaddressed by public policies.

26.2 THE GROUNDWATER BOOM

In line with what has been observed worldwide, groundwater development in the MENA region has boomed over the past 40 years based on the initiative of both the

state and individual users. The surge in the exploitation of groundwater, mostly for agriculture, has been observed in three different situations, as examined here.

26.2.1 Conjunctive use in irrigation schemes

Iconic large-scale public irrigation schemes were developed by most states between the 1960s and 1980s. This was notably the case in Morocco, where King Hassan II's 'hydraulic policy' sought to develop one million hectares of irrigated land, but was also witnessed in northern Tunisia, Syria (Orontes and Euphrates River Basins) and Iraq, not to mention the continued expansion of the Nile Delta/valley system. Supplied by diverted surface water, with time these schemes faced occasional to persistent shortages, due to upstream development (e.g. Euphrates), irrigation 'overbuilding' (e.g. Morocco), competition with domestic or other uses, or increasing climatic variability. As a result, farmers turned to conjunctive use, tapping water available in both nearby drains and streams as well as underlying or downstream aquifers, which to a large extent are fed by irrigation from surface water (Van Steenbergen and El Haouari, 2010). In some areas wells pepper the landscape and provide more water than is distributed through public canals (see Kuper *et al.,* 2012 for a graphic example of the Tadla scheme in Morocco).

On the positive side, the overall efficiency of the schemes is greatly enhanced as return flows are recaptured and farmers enjoy higher flexibility and security in their water supply. This is especially important for capital-intensive crops – fruit trees in particular. On the negative side, conjunctive use incurs additional running costs for farmers, with successive technological adjustments being required by the continual drop in the water table.

The intensity of conjunctive use can be considered as a good indicator of the adequacy of irrigation water supply. In schemes like Tadla in Morocco a significant number of individual wells have been drilled since the 1980s, when the Oum Er-Rbia basin started to be overexploited (Kuper *et al.,* 2012). A similar situation can be observed in the Maghreb region as a whole and in the Ghab Valley, Syria. Elsewhere, the phenomenon is more recent, such as in the Nile Delta, where intensive well drilling has been observed over the last 10 to 15 years (El-Agha *et al.,* 2017). Importantly, the phenomenon is also observed in small-scale communal schemes based on river diversion, springs or *qanats*, notably in oases.

26.2.2 Supplemental irrigation in rainfed areas

A second situation where wells have proliferated is that of rainfed agriculture, where the supply of groundwater has allowed farmers to increase, and more importantly secure, their yields in times of drought. This has been observed in Morocco, Tunisia and Yemen, but most prominently in Lebanon, where much of the Bekaa plain came to be irrigated from different surface and groundwater sources, and Syria, where the plateau between the Orontes River and the eastern deserts has massively resorted to groundwater.

Securing rainfed agriculture, as well as capitalizing on this secure source of water to diversify into cash crops, has generally been a result of individual investment. There are cases, however, where the state has attempted to establish collective distribution

networks based on public wells, as in many parts of Tunisia (Hamdane, 2014) or in the Souss, Morocco. A key example of the state's direct role in conveying groundwater to rainfed areas for irrigation, and also for cities, is Libya's 'Great Man-Made River' project, which aimed to transfer 6.5 Mm^3 of groundwater per day from large aquifers in the desert in the south of the country to the coastal area.

26.2.3 Expanding the frontier into deserts

Groundwater has been mobilized to expand agriculture into arid or desert areas. Large agribusiness companies in, for example, Algeria, Egypt, Jordan, Morocco and Saudi Arabia have invested in tube wells to tap (often fossil) groundwater at great depths. In Egypt 75 percent of all desert reclamation (for agriculture and urban projects) has relied on private investors and corporate modes of farming (Sims, 2015). In general, such capitalist ventures in agriculture have benefitted from generous government subsidies and financial incentives and/or been encouraged by permissive state regulations and a lack of control of groundwater abstraction. In many cases the state has mediated such investments, providing long-term leases for the land (and well licenses), for instance to the companies initially allowed to exploit the Disi aquifer in southern Jordan.

Egypt's desert development projects since the 1950s have included well fields in various oases as part of the 'New Valley' project in the western desert. Since the 1990s the government has reclaimed thousands of hectares for irrigation in oases such as Kharga and Dakhla further south near the border with Sudan (East and West Oweinat). Some public wells have been handed over to groups of farmers to manage them. The state may be the indirect beneficiary through parastatal companies or, more directly, it could be the army (Sims, 2015). Although state-sponsored or private agribusiness dominates such kinds of enterprise across the region, there are also cases where small-scale investors are able to develop small to medium-scale projects in the desert or arid lands, based on one or more wells. This is the case in the highlands of Jordan, in Morocco and on the fringes of the Nile Delta. Conducive conditions for this generally include road accessibility and the relative proximity of urban centres or export facilities, modes of land tenure that make claims/access to land possible, and the ability to obtain well licenses (or authorities turning a blind eye to groundwater development).

26.2.4 Main drivers and consequences

The initial boom in groundwater-based agriculture was largely fuelled by direct or indirect subsidies by the states or donor-funded programs. Tapping groundwater was seen as an easy and decentralized means of supporting rural development and poverty alleviation (Allan, 2007), of compensating for uncertain supply in public schemes, and sometimes of improving food security in the country (Al-Zubari, 2014). The role of the state in driving groundwater development in the MENA region is ubiquitous and can be illustrated by a few cases.

In Tunisia there are over 1,000 user groups managing irrigation schemes of between 30 and 300 ha, most of which were established by the state and based on groundwater resources (Elloumi, 2016). Encouraging individual well development through

various types of incentive, for example drilling wells, buying pumps or, indirectly, buying micro-irrigation equipment, has been a central component of agricultural policies aimed at supporting rural livelihoods. This has also been the case in Algeria, Morocco and the United Arab Emirates (UAE).

The state has often played an active role in the development of groundwater resources as part of a campaign to settle tribes and nomads in rural areas, in some cases as part of a wider program to ensure rural livelihoods or support the development of rural water supply via wells (e.g. Jordan, Saudi Arabia, UAE). Since the early 1980s UAE citizens have received plots of between 2 and 10 ha, ready for cultivation with one well/ha, and interest-free loans to purchase pumps and other equipment (Fragaszy and McDonnell, 2016). Consequently, farmland in the Liwa region, which was approximately 1,000 ha in 1987, peaked at around 21,000 ha in 2002, leaving the oasis peppered with 35,000 wells (many of which are now defunct due to falling groundwater levels).

The development of groundwater can also be linked to the maintaining of patronage relationships within the state apparatus and the state's relationship with local leaders (e.g. Yemen) (Zeitoun *et al.,* 2012). Community leaders and specific groups or elites benefit from permissive regulation and/or connections in their development of agricultural ventures and in drilling wells. Jordan is a case in point and Egypt even more so (notably on the western fringe of the Nile Delta), where the army has received licenses to develop large tracts of desert land (Sims, 2015).

Either directly or indirectly, many state policies have encouraged well drilling and groundwater-based agriculture. In Syria, for example, groundwater-based agriculture accounts for 53 percent of the total irrigated land. During the 1980s and 1990s the development of groundwater abstraction wells and irrigation (from 53,000 wells in 1988 to 124,000 in 1994) was fuelled by input subsidies sponsored by the government, such as a diesel fuel subsidy and crop procurement price support (Aw-Hassan *et al.,* 2014). Donors have also been supportive of groundwater development. In Yemen money from international development agencies, such as the World Bank in the 1970s, or German or Dutch bilateral funds, has been used to develop the country's water-management infrastructure and institutions.

This 'good' idea of harnessing groundwater resources to achieve all these desirable development policy goals eventually turned sour. Uncontrolled well drilling gradually resulted in declining water tables (with typical observed drawdowns of 1 m/year), which made abstraction costlier (either due to increasing fuel costs or the expense of deepening wells) and sometimes pushed smaller farms out of business. Over-abstraction also affected the systems fed by the discharge of the aquifers: springs dried up everywhere; wetlands such as the Azraq oasis in Jordan virtually disappeared; *qanats* – and the huge cumulated investments as well as social capital that sustained them – fell apart (Al-Zubari, 2014). In coastal areas (e.g. Lebanon, Tunisia, Morocco, Oman) lower aquifer levels led to the intrusion of seawater, causing land salinisation and the destruction of agriculture. With the use of deeper layers of aquifer changes in water quality were frequently observed, particularly in terms of salt content (e.g. Jordan), forcing farmers to adapt their crops or discontinue agriculture. In other cases a race to the bottom unfolded on both sides of a trans-boundary aquifer, raising tensions between neighbouring countries (e.g. the Saq-Ram aquifer between Jordan and Saudi Arabia).

26.3 RESPONSE OPTIONS

Because many countries in the MENA region have declared water a state or public resource, and because groundwater is intertwined with many key social and economic issues, widespread groundwater over-abstraction readily puts the onus on the state. International and development agencies have contributed to the dissemination of standard policies and laws considered to be internationally sanctioned best practices. The form of the responses to the degradation of groundwater quantity and quality therefore bore similarities across the region. This section reviews and categorizes the different types of response, and briefly reports the outcome of their implementation. For analytical purposes we distinguish here between three types of policy objective:

1) How to control (limit or reduce) the *number* of existing/active wells;
2) How to control (limit or reduce) the *amount of groundwater* abstracted by existing/active wells;
3) How to 'bring additional water in' to reduce the degree of groundwater overexploitation.

26.3.1 Controlling well expansion

26.3.1.1 Registration of wells

Most countries in the MENA region have put in place a system of licenses or permits for groundwater use (World Bank, 2007), with varying procedures. In some instances (e.g. Jordan, Lebanon, Tunisia) a distinction is made between the drilling license and the subsequent exploitation license, both of which must be obtained.

In most cases the majority of wells were drilled at a time when licensing was either loosely enforced or non-existent. This means that when stricter legislation is passed, making licensing mandatory, the question of the legality of existing wells comes to the fore. In general, a grace period is granted for regularization. Farmers rarely comply for a number of reasons. These include reluctance to follow a burdensome procedure, the (sometimes annual) fee to be paid, the fear of being charged for water in the future, a lack of trust of the authorities' intentions, and the ingrained belief that groundwater is not the government's business. As a result, deadlines are often extended. In Morocco a regularization period for wells dug before 1995 was open until the end of 1998; in 2009 wells dug before 2009 were to be registered within a three-year period, later extended to 2015. In Jordan the 2002 Groundwater Bylaw gave one year to illegal well owners to regularize their wells; an amendment in 2003 gave another six months, and eventually all wells older than 2005 were considered illegal and liable to be backfilled (Al-Naber and Molle, 2017).

In Morocco the authorization of new wells requires the submission of a detailed file, which includes situation maps as well as a technical study for the well and its impacts on neighbouring wells and local water resources (Del Vecchio, 2013). Registration is also burdensome and costly in Egypt, where a large majority of farmers in the Nile Delta have not bothered to register their wells, especially after the 2011 revolution (the Arab Spring) and the undermining of state and police authority (El-Agha *et al.,* 2017). In Lebanon, further to the recent decision to use private companies for

the revision of the technical aspects of permit applications, their number has fallen from 2,000 to 500 per year on account of the increasingly costly (US$960) and tedious process (Nassif, 2016).

In most countries, therefore, the percentage of unregistered wells (whether or not they are known to the administration) remains high (Kuper *et al.,* 2016), with certain exceptions, such as Bahrain and Abu Dhabi (which is currently concluding a national inventory). In Jordan illegal (known) agricultural wells number around 1,268 out of 3,721 registered wells (in 2011), but there are also unknown illegal wells, with some still being drilled in regions such as Azraq and Jafr. In Yemen licensed wells have permits for the abstraction of specific quantities of groundwater per year although no monitoring takes place and the majority of wells do not have permits (Morill and Simas, 2009). Information from a recent UNDP-funded project in Lebanon estimated that there are around 59,124 unregistered (yet inventoried) private wells and 20,537 registered private wells in the country (UNDP, 2014).

26.3.1.2 Controlling and banning well drilling

Limiting the drilling of new wells can be achieved by controlling the drillers rather than the farmers. In Yemen all heavy drilling rigs and metal well casing must meet technical specifications issued by the National Water Resources Agency (NWRA) (Morill and Simas, 2009). However, while 125 drilling contractors were licensed by the end of 2006, some estimates suggest there could be a total of 400, or even as many as 900, drilling rigs in the country (NWSSIP, 2008; FMWEY, 2015). Despite the use of sophisticated technology (e.g. GPS tracking and satellite imagery in the hands of a 'rig tracking unit'), illegal drilling has continued, with blatant violations of regulations carried out by influential people in plain sight (Ward, 2015; Van Steenbergen *et al.,* 2015).

In Oman only government-registered contractors may carry out well construction and maintenance, yield testing and pump installation (Morill and Simas, 2009). In the UAE only one company is licensed by the government. The 2002 Groundwater Bylaw in Jordan requires licenses and authorizations for drilling equipment and drillers. Since 2013 the Ministry of Water and Irrigation (and Jordanian security forces) have confiscated drilling rigs (up to 159 rigs by April 2015) (Jordan Times, 2015). However, drillers have become more creative and it was reported that they now manufacture rigs that can be stealthily loaded on pick-ups (Al-Naber and Molle, 2017). In 2005, in the Souss-Massa in Morocco, the River Basin Agency launched an initiative to control borehole drilling and, by 2010, 190 drilling machines had been seized (BRLI and Agro-Concept, 2012). The Agency is also trying to create a professional association for the drilling companies, which could potentially become a management actor.

Drilling bans have been implemented in various countries, such as in critical zones in Algeria, Bahrain and Tunisia (Faysse *et al.,* 2011) and more broadly in Jordan (agricultural wells, since 2002). On balance, it has proved difficult to control both legal and illegal drillers, and the level of implementation of these bans has been weak. From Jordan to Morocco fingers are in particular being pointed at Syrian operators, notorious for specializing in legal/illegal well drilling across the region.

Well expansion or existing abstraction levels can be monitored indirectly with the use of technology such as satellite imagery. In Jordan the Ministry of Water Resources

and Irrigation uses this technology to identify land use with irrigation and locate illegal wells (Herald Globe, 2014). The control of irrigation surface in dry areas with this type of technology is supported through different donor programs in several countries in the MENA region (e.g. the MAWRED project funded by NASA and USAID), but its use is incipient.

26.3.1.3 Backfilling of illegal wells

The most radical measure in dealing with illegal wells is identifying and backfilling them. Jordan's Ministry of Water Resources and Irrigation launched a campaign in 2013 aimed at sealing and backfilling illegal wells. According to newspaper sources, the authorities (in tandem with Jordanian security forces) sealed 644 illegal wells from 2013 to mid-2015 (Jordan Times, 2015). The task is made difficult in some cases by resistance on the part of the owners, who deploy guards and dogs at the property gates and deny entry to the inspectors – a situation found in Balqa (Jordan Times, 2015), Azraq and other places. However, off-the-record information indicates that the wells that have been sealed were either already dry or unused. This still clearly heralds a tightening of regulation by the government (Al-Naber and Molle, 2017). In 2017 Environment Abu Dhabi (EAD) launched an awareness campaign on the negative impacts of well drilling, encouraging people to report illegal wells as a first step towards their filling.

In the Souss-Massa, Morocco, the policy of removing unauthorized wells or pumps (for example around 70 percent of the pumps found in the Souss area) was never fully implemented (BRLI and Agro-Concept, 2012). Illegal wells identified through campaigns carried out in some Algerian provinces, such as in Oran in 2006, were also meant to be sealed, but there is no sign that anything effectively happened on the ground (Amichi, 2015). In general, it seems that cases where authorities have cracked down are linked to over-abstraction threatening domestic use, or to very specific situations where the owner of an illegal well had conflicting relationships with the authorities or the police (e.g. refused to pay bribes, etc.) (Molle and Closas, 2017).

26.3.2 Controlling and reducing abstraction in existing wells

Once the expansion of wells has been addressed, the second main policy objective is to control (limit/reduce) *actual* groundwater use in *existing* wells. Metering, pricing, abstraction quotas and technology improvements for irrigation are some of the main instruments used by governments to control the abstraction of groundwater in the MENA region.

26.3.2.1 Groundwater metering

Even though groundwater metering is not a tool in itself to reduce groundwater abstraction, it is often seen as a prerequisite for the implementation of pricing instruments and abstraction quotas. Hardly any country in the MENA region has been able to ensure that licensed agricultural wells are fitted with working meters. Jordan prescribed the obligatory use of meters in the mid-1990s and started to equip wells with the support of USAID (Venot and Molle, 2008). However, while in the Amman-Zarqa Basin, 90 percent of wells were equipped with meters, only 61 percent of those meters were

found to be working in 2004 (Chebaane *et al.*, 2004). A recent survey in Azraq found that of a total of 334 wells surveyed only 192 water meters were working (IRG, 2014). Besides technical issues, meter tampering and vandalism are common (Chebaane *et al.*, 2004).

In Syria, despite the fact that current regulations require groundwater wells to have meters installed, the lack of training and technical skills by engineers and public officials affects the implementation of this measure (Albarazi, 2014). This, however, is a typical official explanation and obscures the likely lack of political will to enforce such regulations. In Tunisia meters are not required, even for wells deeper than 50 meters, on account of the admitted incapacity of the state to monitor them (Hamdane, 2014). There is also recognition that meters are costly and this raises the question of who has to pay for them. One option is to shift the cost onto farmers' shoulders but this may make licensing even less attractive to them. In other countries, such as Yemen and Egypt, the requirement to install water meters is nullified by the fact that wells are not registered in the first place.

In Abu Dhabi well metering (and pricing) are floated as possible measures but (so far) are stiffly resisted by farmers. In Oman a law in 1990 established that wells be licensed and metered (with penalties for tampering), but it has not yet been effectively applied (McDonnell, 2016). In Bahrain the metering of all wells was initiated in 1997 and applied for some time (Al-Zubari and Lori, 2006). After a long period of ups and downs, most groundwater wells are now metered and their production is read on a monthly basis. This is made possible by the fact that most agricultural wells are within a one-hour drive in the same (north-west) region and are limited in number (around one thousand). Bahrain passed groundwater regulation as early as the 1960s and enforcement has probably been facilitated by the non-tribal nature of the population. In the Souss, Morocco, the installation of meters was a key measure of the aquifer contract (*contrat de nappe*) but was postponed when it became clear that other clauses had not been implemented (BRLI and Agro-Concept, 2012).

26.3.2.2 Abstraction quotas

Where wells are licensed it is generally the rule that a maximum annual abstraction volume (or average discharge) is granted, as in Lebanon, Bahrain, Tunisia and Morocco. However, it is often unclear what would happen if the limit were exceeded. In any case, there is no evidence of any serious volumetric monitoring of agricultural groundwater use in the MENA region to verify whether quotas are respected.

Quotas can be associated with a block-tariff, where the user is allowed to pump water beyond a minimum quota (which is in general granted for free) but at a cost, with the price of water increasing with the volume abstracted. In Jordan abstraction licenses granted between 1962 and 1992 generally specified the amount allowed to be pumped, most commonly 50,000 or 75,000 m3 per year per well (Venot and Molle, 2008), although these limits were not enforced. The Groundwater Bylaw of 2002 established a new quota system based on block-tariffs (see below).

The application and enforcement of quotas require abstraction to be measured and are therefore difficult and prone to corrupt practices as in Syria, or users tampering with meters as in Jordan for example. Jordan, however, is now increasingly using proxies, such as electricity consumption and the cropping area (with the help of remote sensing),

to estimate and charge for groundwater abstraction (Al-Naber and Molle, 2017). This is certainly an option that is worth exploring in the region, especially since aridity facilitates the identification of irrigated crops by remote sensing.

26.3.2.3 Groundwater pricing

Volumetric tariffs have the potential to encourage users to abstract less groundwater yet have barely been used in the region (despite the emphasis on pricing instruments in state and donor policy documents). One reason stems from the evidence discussed above that metering in agriculture is rare and often dysfunctional. A second reason is that it is close to impossible for governments to tax legal groundwater users volumetrically at a level that is sufficient to elicit conservation measures without impacting income. The situation is different, however, with groundwater for domestic or industrial uses, where the potential for volumetric metering and pricing is higher (Molle and Berkoff, 2007).

In Tunisia groundwater users in small, publicly managed irrigated areas, covering around 24 percent of the irrigated area in the country, have to pay for groundwater supplied through pressurized networks via state-established but user-run decentralized associations (GDAs) (Frija *et al.*, 2014). However, prices are not high enough to affect behaviour, and, if they rise, farmers tend to shift to individual unmetered and uncharged wells (Ghazouani and Mekki, 2015). In Bahrain a decree issued in 1997 on groundwater pricing for all purposes could not be implemented due to socioeconomic and political constraints (Al-Zubari and Lori, 2006). In Lebanon users abstracting over 100 m3/day need an authorization by decree and are supposed to pay for water, but monitoring is non-existent (Nassif, 2016).

In Jordan groundwater pricing is in place via a system of block-tariffs. This system was introduced in 2002 by the Groundwater Bylaw and charged any water use over a threshold of 150,000 m3 per year per well at a level of 0.007 USD per m3 for volumes between 150,000 and 200,000 m3 per year and 0.085 USD per m3 beyond. Such tariffs, and the generous free-block, were found to be ineffective with regard to water conservation, especially in fruit-tree farms with high income (Venot and Molle, 2008; Demilecamps, 2010). It proved difficult for field staff to collect water fees and hardly anyone paid. In 2009 the ministry sent bills with cumulated arrears and since then has stepped up its pressure on farmers to elicit payment. Yet, there are clear limits to the taxation that farmers with legal wells are ready to accept since they already pay to access groundwater and do not accept government intrusion in such matters. In 2010 the Jordanian government moved to using tariffs to hit illegal wells, which are now given no or much smaller free blocks and whose taxation can be justified not because they are using water but because they are illegal (Al-Naber and Molle, 2017). People with unpaid bills are now being barred from accessing other state services or obtaining official documents. This double pressure is starting to be felt and sends a strong signal about the ministry's growing resolve.

26.3.2.4 Buying out wells

The buying out of wells by the state, a last resort in controlling abstraction and the number of wells, has been considered by the government of Jordan. Chebaane *et al.* (2004) found that 50 percent of farmers were in principle in favour of such an option.

The successful implementation of this measure requires substantial funds, as legal well owners are likely to expect significant compensation reflecting the profitable use of water for cash crops. On the other hand, the government rules out paying for illegal wells, which would be antithetic to the law. Zekri (2007) notes that groundwater gains achieved by this option could be pumped again by the active farmers in the area if no further abstraction limits were imposed and controlled. Control of expansion is therefore essential before existing wells are tackled. This combined approach has not yet been implemented in the MENA region.

26.3.2.5 Technology fixes to reduce groundwater use

Technology is invariably cast as central to the strategy of reducing water use in agriculture. This includes solutions such as the use of remote sensing, high-tech meters (with automatic data transfer) and, most commonly, micro-irrigation to 'reduce water losses' and improve irrigation efficiency. While Morocco, Saudi Arabia and Tunisia have extended subsidies to farmers for micro-irrigation, other countries such as Lebanon, Jordan and Egypt have been more conservative, largely leaving it to the market. In Oman, between 2000 and 2016, farmers (with a licensed well) buying modern irrigation technologies received 100 percent subsidies (McDonnell, 2016).

In Tunisia the National Programme for Water Savings, established in 1995, offers subsidies to farmers of 40 to 60 percent of investment costs for water-saving irrigation technologies. Yet national data show no decrease in water use per ha, just the expansion of irrigated areas (Frija *et al.,* 2014). The Green Morocco Plan (*Plan Maroc Vert*), Morocco's national strategy to improve the country's agricultural efficiency and output, can fund up to 100 percent of drip irrigation and 80 percent of the cost of drilling a well (Molle and Tanouti, 2017). Although micro-irrigation generally reduces the quantity of water applied, its impact is mostly neutral, and occasionally negative, with regard to plot-level water consumption (Molle and Tanouti, 2017; Perry and Steduto, 2017).

26.3.2.6 Indirect incentives

Groundwater-based agriculture can potentially be shaped and regulated indirectly, by modifying the prices of input and output factors. While it is next to impossible to impose administered volumetric taxes on well abstraction to encourage water conservation, it could be easier to influence use through the cost of the energy needed to pump water or through targeted crop input/output subsidies.

Indirect incentives through electricity supply and pricing have been extensively studied in the case of India by scholars such as Shah (2009). With regard to the MENA region there has been debate in Tunisia about the possibility of establishing an electricity-based pricing system for private bore-wells – an idea negotiated between the Ministry of Agriculture and the Tunisian Society of Electricity and Gas (Frija *et al.,* 2014). In Jordan a new law has made it impossible to obtain a connection to the grid without a valid well license, condemning illegal wells to using diesel at a much higher cost; with the unintended adverse effect, however, of pushing them towards solar energy, which results in even more groundwater over-exploitation as pumping costs are generally drastically reduced.

In Syria, the cancellation of diesel and fertilizer subsidies for farmers in 2008 and 2009 (with the intention of integrating the country into the global trade system and

joining the World Trade Organisation) pushed prices up and forced many farmers either to revert to rain-fed agriculture or stop agriculture altogether when their wells dried up (de Châtel, 2014; Wendle, 2016). The combination of a severe and lasting drought, which resulted in many aquifers being depleted in northern Syria, and high energy prices fuelled population displacement (Wendle, 2016), which may later have contributed indirectly to the popular uprising. In Saudi Arabia demand for water decreased as a result of policies with intended as well as unintended consequences. In 1994 the government reduced the price of wheat (from SRI 2000/ton to SRI 1500/ton). More importantly, the price of the main input for pumping water – diesel – was tripled, making it far more expensive to pump groundwater (Al-Sheikh, 1997). Saudi Arabia has also recently reduced input subsidies as part of its program to reduce agricultural groundwater use in the 2000s and phase out wheat cultivation by 2018; it has banned fodder exports and recently taken steps to limit alfalfa production significantly.

Water use can also be modified by subsidizing certain crops or paying farmers for certain behaviour. In Abu Dhabi all farm owners receive 90,000 AED/year not to grow Rhodes grass or alfalfa on more than 10 percent of their farmland (if they do not have more than 120,000 AED/year of property income). An additional 10,000 AED/year are provided to all farm owners with 60 or more date palms (low water users) on their farm (Fragaszy and McDonnell, 2016).

26.3.3 Supply-side measures

Groundwater over-abstraction can be reduced via supply augmentation of either surface water (transfers) or groundwater (through aquifer recharge), and also by seawater desalination. The use of technology and the provision of additional resources are seen as the most 'conflict-free' management options. Bringing more water, especially if it is cheaper and/or of better quality, helps decrease the pressure on groundwater and potentially reduce its use. However, in the mid to long term more water being available at the dwelling or farm plot could well result in expanded use and consumption.

26.3.3.1 Bringing more surface water in

Several countries in the MENA region have created infrastructure projects to 'bring more water in' and partly replace the existing demand for groundwater with surface water. Morocco's Water Strategy for 2030 includes a 'water highway', from the north of the country to the south, expected to transfer around 800 Mm^3 of water per year. New water could relieve pressure on the Haouz aquifer in particular by supplying Marrakech with drinking water. The Souss-Massa basin in the south is home to the Guerdane irrigated area (10,000 hectares of citrus plantation), which now receives surface water derived from a reservoir upstream in the basin in order to compensate for declining groundwater resources (Houdret, 2012). The Saïss Plain will benefit from a water transfer from the Sebou river with the aim of reducing aquifer abstraction and ending groundwater pumping for drinking water entirely by 2030 (Del Vecchio, 2013).

In Egypt new investors in the West Delta area have been expanding groundwater-based, high-value agribusinesses since the 1990s. The West Delta Canal project was conceived to complement or replace dwindling groundwater stocks by surface water

from the Nile via a water transfer (Barnes, 2012). However, it has yet to be implemented due to bidding and procurement issues and, more recently, the 2011 revolution. In Tunisia approximately 30,000 km of networks transfer water from the north and aquifers in the west towards the Cap Bon and the coast, including Tunis (INECO, 2007). The transfer to the Cap Bon Peninsula in north-east Tunisia provides water for cities as well as agriculture and serves the western (Grombalia) and southern parts of the Cap Bon region and its 15,000 hectares of citrus.

26.3.3.2 Aquifer recharge

Managed aquifer recharge (MAR) and storage can be used especially where groundwater is a strategic reserve for emergency situations. The injection and enhanced infiltration of water can serve as a way of storing excess rainfall and storm runoff, which otherwise could turn into flooding, or as intermediate storage of treated effluent for later agriculture and industrial use.

In Tunisia wastewater represents around 30 percent of the country's agricultural water supply, and aquifer recharge with wastewater has helped prevent coastal aquifer salinisation caused by groundwater over-abstraction (e.g. in the Korba plain in the Cap Bon) (Ouelhazi *et al.,* 2013). Bahrain also applies aquifer-recharge technology, using gravity-fed aquifer recharge through gulleys, pits, chambers and recharge wells to direct urban runoff from storms to the Khobar aquifer (Klingbeil, 2014). In Abu Dhabi the Liwa aquifer is to be used to store excess desalinated water to increase the Emirate's freshwater reserves from 3 to 90 days (Fragazy and McDonnel, 2016). In the Salalah coastal aquifer, Oman, an artificial recharge scheme of 40 tube wells installed in 2003 has been effective in pushing back the saline zone front (Shammas, 2008).

26.3.3.3 Desalination

Half of the world's desalination capacity is found in the Arab world, with Saudi Arabia and the UAE jointly producing more than 30 percent of the world's desalinated water (UNDP, 2013). More than 55 percent of water supplied to urban areas in the Gulf comes from desalinated water, used directly or mixed with groundwater, contributing around 1.8 percent of the region's total water supply (UNDP, 2013). Countries with less intensive use of desalination, such as Tunisia, are considering expanding the sector. In Algeria desalination plants have been ensuring the supply of drinking water in coastal areas since the inauguration in 2008 of the Hamma desalination plant near Algiers (a second plant is in operation near Oran). The Red Sea-Dead Sea project in Jordan, in whatever form it will eventually take, intends to desalinate all of the water it brings in.

While the increased use of desalination has meant a reduction in the demand for groundwater for urban supply, this has been a response to increasing urban demand rather than a means of addressing the pressure on groundwater resources. Desalination is energy-intensive, produces costly water (between 0.50 and 4 USD per cubic meter in the Arab region depending on the level of subsidies) (UNDP, 2013) and has environmental impacts (disposal of brine and emission of harmful oxides from burning fossil fuels).

26.3.4 Attempts at participatory management of groundwater

Some governments have experimented with participatory management with users, either having realised they cannot manage groundwater alone or having been persuaded by donors who routinely promote participatory approaches as a means of enhancing water governance.

In Bsissi, Gabès Governorate, Tunisia, a decree prohibiting well drilling in 1987, and subsequent decisions by the Ministry of Agriculture to discontinue agricultural subsidies and close illegal wells, triggered farmer protests at the highest level. The regional office of the Ministry of Agriculture (CRDA: Commissariat Régional au Développement Agricole) proposed a negotiation and prompted the formation in 2000 of an association of 103 farmers. Farmers and the CRDA agreed upon a series of give-and-take measures to control both the drilling of new wells and abstraction from existing wells (quota, micro-irrigation). In exchange, the wells of members would be regularized and connected to the electricity grid (lowering pumping costs); and subsidies would be extended for shifting to micro-irrigation and other needs. Farmers committed to assist the CRDA in closing disused or abandoned wells. Despite promising results, it seems that the association has now been affected by the challenge to state authority that came with the 2011 revolution (Frija *et al.*, 2014; Leghrissi, 2012; Hamdane, 2015).

The experience in Morocco with aquifer contracts started in 2004 when the Souss-Massa River Basin Agency carried out an awareness campaign about the new water law and proceeded to close illegal wells. This triggered social unrest, and the governor of the region suspended the decision and decided to approach the problem by creating a commission with representatives from 20 institutional partners (BRLI and Agro-Concept, 2012). An agreement was signed in 2007, which included 22 small dams and 5 large dams to be constructed by the state and the regularization of 'illegal' wells, against a freezing of the expansion of irrigated areas for citrus and vegetables, a (subsidized) shift to drip irrigation, an increase of groundwater user fees and reinforcement of the water police (Closas and Villholth, 2016). Although that contract was never implemented, the government put aquifer contracts in the limelight again in 2014 with a policy that they be established in all (later reduced to three) major aquifers in Morocco by 2016 (L'Economiste, 2014).

In the highlands of Jordan, with financial support from the German Cooperation Agency (GIZ), the Ministry of Water and Irrigation attempted to bring together 60 stakeholders (agricultural water users, government institutions, NGOs and research institutions) in a 'Highland Water Forum', a multi-organisational dialogue mechanism for the area (Mesnil and Habjoka, 2012). The Forum's Secretariat is now based at the Ministry of Water and Irrigation, which saw the Forum as a means of mediating its reforms, while farmers largely took it as a means of claiming benefits. No clear measures to curb abstraction have been agreed.

Although the region is rich in traditional community-managed systems of water use, as recalled in the introduction, these new approaches have largely been disappointing. This has to do in part with the lack of trust between the state and citizens and the fact that state officials are generally unwilling to share power or support co-management. Ultimately, rural livelihoods are precarious, and the effort needed to curb abstraction are often unmanageable given the level of overexploitation that has hitherto been allowed.

26.3.5 The case of non-renewable aquifers

The MENA region has considerable regional non-renewable groundwater systems that extend between neighbouring Arab countries and across the border of the region. These are contained within relatively deep geological formations and store significant amounts of water, but this water has a finite lifespan at present exploitation levels as well as quality limitations (UNESCO, 2012; LAS *et al.,* 2010).

Being non-renewable or 'fossil' groundwater, it is impossible to achieve sustainable development in absolute terms, assuming that managed aquifer recharge cannot make up for the amounts withdrawn. Therefore, sustainability of non-renewable groundwater needs to be interpreted in a social and economic, rather than merely physical context, implying that full consideration must be given not only to the immediate benefits but also to the 'negative impacts' of development, the 'what comes after?' question and, thus, to long-term horizons (World Bank, 2003).

In general, there are two ways in which non-renewable groundwater resources are being utilized in the region. The first is through 'planned schemes', where the mining of aquifer reserves is calculated from the outset to be for a limited time (e.g. the Libyan Sarir Basin; the North Western Sahara Aquifer in Libya, Tunisia and Algeria; and Al-Sharqiyah Sand and Al-Massarat Basin in Oman). The second type of utilization is unplanned, leading to the fast depletion of aquifer reserves and the deterioration of its water quality. Unfortunately, this is the case in most Arab countries (e.g. Saq-Ram aquifer, Tawilah aquifer in Yemen, Sana'a basin and the Palaeogene [Rus-Umm er Radhuma-Dammam] aquifer in the Arabian Peninsula) (LAS *et al.,* 2010).

The unplanned depletion of non-renewable groundwater reserves can undermine, and potentially erode, the economic and social vitality of the traditional groundwater-dependent community, and instances of the collapse of such rural communities are known (UNESCO, 2006). In the 'planned scheme', the management goal is the orderly utilization of aquifer reserves and appropriate 'exit strategies', developed and implemented before the aquifer is seriously depleted. This scheme includes balanced socioeconomic and strategic choices on the use of aquifer storage reserves and on the transition to a less water-dependent economy and modern agricultural technologies. Since agriculture is the main user of these waters in the MENA region it is vital that such reserves are used with maximum hydraulic efficiency and economic productivity; but it is even more important to be able to limit and control expansion. A key consideration in defining the 'exit strategy' will be the identification of appropriate water resource substitution options, such as the desalination of seawater or brackish groundwater. In terms of governance, public awareness campaigns on the nature, uniqueness and value of non-renewable groundwater are essential to create social conditions conducive to aquifer conservation and management, including, wherever possible, full user participation.

26.3.6 Transboundary groundwater resources

While the governance and management of groundwater resources are challenging and complex nationally, they become all the more intense and convoluted in the case of transboundary resources. In some MENA countries the groundwater dependency ratio is extremely high, and almost every country depends, to a varying degree, on aquifers

that are non-renewable and shared with neighbouring countries. For example, the non-renewable Rus-Umm er Radhuma-Dammam aquifer system, which extends from the north to the south of the Arabian Peninsula, is shared between the majority of the Peninsula countries and, in most of those, plays a key role in meeting their water needs.

Despite such high dependency, most transboundary groundwater resources are managed unilaterally, without comprehensive international agreements (for example building on the 2008 UN GA resolution A/RES/63/124 on Transboundary Aquifers). In the absence of such agreements, uncontrolled development practices have had detrimental effects, such as high depletion rates, increased pumping costs, the deterioration of water quality due to the mixing of water between multi-layered aquifers, and the reversal of flow direction in some locations and across international boundaries. The development of groundwater to meet increasing water demand is expected to lead to further mining of shared aquifers, with the potential for regional disputes (LAS *et al.*, 2010; ACSAD, 2009).

However, some modest but encouraging steps have been taken. For example, a technical MOU was signed in 2007 between Saudi Arabia and Jordan, who share the Saq-Ram aquifer system. The agreement prohibited the drilling of new production wells and the expansion of agricultural activities within an area of 10 km along both sides of the border (UN-ESCWA and BGR, 2013). With the support of OSS, UNESCO and others, scientists from Algeria, Libya and Tunisia have been working together since the 1960s to develop a common database on their shared North Western Sahara Aquifer System (NWSAS). Having agreed on the impact of different resource use scenarios, their example illustrates the benefits of finding consensus on datasets and building trust (Benblidia, 2005). Likewise, a protocol was signed between Egypt, Libya, Sudan and Chad, which share the Nubian Sandstone Aquifer System (NSAS), providing a framework for scientific collaboration, data exchange, joint capacity development and aquifer development plans (Salem, 2007).

26.4 OVERALL MISMANAGEMENT?

In the previous sections, we reviewed the diversity of policy tools designed and implemented in the region and suggested that their efficacy has been generally limited. We turn here to analysing the reasons for this state of affairs and try to pinpoint regional commonalities and specificities, while recognising that countries elsewhere in the world fare little better.

26.4.1 The top-down enforcement of regulations with weak results

Although in theory virtually all countries issue permits for well drilling and exploitation, many prohibit the drilling of new wells and control drillers, and several have volumetric quotas and even pricing, the top-down application of these tools has proven difficult in practice. In Syria, Yemen, Jordan, Morocco, Oman and elsewhere, despite comprehensive regulatory frameworks, wells are still being drilled without permits; meters have not become the rule; and use is barely monitored by the state. Merely

codifying such measures within the law makes little difference to farmers' choices and strategies. Although the situation is not radically different from other regions of the world, the seriousness of water scarcity in the MENA region makes this regulatory failure more worrying.

The top-down application of regulation neglects the fact that the power of the state dramatically dwindles as one penetrates the countryside. Locally, people find ways around regulations, and the reality on the ground is often very far from what governments like to proclaim. Legal pluralism, where the state's very control of water and land resources is contested (see Al-Naber and Molle, 2016 for the case of Jordan), is pervasive. In addition, when attempted, regulation is generally enforced 'without teeth'. In Yemen, as Alhamdi (2012) reflects, "we have a water law; we have good policies and reasonably good strategies; but the problem is their implementation and enforcement". There is no real political will to tackle the problem, and water management policies are not at the top of the political agenda. In the MENA region in general it is perceived that "although policies exist, enforcement is lacking" (Tutundjian, 2012).

In the case of Oman, despite the issuing of strict provisions in 2009 and most aquifers being declared 'at risk' (having a negative water balance), drilling is not banned but still allowed with a permit. Likewise, Morocco has yet to define any 'zone of prohibition' as provided by the law, despite the catastrophic situation of many aquifers. This demonstrates limited political resolve to tackle overdraft for fear of curtailing the source of important social and political gains (Kuper *et al.,* 2017; Molle and Closas, 2017).

The organizational culture and professional background (mostly hydraulic engineering) of water agencies and departments means they attach great importance to data acquisition and modelling but less to understanding the agricultural sector and the diversity of actors (Faysse *et al.,* 2011). Yet, assessments of groundwater resources remain problematic (Leduc *et al.* 2017) and technical parameters are often out of date. In Tunisia the distinction between shallow and deep groundwater (the 50 m limit) appears to be very arbitrary (Hamdane, 2014). It does not take into account the aquifer's characteristics, such as possibly having interconnected layers. Similarly, in Lebanon, the age-old depth limit of 150 m, below which no drilling permit is required, is obsolete but has yet to be scrapped.

26.4.2 A constrained environment

Campaigns to regularise existing wells, the control and sanctioning of illegal wells and the monitoring of water use invariably cause logistical nightmares, not least since most authorities are short-staffed and lacking in funds. In Yemen, between 2003 (when the Water Law was passed) and 2007, the National Water Resource Authority received around 2,000 license applications, of which 47 percent were approved. But this must be contrasted with the close to 100,000 wells existing across the country (Redecker, 2007). In Abu Dhabi installing meters in the 100,000 existing wells would require a great effort, not to mention that the equipment itself is expensive and must also be able to withstand the very harsh conditions of the UAE desert. The same applies to Oman's 130,000 wells. In Lebanon there is glaring understaffing at the department responsible for the licensing and monitoring of wells. An official at the Ministry of Energy and Water reported that around 100 officials are needed to conduct regular field visits

across the country, while no more than 10 employees were currently working in the department (Nassif, 2016). The technical side of well-drilling projects and monitoring has been outsourced to private companies.

In the Souss-Massa region of Morocco the water police is short-staffed and users drill overnight and during holidays and weekends (BRLI and Agro-Concept 2012). In Lebanon officials indicate that while department officials can theoretically perform field visits without being accompanied by the Internal Security they prefer not to do so for safety reasons (Nassif, 2016). In Jordan the number of field staff is insufficient (e.g. only three for the 400 registered wells of Azraq and as many illegal wells) and they are too close to farmers (Al-Naber and Molle, 2017). In Tunisia the lack of authority and absence of a 'water police' monitoring compliance with rules and restrictions are major obstacles (Hamdane, 2014). In many countries, including Jordan, Yemen and Morocco, staff can face intimidation and violence, or simply do not have the power to risk antagonising powerful people.

A third limitation to state action is corruption and the abuse of political power. Lebanese officials are frequently reported to accept bribes to turn a blind eye to infringements (Nassif, 2016). In Aleppo, Syria, the lack of clearly defined administrative roles within the Ministry of Agriculture (responsible for the issuing of groundwater permits) has led farmers to seek 'informal permits' from the local police (Albarazi, 2014). The corruption of enforcement officers also undermines the application of rules on the ground. As described by Wendle (2016), well drillers had connections and trusted contacts to local government officials, on whom they could count "to look the other way" if they bent the rules.

When the question of groundwater control is embroiled in larger issues of land speculation it becomes even more intractable. The "disastrous management of public land" in Egypt, as bleakly described by Sims (2015), reveals dysfunctional property titling, registration and transfer systems. Since 2007 numerous land scams involving officials and influential people have been unearthed and made publicized. According to Sims (2015), the mess remains untidied for a purpose: "to keep the machine producing 'rents' and windfall profits for vested interests and space for pervasive corruption." Accessing public (desert) land, whether for productive or speculative purposes, is conditional upon the obtaining of licenses to drill wells or the capacity to ensure that authorities turn a blind eye to illegal occupation and drilling. A similar situation is found in certain parts of Jordan, such as Azraq, where the engine of groundwater depletion is partially linked to the preservation of the Bedouins' capacity to mediate investors' access to land against payment (Al-Naber and Molle, 2016).

26.4.3 Administrative organization of the groundwater sector

The administrative and organizational regulation of groundwater abstraction within state structures and governments in the Arab world can be problematic. In some cases the amalgamation of the regulator and operator roles within the same ministry carries the risk of confusing these roles and weakening the implementation of legislation. In Tunisia the Ministry of Agriculture and Environment is responsible for surface and groundwater monitoring and control, as well as agriculture. Indeed, CRDAs are strong local authorities, which need to weigh resource conservation on one hand and development needs as expressed by the population and the governor on the other.

It is more common, however, to have splintered administrations, with a large number and diversity of state and sectoral actors with a stake in groundwater use and/or management. A first issue is that of the positioning of the 'regulator', responsible for 'resource management', which often generates turf battles for prerogatives and derived benefits. A second issue is linked to the inconsistencies and lack of coordination associated with an administrative organization in sectoral silos (Faysse *et al.,* 2011; Al-Zubari, 2014).

Where development and regulatory agencies are separate, it is generally the former that dominates over the latter. In Morocco groundwater regulation is the responsibility of the River Basin Agencies, but these lack funds and are understaffed. They are confined to data collection, contracting out technical studies, planning tasks and the licensing of well drilling, and must compromise with the ORMVAs (Office de Mise en Valeur Agricole, representing agriculture) and the Ministry of Public Works, under which they are situated (Tanouti and Molle, 2013). In Yemen, "at least until the updated 2010 Sector Strategy […], the Ministry of Agriculture and Irrigation looked upon the Ministry of Water and Environment 'as a menace to its power'" and resentment between these ministries is expressed through inequitable budgets (Alderwish *et al.,* 2014). The newly created NWRA (dependent upon the Ministry of Water and Environment) is seen by the Ministry of Agriculture as "ineffectual and hostile to the interests of farmers", with little ability to plan or act (Ward, 2015). In Algeria the proliferation of illegal wells was partly due to a lack of coordination between those authorities responsible for water resources, with the division of administrative tasks between the *wilayas* (in charge of issuing drilling permits) and the National Agency of Hydrological Resources (in charge of studying and monitoring the resource) (FAO, 2008).

As described in the Introduction, groundwater development in the MENA region has often initially been part and parcel of plans aimed at raising rural incomes, ensuring national food self-sufficiency or the settlement of Bedouins. Government subsidies to develop agriculture or enhance its performance, such as domestic price support, barriers to imports or energy subsidies, have further fuelled groundwater abstraction and the expansion of irrigated agriculture, encouraging farmers to over-irrigate or use water for low-value crops (World Bank, 2007). While policies supporting irrigated agriculture were important historically, they have rarely been phased out once their impact on resources was recognised. A World Bank study (2007) identified that most countries in the region still had incentives for irrigation in place, notably subsidized credit for farmers. With few exceptions, such as the wheat policy in Saudi Arabia, policies by the ministries of energy, agriculture, urban development or tourism still frequently incentivise the use of (ground)water.

A textbook illustration of policy contradiction is provided by the current 'Plan Maroc Vert' – a major nationwide investment plan to boost agriculture. It makes light of environmental requirements and even provides a loophole for farmers to use illegal wells in overexploited aquifers and receive subsidies, which contradicts attempts by the River Basin Agencies to regulate (over)exploitation (Molle and Tanouti, 2017). In addition, the subsidised development of drip irrigation results in increased water consumption rather than 'savings'. Water consumption increases at the plot level (better uptake of water by the plants, densification of plantations, e.g. in Morocco or Tunisia, where olive groves with 200 trees/ha have been transformed into olive + fruit trees

at 800 plants/ha), as well as due to the expansion of the irrigated area. Since an individual well's abstraction is more or less unchanged (and based on the capacity of the well), the water 'saved' can be reallocated to an expanded plot (see Molle and Closas, 2017). While both production and water productivity increase, benefiting farmers and the nation, the total water consumed also increases, to the detriment of return flows (which, in many cases, is the main recharge of the aquifer), thereby rendering it an unsustainable enterprise in the long term (Molle and Tanouti, 2017). In Jordan the Ministry of Energy and Mineral Resources favours the development of solar energy for groundwater pumping (and even received subsidies from the EU for 200 units), while the Ministry of Water and Irrigation fiercely opposes the idea, as it leads to greater groundwater exploitation.

Finally, state capacity in managing groundwater can be confused by the contradictory influences donors may have on water management and water sector reforms. In Yemen many projects have made the country's institutions dependent on foreign funds, such as the NWRA where, by 2009, more than a third of its staff was contractual and paid by donors (Ward, 2015). According to Alhamdi (2012), "Water is always perceived in Yemen as a donor sector, pushed by donors, with a weak role of the Yemeni side", which creates low levels of leadership and ownership by the Yemeni authorities.

26.4.4 The state, vested interests and groundwater governance

A last major difficulty for state-centred groundwater governance in the MENA region is the vulnerability of the state, associated with multiple structures of authority, and its tolerance of various types of rent-seeking strategies by actors both internal and external to the state.

In Yemen tensions underlying water management and water politics arise from the contest between established traditional authorities and a relatively young Yemeni state attempting to establish itself and find its own legitimacy within the country's various tribal systems and allegiances. Forces external to the formal branches of government and various vested interests affect the development of national politics, such as families controlling the bulk of commerce and tacit coalitions between sheikhs and local security officials and representatives (Zeitoun, 2009). In such a political context, patronage and control of political life are pervasive (Van Steenbergen *et al.,* 2012). In the past, access to groundwater played a role in integrating tribal elites into the government's 'formal ruling establishment' (Moore, 2011). In many tribal rural areas, tube wells came to be seen as a sign of wealth and prestige, and financing groundwater abstraction amongst tribal elites became an effective patronage mechanism. Wells were used as political gifts, through which local leaders could be co-opted into power.

A similar situation can be found in Jordan where, as Richards wrote (1993), "all government decisions must be viewed through the lens of His Majesty who must balance contentious internal and external forces", and agriculture is viewed as "a source of patronage for key constituencies [in particular Bedouin tribes] whose support is essential to achieve domestic stability/foreign policy goals, or as a source of income for the population". Controlling access to and distribution of (state) land and water to specific constituencies is part of a key political balancing act (Al-Naber and Molle, 2016, 2017).

Corruption, in terms of mediating benefits that can be obtained from the state, is often, as in Yemen, considered to be "the main point of business rather than its murky illegal underside" (Bafana, 2012). It is part of a prevalent system of patronage, networks of influence, political, economic and social power where *wasta* (or connections) with people well positioned within the establishment is key (Robinson *et al.,* 2006). In the UAE, where the tribal community structure is considerable, landowners wield significant power through *wasta* in opposing the implementation of regulation. As one agricultural official in Abu Dhabi summed up: "here there isn't such a thing as 'illegal' for a local who has good connections" (Fragaszy and McDonnell, 2016). In Lebanon's Bekaa local political leaders sometimes intervene at the Ministry of Energy and Water to issue permits for their electors (Nassif, 2016).

The power of particular interest groups can also be seen in their capacity to obtain land concessions or well licenses, to attract state investment and subsidies and the preferential allocation of water, as in the El Guerdane project in Morocco (Houdret, 2012) and the (stalled) West Delta Project in Egypt. The example of Israel shows that organized agricultural lobbies can deflect attempts by the treasury to curtail the abstraction of water and tax its use (Feitelson, 2005).

26.4.5 Coping strategies and induced social dynamics

The overexploitation and salinisation of groundwater resources have had negative environmental and social impacts. Facing groundwater depletion and the 'race to the bottom', farmers and other users have devised solutions to cope with the loss of the resource. Dropping aquifers have forced farmers to continuously deepen their wells, especially in agricultural frontier areas, such as the Jordanian highlands and the Souss-Massa in Morocco. In large plains, such as the Saïss and Haouz (Morocco) and Bekaa (Lebanon), as well as in large-scale public irrigation schemes, the combined use of surface and groundwater gives farmers more flexibility, as in the Tadla in Morocco and the Nile Delta in Egypt. Seawater intrusion has led to the destruction of agricultural areas and the loss of livelihoods (e.g. Oman, Morocco and Tunisia).

Farmers adapt to changing conditions by deepening their wells, investing in collective wells (e.g. Egypt, Morocco, Yemen), adjusting cropping patterns or even reverting to rain-fed agriculture, but many abandon agriculture altogether when they can no longer meet the rising costs. Access to capital is therefore essential in determining the type of strategy followed by groundwater users (Faysse *et al.,* 2011). It is apparent that small farmers are often displaced by wealthier users who can afford to invest and pump deeper (e.g. Souss-Massa, Morocco, Syria, Lebanon). Unmanaged aquifers therefore exacerbate social differentiation.

26.5 CONCLUSIONS

The groundwater situation in the MENA region is certainly worrisome when judged by the many key aquifers that are subject to overexploitation or degradation, including those that are non-renewable. On paper most countries appear to have adequate formal institutions, especially at the national level, including strategies and laws. The shortcomings of their implementation on the ground are often ascribed to the fact

that these institutions still need a lot of support (capacity building, strengthening of technical capacities of staff and budgetary support). Although this is certainly the case, such assessments can serve as a fig leaf for a deeper lack of political willingness and/or an ability to address the issue head on. This is illustrated by a number of countries, including the UAE, Oman, Lebanon, and Morocco, which have yet to apply drilling bans, despite the critical status of most of their aquifers. This lack of resolve has undermined the implementation on the ground of tools such as well registration, metering, pricing and quotas. One obvious conclusion is that it would be senseless to implement measures aimed at reducing abstraction while well expansion remains uncontrolled. Registration, not to mention metering, has proven to be a costly logistical nightmare and is rarely exhaustive (except in a few cases, including Bahrain and Abu Dhabi).

Policies 'without teeth' have been shown to relate, in some cases, to tribal politics, clientelistic practices and the pervasive use of *wasta* to circumvent or evade regulation. More profoundly, the economic and political benefits from groundwater use accruing to both farmers/users (in particular powerful investors with high-level connections) and the state are too great to allow the control of the growth (and bust) of the groundwater economy (Molle and Closas, 2017). Examples of the vulnerability of this economy to changes in the price of energy have sent a strong message to governments: in Yemen a reduction in diesel subsidies generated a crisis of unprecedented severity and exacerbated the political and social unrest that beset the country following the Arab Spring. In Syria the withdrawal of diesel and fertilizer subsidies, combined with consecutive years of drought, reduced crop yields and increased food prices, causing numerous farmers to abandon their land and fuelling a humanitarian crisis in and beyond the north-east of the country (Kelley *et al.,* 2015).

Current policies certainly overestimate the power of the state in such contexts and point to a deficit in participatory groundwater management. It is striking that the few attempts at such forms of management, as observed for example in Bsissi (Tunisia) and the Souss region of Morocco, originated in confrontations between groundwater users and state bent on enforcing regulations. In contrast, Jordan's Highland Water Forum can be seen as the culmination of 15 years of donor projects in the Azraq region rather than an endogenous state initiative. This helps explain the low level of participatory management in the MENA region, and reflects the overall 'top-heavy' system of governance (Al-Zubari 2014).

In sum, the benefits provided by groundwater to rural communities, and thus its political role as an 'escape valve', work against regulation, as does its use in agribusiness ventures by investors often with political connections. The authority is hampered by a lack of political will (due to those benefits) as well as by the discouraging magnitude of a problem that has spiralled out of control, the weakening of state power, particularly in the wake of the Arab Spring, and the troubled and mistrustful relationship between the state and its citizens that runs counter to co-management solutions.

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