

# Controlling groundwater over abstraction: state policies vs local practices in the Jordan highlands

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## Abstract

The control of groundwater over abstraction is a vexing problem worldwide. Jordan is one of the countries facing severe water scarcity which has implemented a wide range of measures and policies over the past 20 years. While the gap between formal legal and policy frameworks and local practices on the ground is widely acknowledged, few studies investigate how local users react to state regulations and document their tactics to circumvent them. This paper examines the major tools implemented by the Jordanian government to control well expansion and water abstraction and how farmers in the Azraq basin have responded to these measures. It then documents how, in response, the Ministry of Water and Irrigation has recently enacted a series of creative counter-measures, both direct and indirect, in an attempt to toughen law enforcement and raise pressure over groundwater users. The lessons learned are highly relevant for countries with similar situations, both in the region and elsewhere.

*Keywords:* Azraq; Groundwater management; Jordan; Over abstraction; Water governance; Water policy

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## Introduction

The use of groundwater resources has long been overshadowed by the more prominent and visible use of surface water; but as the exploitation of surface water has reached (or exceeded) its limits in many river basins, groundwater has gradually taken center stage and now makes up 26% of total withdrawals at the global level (Margat & van der Gun, 2013). The continued expansion of irrigation worldwide in the past 30 years has largely been fueled by increasingly resorting to groundwater (Food and Agriculture Organization (FAO), 2015), but the annual contribution of *nonrenewable* groundwater abstraction to irrigation globally tripled from 75 to 234 billion ( $10^9$ ) m<sup>3</sup> over the 1960–2000 period (Wada *et al.*, 2012). This worrying situation, where half of groundwater-based

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agriculture is unsustainable, is nowhere more explicit than in North Africa and the Middle East, where unsustainable groundwater development for irrigation is taking place in arid or desert land (United Nations Development Programme (UNDP), 2013a; Voss *et al.*, 2013; Famiglietti, 2014; FAO, 2015).

Although a lot of research has been conducted on physical aspects, the question of how groundwater is and should be governed by societies remains largely a moot issue, bedeviled by a baffling diversity of situations (Burke & Moench, 2000; Mukherji & Shah, 2005) and the thorny issue of common property resource management (Ostrom, 1990). Following standard views on Integrated Water Resources Management and governance (Rogers & Hall, 2003), emphasis is often put on the structure and roles of state administrations, as well as on the legal and policy ‘tools’ they deploy, beside a conventional call for participation. The overemphasis on law and regulations, fueled by donor-supported policy reforms, has led to a situation where most countries ‘have state-of-the-art policies and regulations, but the problem is enforcement and implementation’, as this ubiquitous statement goes. Little attention has been devoted to documenting the reasons for such failure and how local actors effectively evade or circumvent the law.

Jordan is a prime example of a country critically dependent on groundwater that has enacted and tested a large range of policies. It is ranked as the world’s second poorest country in terms of per capita water availability, with a yearly water abstraction that has fluctuated between 800–900 million m<sup>3</sup> (MCM) during the past 15 years, and an average available resource of 602 MCM (Humpal *et al.*, 2012; Ministry of Water and Irrigation (MWI), 2013b), the shortfall coming from groundwater destocking. The pressure on water resources is increasing under several external and internal factors, such as the huge increase in population generated by successive waves of refugees in the country’s history, and what economists consider to be a sectoral misallocation of its limited available water resources. The percentage of supply going to agriculture in Jordan averages 53%, followed by domestic (42%) and industrial uses (5%) (MWI, 2013b), despite the fact that agriculture only contributes 3% of the Jordanian gross domestic product and employs 2.6% of the Jordanian labor force (Department of Statistics (DoS), 2014).

Jordan draws 60% of its supply from groundwater, while the remaining comes mainly from the Yarmouk River, with some contribution from the Jordan River and side *wadis* along the Jordan Valley (Humpal *et al.*, 2012). Reuse of treated wastewater now amounts to 123 MCM/year. The municipal sector stands out as the first user of groundwater (48%), followed by agriculture (46%) and industry (6%) (DoS, 2014), with a total abstraction of 540 MCM (MWI, 2013a). This foreshadows the competition between cities and farmers for precious groundwater resources, and the political costs of favoring the latter over the former. The Amman-Zarqa and Azraq basins make up 42% of the total renewable groundwater resource and are the most over-abstracted aquifers nationwide, with abstraction estimated at 176% and 215% of the safe yield, respectively (MWI, 2009).

Groundwater-based agriculture started in the highlands in the early 1960s (Demilcamps, 2010). With the dramatic expansion of irrigation and the growing abstraction by cities, Jordan’s groundwater resources started to decline and to deteriorate in terms of quality. With average drops in water tables around 1 m per year (Goode, 2012), the unsustainable nature of the groundwater economy became apparent and triggered a series of institutional and legal changes, starting in 1988 and including the 1998 water policy, which established the priority of domestic water over other uses, leaving agriculture as the main sector to be impacted by reallocation.

This paper starts by briefly describing the chronology of groundwater policies in Jordan and then moves to documenting and analyzing their application on the ground, focusing on the aquifer of the

Azraq basin (with the two distinct areas of Azraq proper and Mafraq). It illustrates how water users have responded and adjusted to the successive measures taken by the government, but also to changes in their wider economic and political environment, and how, in response, the Jordanian government has recently taken further measures and toughened law enforcement.

Although there are numerous reports on, and studies of, formal groundwater regulations and policies, it is much less common to see studies on farmer/users' local practices and responses to policies on the ground (exceptions include, for example, recent works by Reis (2014) on Mexico, or Aarnoudse *et al.* (2012) on China). We believe, however, that careful documentation of local practices is key to understanding how measures can be designed more efficiently and farmers' behaviors influenced towards a shared goal of sustainability. Jordan's experience in groundwater management is extremely compelling due to its exceptional situation of limited resources and the broad range of policies that have already been implemented and tested. Lessons that can be drawn from Jordan's experience for other countries, most particularly in the Middle East and northern Africa, may prove to be extremely valuable, at a time when the government is showing unprecedented resolve to 'tighten the knot' on users through various creative measures.

### **Key steps of groundwater policy in Jordan**

The modern management of water in Jordan started in 1952 with the Land and Water Law, which already considered allocating water through water entitlements, followed by the Groundwater Monitoring Bylaw No. 14 (1961) that focused on the drilling of wells and the licensing of drilling activities through permits granted by the National Authority for Natural Resources that was established in 1965. Groundwater exploitation for irrigated agriculture was encouraged by the government in the early 1970s because it held the promise to provide a reliable source of income, improve social welfare and stability in rural areas, and help settle Bedouins (UNDP, 2013b).

Well licenses and soft loans for drilling private wells were granted to users by the state. The licenses indicated in general a maximum annual volume of 50,000, 75,000 or 100,000 m<sup>3</sup>. These volumes were, however, not respected due to weak to non-existent law enforcement and monitoring of groundwater, and to the lack of a metering system (Chebaane *et al.*, 2004). Consequently, the highlands became one of the most important agricultural regions in Jordan, with olives, grape, vegetable and fruit trees (Ministry of Agriculture (MoA), 2010).

The management of groundwater resources remained with the National Authority for Natural Resources until 1984, when it was handed over to the Water Authority of Jordan (WAJ), and to the Ministry of Water and Irrigation (MWI), later established by the Water Authority Law No. 18 of 1988.

#### *Water Authority Law No. 18 of 1988*

Law No. 18 defined the distribution of roles and decision-making power among state administrations and established the WAJ, which was, among other things, to:

- survey and conserve all water resources and set priorities for their utilization;
- regulate the drilling of public and private wells; and
- explore water sources through exploratory wells, and issue licenses for drilling rigs and drillers.

This law clarifies the fact that all existing water sources, whether surface or groundwater, within the borders of the Kingdom are considered as state property and may only be used or transferred in accordance with the provisions of state laws. Law No. 18 was the first piece of legislation to introduce fines and prison penalties for illegal well drilling or when the conditions stipulated in the permits were not respected.

### *The groundwater Bylaw of 2002*

Most of the measures pushed by donors and the World Bank in the 1990s and expressed by the government in its policy papers eventually coalesced in a watershed Bylaw enacted in 2002, under which the WAJ was reaffirmed as the only legal entity allowed to issue drilling licenses to users. Legal well owners have to renew the abstraction licenses yearly, by paying 50 JD. Licenses specify the type of use and the area of land to be irrigated (it is illegal to irrigate more than one land plot or property with a given licensed well). In order to obtain a license, the land area to be irrigated has to be larger than 10 ha and the minimum distance between wells has to be 1 km. The authority has the right to backfill the well if groundwater is sold as drinking water without a special permit, when wells have been drilled without a license, or if well owners do not comply with the terms of the licenses/permits granted.

An owner can also apply for a permit for cleaning, deepening and/or changing the location of an existing (licensed) well. Theoretically, a license for a new well is only given after the original well has been backfilled. Following the Bylaw, each well has to have a metering device and the well owner should inform the WAJ within 48 hours if the meter stops working.

Transitional measures were necessary to take into account pre-existing illegal wells. Wells ended up classified into four types: (1) legal wells with a *license (rukhsa)* from the WAJ; (2) illegal wells registered in the WAJ database but which got a *permit (ijaza)* when it was considered that ‘there are economic or social factors justifying continuation of water extraction’<sup>1</sup>; (3) registered wells which did not receive a permit; (4) illegal wells unknown to WAJ (or to which they turn a blind eye) (not explicitly referred to in the law)<sup>2</sup>. Wells with permits drilled on a land without official title may be regularized if/when private land ownership is confirmed. *Permits* are renewed every 3 years (at the cost of 150 JD) and WAJ has the right to modify or cancel them.

Bylaw 85 introduced block-tariffs for groundwater, which vary with the type of well (Table 1). Licensed wells were granted a generous free block of 150,000 m<sup>3</sup>/year and rather limited tariffs for blocks beyond this volume. Areas with saline water were granted lower tariffs (on account of associated low agricultural revenues). Illegal wells, by contrast, faced much higher tariffs starting from the first cubic metre. Wells with permits stood in the middle with a free block of, generally, 50,000 m<sup>3</sup>. If a well has no meter, the abstracted amount can be estimated by WAJ according to the irrigated area, cropping patterns, or the energy consumption of the pump (if there is any electric connection).

<sup>1</sup> Against payment of a fee of 150 JD/metre of well.

<sup>2</sup> Recent official data indicate that Jordan has 1,559 (identified) illegal wells, out of which more than 50 wells are owned by influential people (such as former ministers, former parliament representatives, senators, and former political and royal councillors) (Sawaleif, 2013), which seems an understatement if judged from the situation observed in Azraq.

Table 1. Water tariff for registered and unregistered wells (Bylaw 85-2002/4, and amendment 2014) (1 K m<sup>3</sup> = 1,000 m<sup>3</sup>; 1 JD = 1,000 fils = 1.41 US\$).

Water blocks	Wells with license/ permit (2002/4)	Wells with permits in Azraq (2002)	Illegal wells (registered) (2002)	Illegal wells (registered) (2014)
0–10 K m <sup>3</sup>	Free	Free	Free	25 fils/m <sup>3</sup>
10 K–30 K m <sup>3</sup>	Free	Free	Free	30 fils/m <sup>3</sup>
30 K–50 K m <sup>3</sup>	Free	Free	Free	35 fils/m <sup>3</sup>
50 K–100 K m <sup>3</sup>	Free	20 fils/m <sup>3</sup>	25 fils/m <sup>3</sup>	35 fils/m <sup>3</sup>
100 K–150 K m <sup>3</sup>	Free	60 fils/m <sup>3</sup>	30 fils/m <sup>3</sup>	35 fils/m <sup>3</sup>
150 K–200 K m <sup>3</sup>	5 fils/m <sup>3</sup>	60 fils/m <sup>3</sup>	35 fils/m <sup>3</sup>	35 fils/m <sup>3</sup>
>200 K m <sup>3</sup>	60 fils/m <sup>3</sup>	60 fils/m <sup>3</sup>	70 fils/m <sup>3</sup>	35 fils/m <sup>3</sup>

#### *Amendments to the 2002 groundwater Bylaw and Law No. 18 of 1988*

Several amendments to the Water Bylaw were made in 2003, 2004, 2007, 2013 and lastly in 2014. In 2003 the WAJ modified the tariff of the second block for legal wells (from 5 fils/m<sup>3</sup> to 25 fils/m<sup>3</sup>), which generated political opposition and the intervention of some Members of Parliament who exerted political pressure on the then Minister of Water (interview with official, 2015). The rise was eventually cancelled by another amendment in 2004 (Addustour, 2004).

The establishment of water tariffs and quotas with the aim of influencing behaviors and controlling abstraction was a bold step, since there is no other place in the world where administered prices for groundwater have been set up with such an objective (see Molle & Closas, 2016). This policy, however, was weakened from the start because farmers tended not to pay their bills and regulation was not enforced; some wells had meters installed by the WAJ but others not; farmers' tampering with meters was widespread; the consumption figures collected on the ground were distorted by different mechanisms clarified later in this paper. On the other hand, the generous free block and the relatively low water tariffs made this payment for water modest compared with actual pumping costs or incomes, which defeated the measure (Venot & Molle, 2007).

The 2007 Amendment indicated that a permit might be obtained if the well owner had asked for a settlement with the MWI before July 2005. Well owners in this case had in general dug a well illegally because their land was not legal, expecting their land to be legalized later through a settlement procedure carried out by the Department of Land Survey (DLS). The 2014 Amendment went one step further and specified that all the wells not having initiated such a process of regularization before 2005, as well as all other unlicensed wells, should be backfilled by their owners at their cost and under the supervision of WAJ. Failing this, the WAJ would close them (with police or border patrol support if necessary). Farmers should also install metering systems and new (minimal) quotas were issued for registered illegal wells. Corresponding tariffs were dramatically raised, to the point of virtually making any use unprofitable, showing the government's resolve to end illegal wells. In 2014 the WAJ started closing illegal wells, first acting, however, on the non-working or unproductive wells.

Other important policy measures were introduced through an amendment of Law No. 18 of 1988 (also in 2014):

- Farmers cannot initiate or request anything from the administration until all due water bills are paid.
- The penalty for drilling illegal wells was changed from six months to two years in prison to one to five years, with a payment of 2,000 to 7,000 JD; while not respecting the conditions of the license would attract fines between 1,000 JD and 5,000 JD and prison between one and three years.
- Illegal abstraction will be estimated according to the cultivated area, cropping pattern, energy consumption, or remote sensing images, and charged to the user.

Current policy objectives are well delineated in the 2008–2012 national Water Strategy (Hashemite Kingdom of Jordan (HKJ), 2009), which emphasizes the willingness to enforce Bylaw 85/2002 and a strict monitoring of groundwater use, introduce metering, use tariffs to discourage planting crops with high water requirements, and close down illegal wells.

## Methods and context of the case study

### *Methodology*

The present case study on Jordan's highland focuses on the aquifer of the Azraq basin (with the two distinct areas of Azraq proper and Mafraq). Fieldwork was carried out in 2013 and 2014, and included interviews with 80 farmers (local residents, investors, past farmers), line agencies personnel, wetland manager, and local leaders, completed by semi-structured interviews of nine policy makers, staff in water, land and agriculture administrations, and water experts in Amman (2014 and 2015). The questionnaires covered issues of land tenure, cropping patterns, production, water and energy sources and use, animal breeding, crop/farm budgets, future perspectives on Azraq, and responses to/perceptions of water policies. Because of the sensitivity of the topic and the reluctance of some interviewees to be cited, the information gathered is anonymized and interviewees are referred to as either 'Official' or 'Farmer'. Additional information is drawn from newspapers and the general literature.

### *General physical features of Azraq basin*

The Azraq basin is located in the north-eastern part of the country with an area of 12,710 km<sup>2</sup> (Figure 1). The largest part of the catchment (94%) lies in Jordan with smaller parts in Syria (5%) and Saudi Arabia (1%) (Shahbaz & Sunna, 2000). The basin is a semi-desert area characterized by a hot and dry summer and fairly wet and cold winter. The mean annual rainfall ranges from 50 mm/year in the Azraq oasis area to 500 mm/year in the Jabal Al Arab area, with an average of 87 mm/year (Jordan Meteorology Department (JMD), 2011). The average evaporation rate in the area is 2,400 mm/year (El Naqa *et al.*, 2007). The dominant soil type in the region is a silty clay loam soil with high soluble salt content in the subsurface horizon.

The Azraq basin consists of three aquifer systems (upper, middle and deep aquifers) that are hydraulically connected in certain parts. The depth of groundwater in the upper aquifer varies from a few metres in the center of the Azraq oasis to 400 m in the northern catchment area. The Azraq basin safe yield has been established by the Ministry at 24 MCM/year (MWI, 2009; Demilcamps, 2010), while the total estimated recharge is about 34 MCM/year (Bajjali, 1990; MWI, 2013a, 2013b). Groundwater flow moves from the north east and south west of the basin to its center, the qa'a, that is, the depression where a permanent

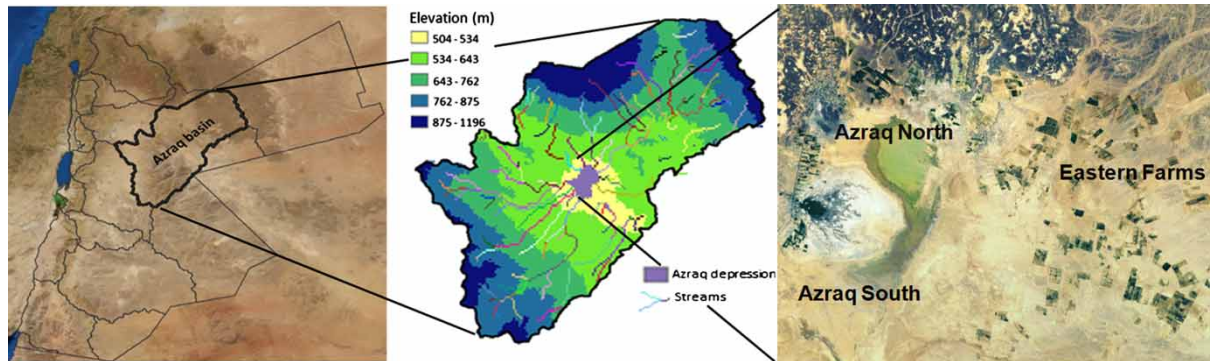


Fig. 1. Azraq basin elevation and streams.

wetland was initially found (Figure 1). Likewise, rainfall generates runoff that flows in the same directions through wadis and accumulates in the qa'a, while recharging the aquifer.

#### *Azraq oasis and communities*

Three main communities are found in the Azraq basin: Chechens, Druze and Bedouins. Even though Bedouins were mostly pastoralists, some of them started farming when agriculture boomed in the area. Others preferred to work as land brokers. At the beginning of the 20th century Chechen and Druze settled in the city center, close to the natural springs, the former in the south and the latter in the north. Most Chechens engaged in farming but agriculture's productivity remained limited by the relatively saline groundwater found in the lands located near the central mudflat (qa'a).

The Azraq oasis (or Azraq wetland) initially had a naturally flooded area of 1,200 ha and was declared an international Ramsar site in 1977 (Al Eisawi, 2012). It was an important reserve for migratory birds and a breeding site for about 70 bird species. The oasis was fed by surface runoff but sustained during the dry period by three springs which eventually dried up in 1992 (Daoud *et al.*, 2006), due to intensive pumping for agriculture and water supply to Amman. This caused the deterioration of the wetland and a decrease in the flooded area, leading to an environmental catastrophe and a reduction of the site's tourist attractiveness. The oasis is now artificially recharged with groundwater supplied by one public well and covers 10% of its original extension (Hresha, 2013).

#### *Agriculture and the water situation in the Azraq basin*

Initially, subsistence agriculture depended on traditional surface irrigation techniques and shallow dug wells with low abstraction rates. Modern groundwater-based agriculture developed in the 1970s/1980s with: the introduction of diesel engines (Venot & Molle, 2007); the availability of modern irrigation techniques such as drip and sprinkler irrigation systems (MWI, 2015a, 2015b); improvements in well-drilling techniques; subsidized energy costs; cheap and easy access to land and water licenses (MWI, 2015a, 2015b); good water quality; and very favorable export market conditions, especially to Gulf countries (United States Agency for International Development (USAID), 2014). These factors contributed to making agriculture a prime investment option in the highlands in general and Azraq in particular.

The expansion of agricultural land continued in the 1990s with the introduction of new irrigated cropping patterns in Azraq, including grapes, and pomegranates later in the early 2000s, and farmers diversifying away from olive trees. Although water salinity problems resulted in a few farms being abandoned, especially in the south Azraq area (Demilcamps, 2010), agricultural expansion continued in north and east Azraq, with deeper drilling and a typical drawdown of the aquifer by one metre per year, and the introduction of new crops such as date palm and alfalfa. According to the Ministry of Agriculture, and despite the toughening of state regulations, the cultivated area increased, between 2005 and 2011, from 6,120 ha to 11,433 ha (MoA, 2012).

Although desert land is officially state land, Bedouins consider it as their tribal land and while some of them found in agriculture a good investment, others ‘sold’ their land to investors from Amman, Iraq or the Gulf countries. A key driver of the expansion of land cultivation in Azraq is therefore land speculation, with tribal leaders mediating the (paid for) transfer of land to investors moved by the returns of agricultural and/or (more often than not) speculative motives, claiming land in the hope that it will be later regularized, with its value increased many-fold (Humpal *et al.*, 2012; Al-Naber & Molle, 2016). But well drilling is costly (especially in Mafraq where depths of 350 m are common) and establishing a 20-ha farm with drip irrigation costs around half a million JD.

Azraq groundwater is also a major source of drinking water for Amman, Irbid and Zarqa as well as for the Azraq area itself. Via a series of well fields, the government abstracts about 23 MCM of groundwater from the Azraq basin every year for drinking purposes (WAJ, 2010), while agriculture abstracts around 28 MCM, nearly the equivalent of the basin’s safe yield (24 MCM per year) (MWI, 2009). This clearly indicates the magnitude of the challenge of achieving sustainable use, since this means that agriculture should be basically discontinued<sup>3</sup>. The total abstraction is estimated at 215% of the safe yield (MWI, 2009), but two recent studies conducted in the Azraq basin have found that actual groundwater use for agriculture in the basin exceeded twice the official recorded data (USAID, 2014; Al Bakri, 2015).

### **Policies in action: local practices in the Azraq basin**

Laws and regulations have been introduced in order to monitor and control groundwater abstraction. After presenting Jordan’s water policies and the context of Azraq, this section illustrates the common gap between formal policies – on paper – and local practices, identifies enforcement difficulties, and analyzes the tactics adopted by Azraq groundwater users in response to these policies. (The information has been provided by farmers or officials/experts; when this is not the case the reference is given.) The strategies pursued are to evade taxation and circumvent restrictions on groundwater use, whether at the extensive margin (new illegal wells) or at the intensive margin (consumption from an existing registered well).

#### *Farmer tactics to circumvent regulations*

*Well licenses and permits.* Farmers without legal land titles have dug wells and obtained a *permit* for their illegal (but registered) well. Some farmers later legalize their land through ‘settlement’ or

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<sup>3</sup> Unless abstraction for domestic use is reduced. WAJ’s promise to do so once water from the Disi aquifer reached Amman has not been kept, officially due to the pressure on water resources added by refugees.



‘delegation’ processes (see Al-Naber & Molle, 2016) and then legalize the well accordingly. But this is now constrained by the fact that any well considered should have been drilled before 2005. Legalizing land/wells substantially increases the value of the land and, as mentioned above, the water tariff for legal wells has a generous ‘free block’ and is much lower than for illegal ones. Farmers are therefore bent on legalizing their wells by either exerting pressure on the DLS to have their land status corrected (interview with farmer, 2014), or making the farm where the well is dug look older than 2005 in order to be able to claim land in case a settlement procedure is announced. It was reported that fake land deeds were also used to obtain a license for a well.

*Well maintenance (cleaning, replacement and deepening).* Three types of well maintenance can be carried out for licensed wells: well cleaning, well deepening and well replacement. Well cleaning is used to remove plants, roots, earth or anything that can have an effect on water quality and pumping. Well deepening is made necessary by the drop in the water table. Well replacement is accepted if there are technical problems with a well. Each well maintenance procedure needs a specific license from the WAJ.

Some informants indicated that these lawful operations are used to bypass the 1992 drilling ban (later made official in the 2002 bylaw): some apply for a well cleaning license but instead deepen the well to get more water (especially if groundwater is saline in the area); others, who obtained a well deepening license, do not respect the stipulated depth. Farmers can also seemingly damage a working well in order to be able to apply for a replacement license. They may fill it with soil or obstruct it superficially, so that when the WAJ inspects it a replacement license is approved. After the new well is drilled they remove the obstacles and open the old well again.

*Metering systems.* As indicated in the bylaw, each well must have a functioning metering system, but the reality is far from the theory (Fitch (2001) found that only a few years after having been installed 40% of the meters were out of order). In many farms visited during fieldwork, wells were found without a metering system. Some farmers complain that their meter is broken and is not working, while others tamper with the meter so that it records less water consumption (for example by using a drill to rewind the meter backward). Some farmers also bypass the meter with a parallel derivation pipe, so that not all the water pumped is metered.

It is also indicated that the WAJ should visit the wells every 3 months to take meter readings. This is clearly way beyond the capacity of its limited staff (there are 420 working wells with licenses or permits in Azraq, and as many ‘non-working’ wells), and frequency is rather every year. Some are asked their readings by telephone.

*Requesting a well for domestic or industrial use.* Drilling new agricultural wells was banned in 1992. Some farmers then tried to apply for domestic or industrial well licenses to dig a well, and later use it for agricultural purposes.

*Sealing wells.* It was already stipulated in the 2003 amendment that illegal wells without permits should be backfilled within 6 months, but such measures were not implemented. A government campaign to close illegal wells started in 2013. In some cases, well users would use a fake well with a pipe in the ground pretending to be a well and would have it sealed. The original well would be reopened after the inspection. Another reported technique is to insert in the well a smaller pipe, which

is only a few metres long and closed at the bottom end. After being filled in and obstructed with earth and rocks, the pipe is later removed to make the well operational again.

*Hiding illegal wells.* Farmers can drill illegal wells to make up for a declining existing (registered) well, or to mix waters when the existing well is getting more saline, and/or to expand cultivation. This is why it is common that farmers with one (or several) licensed wells also have additional illegal ones. Another reason is the rule that a farm can only be irrigated by one given well, which means that larger farms are all likely to have an illegal well alongside a legal one.

The relationship between a well and the irrigated area is not always straightforward, especially if the well is not metered and its yield is therefore unknown. This also helps in hiding additional illegal sources of water. Such wells are also dissimulated and hidden (such as the case reported by a MWI official of a well in the Jordan Valley that was hidden under the bed of the owner), covered with plants or rubbish; or the road reaching the farm can be cut in order to prevent easy access by officials (Addustour, 2004).

*Bribing.* The transaction costs of checking the situation on the field (existence or effective use of a well, meter readings, etc.) are quite high. WAJ only has three staff in Azraq who can engage in monitoring tasks, which is clearly insufficient to carry out what is expected from them.

Some farmers will also pay for WAJ staff to underestimate the meter readings or to turn a blind eye to an illegal well. Such practice is likely to be quite widespread, judging from the gap recently found between official and estimated abstraction figures. The social proximity of WAJ staff and farmers in some cases (if they are from or live in the same area) can also limit the effectiveness of rule enforcement and control.

*Social power and intimidation.* In other cases, WAJ staff work is made difficult by intimidation tactics (cases where visits are discouraged by show of a weapon), or by display of social power by some influential land owners, as illustrated by one interviewee's comment on a Bedouin farmer: 'it is a tribe and the tribe has power; the small government employee cannot say no to the big tribe'. An example, reported during the interviews, was a case in which three farmers attacked WAJ staff during a field inspection, opening fire and injuring one of the staff. Abbadi (2003) recorded eight similar attacks but without injuries.

*Transfers of water.* Although it is prohibited to use water from a well in a farm that is not the one cultivated by the owner of the well, some farmers have circumvented the difficulty in drilling new wells by transferring water by pipe from neighboring legal or illegal wells, over distances that can reach several kilometres. If these wells are not metered, abstraction is calculated based on the nearby cultivated area (only) and can therefore be greatly increased. This transfer can be paid for but, in a case observed in Mafraq, an investor had to supply his Bedouin neighbor, for fear of reprisals if he did not agree.

*Dividing the land.* Article 30 in the bylaw states that it is 'prohibited to grant more than one drilling or extraction license for one plot of land'. To evade this measure, Bedouin sheikhs occupying or claiming large tracts of land which cannot be irrigated by one single well divide their land between their sons or relatives.

*Illegal drillers.* The Ministry is trying to monitor and control the presence of illegal drillers by introducing tougher penalties on those drillers. But these drillers also find ways to circumvent the law. Some hide the drilling machines between trees, others install it on a broken machine said to be out of order and use it at night (Addustour, 2013). A recorded witness highlighted that one driller with the help from some locals tried to cut the road to get enough time to hide the drillers before a WAJ visit. New types of rigs can now be loaded upon and transported by a pickup and are more difficult to spot (interview with official, 2016).

#### *Policy responses by the government*

Faced with a situation of insufficient monitoring and enforcement, the MWI has tried to toughen its stance and practices, and developed several parallel ‘counter-measures’.

*Departmental coordination.* After the passing of the 2002 bylaw, groundwater tariffs were increased in 2003, and then decreased in 2004, so farmers did not take the new law amendment seriously and most of them did not pay. In July 2009 WAJ distributed the bills again, covering the period from 2003 to 2010. Some farmers still refused to pay their bill while others paid. In 2014, the government sought to interconnect all governmental departments by a computerized system, so that any governmental procedure (purchase transaction, passport or driving license request, etc.) would be refused, had the farmer not paid his water bill. This is in particular the case for farmers wanting to hire labor for their farm (the approval of the Ministry of Agriculture being made conditional upon payment of the water bill), or wanting to sell their land.

*New water tariffs.* Illegal well drilling thrived in the past 20 years and WAJ tried to tackle existing illegal wells by introducing a new and very high water tariff in 2014 (Table 1). It is hoped that this new tariff combined with the administrative measures described above will strongly discourage farmers from drilling new wells, and will force them to either use little water so that they stay in the lower tariff blocks (30,000 m<sup>3</sup>) or discontinue operation. This measure acknowledges the difficulty in backfilling illegal wells and attacks them through taxing and the indirect enforcement measures described above.

*Controlling drilling companies.* The registration of drilling companies and the conditions/constraints established for their activity have been specified in the 2002 bylaw. Equipment spotted while carrying out illegal drilling is liable for seizure. Official statistics mention the number of rigs seized every year and such actions are frequently reported in newspapers. In 2013, the Ministry confiscated 14 illegal drills (Assawsana, 2015) and repeatedly publicized its action in the newspapers. It is not clear, though, how much of a deterrent to illegal well drilling this is, since similar announcements were also made in 2003 in the wake of the bylaw (Addustour, 2004).

*Satellite imagery.* MWI is now using satellite imagery to control the expansion of cultivated areas and illegal well drilling. Satellite imagery also allows for a comparison between reported abstracted volumes and water requirements estimated based on the cultivated area and crop type. Recent studies (USAID, 2014; Al Bakri, 2015) have indicated that abstracted volumes have been seriously underreported, prompting a toughening of the policies pushed by the Minister.

Satellite imagery was used as far back as 20 years ago to check cultivated areas (and was already mentioned in the 1988 law – Article 30). However, the situation has now significantly changed because of a dramatic drop in the price of these images, a much easier availability, and more powerful computer processing. They can now indicate yearly changes and even spot pump houses on the fields.

*Destroying illegal wells.* The law indicates that illegal wells should be backfilled at the cost of the well owner. Given the different user tactics to avoid control and well sealing discussed above, the Minister has decided to use dynamite to close wells, to ensure that they cannot be used again, while ordering pictures to be taken for each case.

*Stopping land settlement processes.* Opening a ‘settlement’ or ‘delegation’ procedure (where state land ownership or use is transferred to individuals) encourages Bedouins and investors to claim more lands in the hope to see this land eventually legalized as private property. Land ‘ownership’ (that is, occupancy) has to be proved either by cultivating the land or by building a house on the land plot. Most people choose the first option as it is easier and the loss more limited if that claim is not accepted and their cultivation destroyed by the government. In 2010 a rumor went around Azraq saying that the government would release more land for farming. As a result, people started claiming state lands and planting trees (sometimes old ones to pretend that the farm was old), and 1,600 ha of new land ended up ‘cultivated’ in Azraq within 2 weeks. The Ministry was able to remove 1,000 ha of newly cultivated land but the other 600 ha remained as they were cultivated by an influential sheikh from the Bani Sakher tribe. During an attempted visit to the land by the Ministry, the sheikh used weapons to intimidate the visitors. As a result of such situations, settlement and delegation processes in Azraq, and more generally in Jordan, were discontinued by the DLS.

*Naming and blaming.* The Ministry started a new procedure for unpaid bills. Officials claim the unpaid amount from the well owners and give them a period of 15 days to pay. After that, the Ministry publishes the names of the well owners and the unpaid amount in the newspapers (including the Official gazette) and gives them an additional period of 60 days to settle the charges. If the owner still refuses to pay the amount then the Minister has the power to seize the account of the well owner (Khaberni, 2014; Alwakeelnews, 2015). At the end of 2015 the Ministry had already published a first list of 70 well owners in the official newspapers. Unsurprisingly, some of them are well known and influential people in Jordan (owing, some of them, more than 200,000 JD of unpaid water bills) (Mbayden, 2013; Khaberni, 2014). In Azraq alone, the Ministry sent 495 notifications for water payment, out of a total of 1493 (Alwakeelnews, 2015). The Ministry has also opened the possibility for well owners to settle unpaid bills by installments (Sarayanews, 2013).

*Cutting other benefits.* Another important decision taken by the Ministry has been to stop giving agricultural loans or credits to illegal well owners and to cut off the electricity supply to farms with illegal wells. Also, through the Ministry of Agriculture, owners can be refused labor permits (when it comes to employing full-time workers) (Petranews, 2014).

*Constraining access to labor.* The registration of the cultivated plots with the Ministry of agriculture gives the right to the investor to ‘import’ farm labor (in general from Egypt), with a generous allocation of one worker per ha, and even 0.5 ha if one cultivates vegetables. Someone with 20 ha irrigated

theoretically has the right to 20 workers, although he might only need two or three in practice. This surplus labor can be transferred to the construction sector, for which middlemen will pay between 300 and 800 JD to the farmer for letting go one of ‘his’ workers (the monthly salary for a worker is 300–350 JD in Azraq, but 750 in the construction sector in Amman). This ‘labor market’ also gives way to bribes and faulty reporting of cultivated areas (to maximize the number of workers). But this ‘right’ has now been reduced to one worker for each 5 ha. And a new law has been passed to disallow the granting of work permits to farms with illegal wells.

*Raising awareness.* The Ministry has also been using public debates, publishing a series of articles highlighting the water problem in the country, and public awareness-raising campaigns and school programs (Subeh, 2006). Such campaigns have also been directed at judges and imams. Actions such as seizing rigs, sealing illegal wells, fining people for illegal fixtures on mains have been repeatedly and insistently publicized in the newspapers since 2013; the Minister of Water and Irrigation also makes frequent appearances on TV channels (El Naser, 2013). In 2014 there were more than 15,000 cases of groundwater-related offenses reported by the WAJ, some for tampering with meters, others for digging illegal wells, or sabotage of WAJ’s water distribution pipes (Jordannews, 2015).

Also, the King formed a Royal Commission on water resources in 2008, which issues frequent reports describing the country’s water situation and need for strategies to conserve water (Prime Minister’s website, 2008), directed at the public but also at Members of Parliament.

## Discussion and conclusions

Since the first ban on agricultural wells in 1992, Jordan has experimented with a wide range of regulations and policies aimed at controlling groundwater abstraction in the country, most notably in the Highlands. The 2002 bylaw has been seen as a watershed legislation but implementation on the ground has been lacking and the drilling of new wells has continued unabated, fueled by the profitability of irrigated agriculture as well as land speculation. To deal with pervasive problems of illegal well drilling, meter tampering and unpaid water bills the government has used both direct and indirect tools.

Direct measures include well licensing, establishing annual quotas per well, sealing illegal wells (and destroying them with dynamite), licensing and monitoring drilling companies, limiting the number of well licenses to one per plot of land and banning well drilling for agriculture. Indirect measures include a block tariff pricing system, increasing the water tariff of illegal wells, constraining the granting of labor permits, publishing the names of violators in newspapers and publicizing tough actions on the ground, using satellite imagery to estimate and charge water consumption, and improving inter-departmental coordination to force users to pay water bills.

Application of direct tools in the field proved to be bedeviled by the transaction costs of reading meters, checking the existence and characteristics of wells, or demanding payment. Such direct enforcement requires heavy presence in the field, something that clearly exceeded the capacity and the material means given to the few WAJ field staff, not to mention the constraining factors associated with the social proximity of WAJ staff and farmers, incentives to bribery, intimidation by local Bedouins, and the feeling that the degree of resolve of higher-level authorities in enforcing the law was wavering. Direct metering, a standard recommendation of groundwater policy packages, appears to be more of a conduit for corruption than any kind of real monitoring. Indirect metering through satellite imagery

is being developed at the moment in the Ministry and provides a better solution in a desert environment where cultivation is clearly visible. Acting forcefully on illegal agricultural wells in use and on tree plantations has proved to be politically problematic. The Chinese case described by Aarnoudse *et al.* (2012) remains a kind of exception linked to exceptional circumstances (Molle & Closas, 2016). The backfilling of illegal wells used to irrigate crops, particularly trees, is almost unheard of (Molle & Closas, 2016). As a result, the Ministry concentrated its action on the violations on water supply mains, including illegal fixtures on the Disi-Amman pipe, on reducing non-revenue water in urban networks (still around 50%), and put a greater emphasis on indirect tools.

Indirect tools such as reducing the attractiveness of land reclamation (stopping settlement processes) and constraining it (through denying labor permits or connections to the electricity grid for illegal wells), are sound measures. Water pricing, however, has proved marginal if not illusory with regard to legal well owners for whom it is hard to justify high levels of taxation. The Ministry, in 2014, therefore concentrated this tool on illegal wells, with tables of tariffs that make open-field cultivation virtually impossible. But a (too) big stick becomes hard to use and it is not yet clear whether the measure will succeed in phasing out illegal wells. Exacting payment of such massive bills is not easy but the Ministry has come up with a very innovative additional stick by connecting the various administrations (and making any procedure dependent upon the settlement of water bills) and even threatening to freeze the accounts of violators (whose names are published in newspapers).

Even though the law should target all users equally, some farmers in Azraq complained that the government was selective and enforcing the law only on them. This raises the crucial issue of the political economy of policy implementation. Political considerations explain why some of the instruments have been lacking ‘teeth’ (for example the overly generous ‘free block’ of the water tariff – it is now envisaged to halve the free allowance –, the leniency towards illegal well drilling or meter tampering, land encroachment, etc.). The country largely holds to the support of tribes and investors, both being the main actors of land and water development. The tribal politics of Jordan and their constitutive role in state-building, have been the subject of much scholarship (Alon, 2007; Kark & Frantzman, 2012). The Crown, in order to win their support for the new Hashemite power, has always been engaged in a give-and-take relationship with local tribes, a crucial balancing act for the sustainability of the regime. Likewise, many high-ranking officials and wealthy individuals have stakes in the land reclamation business, and therefore in accessing the key factor that makes it possible: water (Zeitoun *et al.*, 2011). Last, settlers and smaller scale farmers – more generally rural dwellers – are often suffering from the current political and economic situation, making it politically costly to antagonize them, especially in the wake of the Arab Spring in the region.

Several factors, however, are slowly reshuffling the cards. First, groundwater is increasingly considered as a key strategic resource to ensure domestic water supply, the Minister emphasizing publicly that the alternative sources (through desalination or the Red-Dead project) will be six to seven times more costly (El Naser, 2013). Second, there is a growing awareness of the water crisis among Jordanian citizens in general and politicians in particular (as expressed by an MP interviewed). Outrage at the violations on the Disi pipe and water mains slowly extends to illegal wells, undermining the overall tolerance for abuse. Some powerful people have been heavily fined, named and shamed in the newspapers, which is certainly a rare instance in the Middle East and North Africa region in general. Last, the current Minister has shown an exceptional level of leadership in attacking the problem on several fronts, while securing high-level support, not least from His Majesty the King. While donors (most particularly USAID), had been influential in the past in pushing for measures such as metering and

tariffs, there is a feeling that the government is now coming to grips with an issue that threatens the country's stability.

Although it is too early to make a definite assessment of the policy reforms recently undertaken, a few important lessons that are relevant to the region and beyond can be mentioned. First, direct measures are hard to implement on the ground and often overestimate the power of the state to act on the ground; this is in particular the case for metering which can be replaced by indirect measurement through remote sensing imagery. Second, too big 'sticks' (sealing wells or prohibitive water tariffs), while signaling the gravity of the violation, may turn out to be non-credible and even counterproductive (by pushing people into illegal solutions). Third, the creative tools deployed (administrative interconnection, naming and blaming, etc.) may be inspirational for other countries. Fourth, aggressively raising awareness, not only of citizens but also MPs, judges or imams, may well bear fruit over the long term. Last, it is hard to assess the effectiveness of each measure and it is likely that success will depend on both articulating a diversity of tools and the advent of a felicitous mix of leadership and high-level support. Whether the resolve currently shown by the Ministry, buttressed against a growing sense of urgency and water crisis, will succeed in balancing private interests remains to be seen, but is also exposed to being overturned at any time due to the region's political volatility.

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