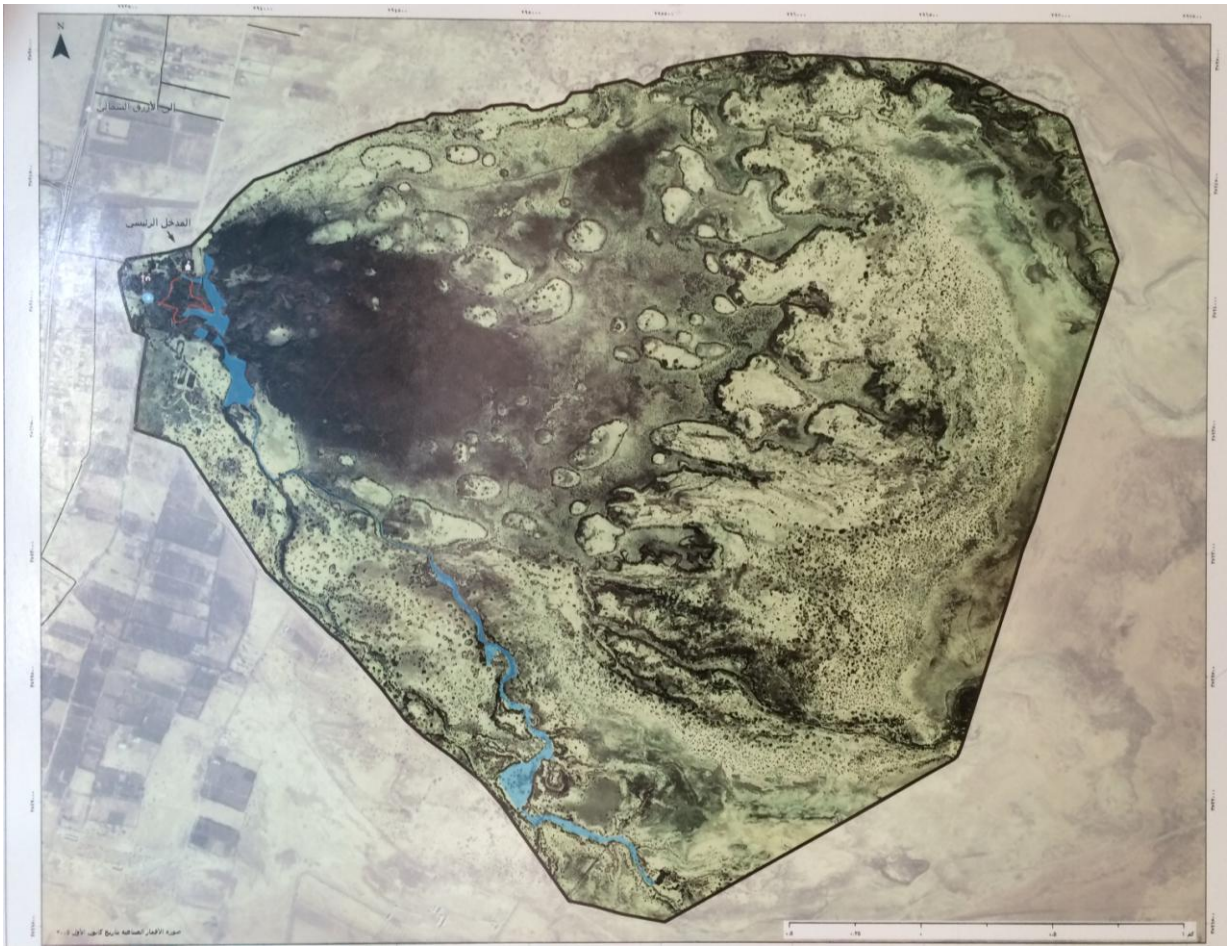


Groundwater Governance in Jordan
The case of Azraq Basin

A Policy White Paper

Groundwater Governance in the Arab World April 2017

This is an IWMI project publication – "Groundwater governance in the Arab World – Taking Stock and addressing the challenges"

This publication was made possible through support provided by the Middle East Bureau, U.S. Agency for International Development, under the terms of Award AID-263-IO-13-00005.

DISCLAIMER
The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Agency for International Development or the United States government.

Cover photo credit: François Molle (from Azraq Wetland Museum)

Groundwater Governance in Jordan
The case of Azraq Basin

A Policy White Paper

François Molle
Emad Al Karablieh
Majd Al Naber
Alvar Closas
Amer Salman

2017

Table of contents

Foreword

This Policy White Paper is part of a project on "Groundwater Governance in the Arab World" funded by USAID which includes a review of groundwater management and policy options in the world, with a focus on the MENA region, as well as case studies in Tunisia (Haouaria region), Jordan (Azraq groundwater basin) and Lebanon (Central Beqaa). Each country case study has been the object of two scientific reports: a study of the groundwater policy background and history; and a report on field investigations in each basin carried out to document current dynamics and problems of groundwater-based agriculture. Further to these studies, *Dialogues* have been conducted with and between local stakeholders and policy-makers in each location. Problems and management options have been discussed and confronted at length, and opinions and suggestions have been shared. This White Paper is meant to tease out important points from all these research outputs in order to provide policy ideas and orientations in a summary form. Analyses and recommendations stem from the ideas advanced by stakeholders during the workshops held, but also from field work and from the evidence synthesized from experience at the world level by this project. The control and regulation of groundwater abstraction is perhaps the most vexing challenge of water management worldwide, with very few encouraging or 'success stories'. Mindful of the political complexities of groundwater regulation, this White Paper is an attempt to contribute to groundwater policy thinking in Jordan.

1 Introduction

Groundwater in Jordan has been used since the early 1960s for different purposes, including domestic, industrial, agriculture and environmental use. Irrigated agriculture was the major consumer of groundwater in Jordan up until 1995, especially in the Highlands, the main irrigated area in the country after the Jordan Valley, but its share has now dropped to 42% (2015). The development of modern groundwater-based agriculture over the years in the Highlands has been driven by the improvement in well-drilling techniques, the decrease in energy costs, land affordability and accessibility, and good water quality and quantity. All these factors helped make irrigated agriculture a prime investment option. But this expansion has also been kich-started and encouraged by the government who freely awarded licenses for wells in the 1980s and early 1990s. Even though investors and farmers enjoyed a good economic return on these activities, in the mid-1990s the government, sensing the increase in groundwater use in the area, tried to control abstraction by banning new wells and introducing metering in the Highlands. This concern went in parallel with the strategic necessity of preserving the resource, given the dependency of Amman's drinking water supply on the same groundwater, and incipient environmental concerns regarding the preservation of the internationally renowned Azraq Wetland.

The measures aimed at monitoring groundwater abstraction and reducing over-abstraction in the late 1990s, and later with the By-Law of 2002 that introduced dramatic changes, remained largely ineffective due to the weak monitoring of actual use on the ground. The mismanagement of groundwater use by both the government, through its lack of control, and private users, who still engaged in illegal drilling, caused continued deterioration of water quality and quantity. Water tables dropped by 25 meters on average during the last 28 years. In some aquifers, abstraction is close to three times the estimated safe yield. Yet, in the past 4 to 5 years, the government has shown unprecedented resolve and political will to enforce existing regulations but also passed stringent new ones, in particular with regard to the control of illegal wells.

This Policy White paper starts with an overview of Jordan's water resources and governance. It then illustrates policies as applied on the ground by taking the case of Azraq. This practical experience is then used to discuss Jordan's wealth of experience with groundwater regulation tools, assess the current situation, and draw conclusions on the scope for strengthening or improving existing policies.

2 Background on groundwater resources and governance in Jordan

2.1 Jordan's groundwater resources

Groundwater resources in Jordan can be divided in 12 major aquifers, 2 of which (Jafr, Disi) are non-renewable (Table 1: Abstraction from Groundwater basins in Jordan and their safe yields in 2015

	Basin	Safe yield MCM	Total uses (MCM)	Balance	No of wells	Percent of Safe yield
1	Yarmouk	40	54.16	-14.16	203	135
2	Amman Zarqa	87,5	166.11	-78.61	955	190
3	Jordan River Side Wadis	15	46.73	-31.73	139	312
4	Jordan Valley	21	17.02	3.98	334	81
5	Dead Sea	57	89.98	-32.98	469	158
6	Azraq basin	24	52.54	-28.54	580	219
7	Hammad basin	8	1.87	6.13	15	23
8	Wadi Araba North	3,5	6.33	-2.83	37	181
9	Wadi Araba south	5,5	8.48	-2.98	62	154
10	Sirhan	5	1.71	3.29	23	34
11	*Jafer non-renewable*	9	*32.85*	*-21.85*	*205*	*365*
12	*Disi, non-renewable*	125	*146.96*		*116*	*118*
	Total	**418,5**	**624.74**		**3138**	**149**

Source: MWI, 2016 open files (in Al-Karablieh and Salman, 2016).

Figure 1). The 10 aquifers with significant recharge together have a safe yield believed to be around 275 Mm3/year. Total groundwater use is estimated at 445 Mm3 in 2015. This estimate is based on a database of 3138 wells, either with licenses or permits, or illegal but registered by the Water Authority of Jordan (WAJ). All numbers are of course, and this is not specific to Jordan, associated with a rather large uncertainty. The number of wells does not include illegal wells unknown to the WAJ, and abstraction volumes are derived from WAJ field offices and are admittedly marred with several limitations (more on this later). Even with conservative estimates, official abstraction was estimated in 2004 to be 1.8 times higher than the considered safe yield (MWI 2004).

Table 1: Abstraction from Groundwater basins in Jordan and their safe yields in 2015

	Basin	Safe yield MCM	Total uses (MCM)	Balance	No of wells	Percent of Safe yield
1	Yarmouk	40	54.16	-14.16	203	135
2	Amman Zarqa	87,5	166.11	-78.61	955	190
3	Jordan River Side Wadis	15	46.73	-31.73	139	312
4	Jordan Valley	21	17.02	3.98	334	81
5	Dead Sea	57	89.98	-32.98	469	158
6	Azraq basin	24	52.54	-28.54	580	219
7	Hammad basin	8	1.87	6.13	15	23
8	Wadi Araba North	3,5	6.33	-2.83	37	181
9	Wadi Araba south	5,5	8.48	-2.98	62	154

10	Sirhan	5	1.71	3.29	23	34
11	*Jafer non-renewable*	9	*32.85*	*-21.85*	*205*	*365*
12	*Disi, non-renewable*	125	*146.96*		*116*	*118*
	Total	**418,5**	**624.74**		**3138**	**149**

Source: MWI, 2016 open files (in Al-Karablieh and Salman, 2016).

Figure 1 shows the spatial distribution of wells and the extension of groundwater basins. Most wells are to be found in the Jordan valley and in the northern part of the Highlands, including Yarmouk and Amman Zarqa basin (AZB), the Dead Sea basin, and Azraq (with a concentration around Azraq's wetland). As indicated in Table 1, all these aquifers are overexploited, notably Azraq, Amman-Zarqa and Jordan Valley Side Wadis.

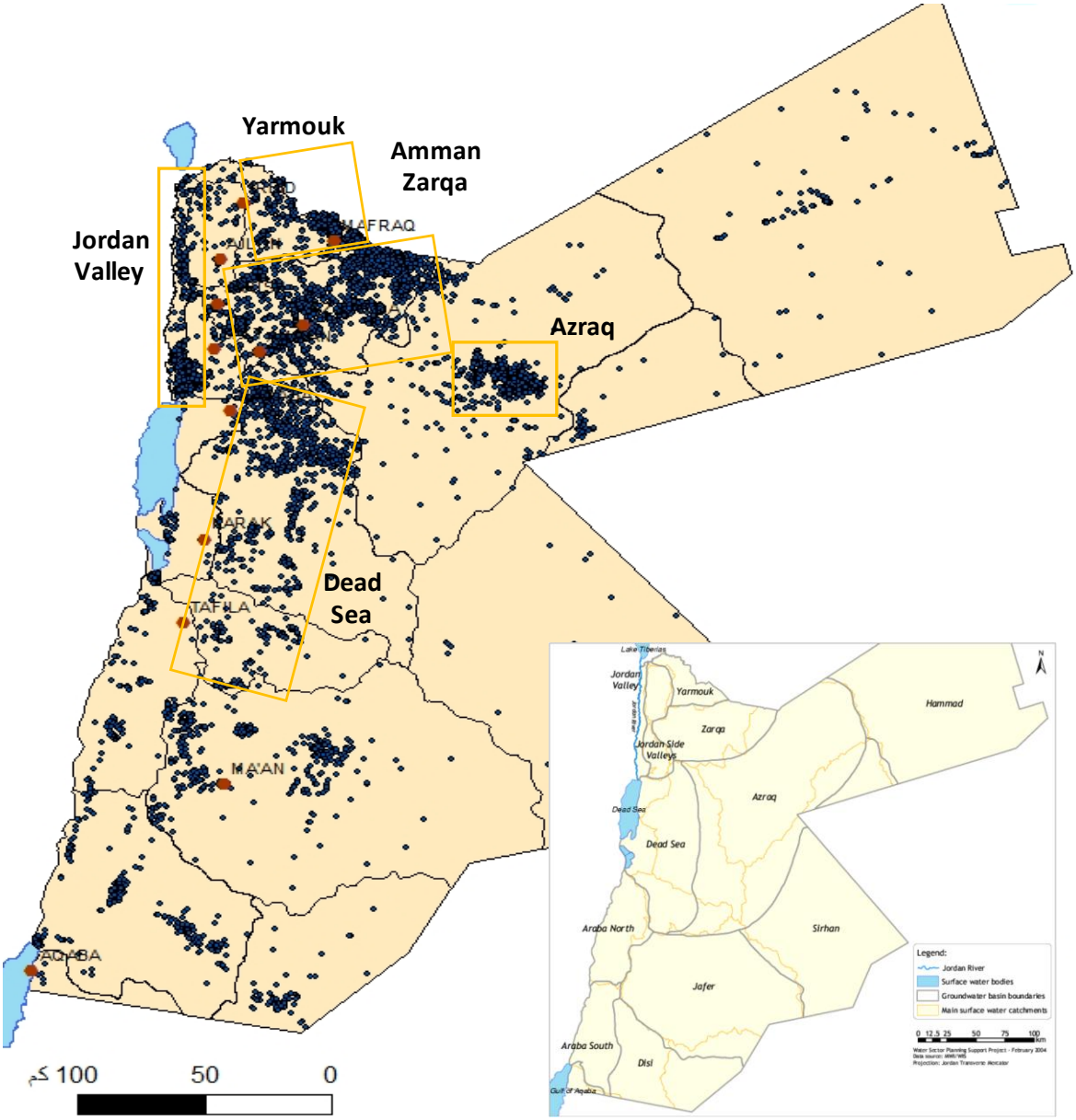
With few exceptions, all wells in the highlands are tubewells, with depths between 100 and 450 m (although some more shallow wells can be found in Azraq, on account of the higher water table). Drilling well is therefore costly and this, together with an overall limited aquifer recharge and instances of saline groundwater, largely explains why the number of wells in Jordan is relatively limited. At the moment (2015), WAJ's official data account for 3,138 *working* wells abstracting 625 Mm3/year, 2,163 of which are used for agricultural use. To what must be added a number of illegal unknown wells (taken at 1,000 as an order of magnitude, considering Al-Bakri's (2014) study). For the sake of comparison, the number of wells in Yemen, Morocco and Lebanon is estimated at about 100,000, that of Tunisia and Algeria at 150,000, and that of Syria at 250,000.

Table 1: Abstraction from Groundwater basins in Jordan and their safe yields in 2015

	Basin	Safe yield MCM	Total uses (MCM)	Balance	No of wells	Percent of Safe yield
1	Yarmouk	40	54.16	-14.16	203	135
2	Amman Zarqa	87,5	166.11	-78.61	955	190
3	Jordan River Side Wadis	15	46.73	-31.73	139	312
4	Jordan Valley	21	17.02	3.98	334	81
5	Dead Sea	57	89.98	-32.98	469	158
6	Azraq basin	24	52.54	-28.54	580	219
7	Hammad basin	8	1.87	6.13	15	23
8	Wadi Araba North	3,5	6.33	-2.83	37	181
9	Wadi Araba south	5,5	8.48	-2.98	62	154
10	Sirhan	5	1.71	3.29	23	34
11	*Jafer non-renewable*	9	*32.85*	*-21.85*	*205*	*365*
12	*Disi, non-renewable*	125	*146.96*		*116*	*118*
	Total	**418,5**	**624.74**		**3138**	**149**

Source: MWI, 2016 open files (in Al-Karablieh and Salman, 2016).

Figure 1. Spatial distribution of wells in Jordan, and main abstraction areas



2.2 Main groundwater policies and regulations passed and implemented

Because surface water is fully used and because it constitutes a strategic reserve that can be tapped, in particular, to weather possible critical dry spells, groundwater is a key resource for Jordan. Controlling its use is therefore critically important, more so than in the Gulf countries (which may resort to desalination) or in countries with more surface water (like Morocco). As a result Jordan has a long history of public policies and regulations that have been passed in the last 50 years in an attempt to rein in groundwater use.

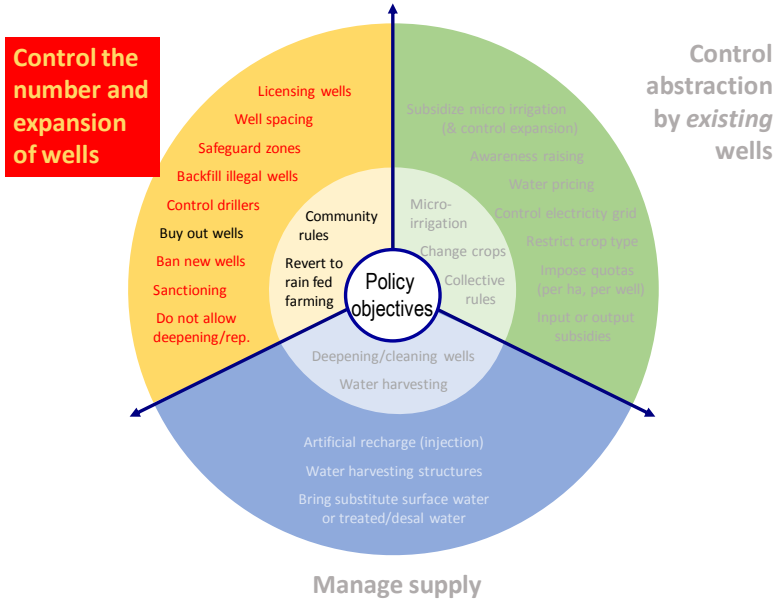
Because of the priority given to domestic supply, the government policy is now to *reduce* the use of groundwater by agriculture in the highlands. This goes against the support lent to agriculture in the 1970s and 1980s and to the endogenous expansion trends which have been observed and have been hard to check ever since.

2.2.1 Controlling the expansion of wells

Leaving aside the question of water quality and contamination of groundwater resources (although relevant to Jordan, it is not addressed in this report), the three main state-driven groundwater policy objectives are summarized in Figure 2. The first objective refers to managing supply, that is, increasing the availability of groundwater: this can be done, for example, by increasing natural recharge through water harvesting, practicing artificial recharge, or substituting surface water for groundwater. The second objective is to control the number and the expansion of wells. The third objective is the control of/reduction in abstraction by existing wells. Managing supply is capital-intensive but is often the politically preferred solution because it is perceived as not affecting existing uses. In Jordan, however, this potential is limited by the fact that any surface runoff captured in the Highland will be deducted from the water used downstream (we do not address this issue in this paper)(USAID 2001). The latter two objectives come under *demand management policies*. It is crucial to understand that controlling existing abstraction is a much thornier issue than controlling the number and the expansion of wells (which is itself a very difficult issue), because it is even more intensive and demanding in terms of data collection.

Figure 2 recalls the three main types of state-driven policies and spells out those usually resorted to in order to attempt to control the expansion of wells (those tested in Jordan are highlighted in red). A cornerstone of these policy tools, upon which many others rest, is the registration and licensing of wells.

Figure 2. Policy tools to control well expansion implemented in Jordan



2.2.1.1 The registration conundrum

Nearly all groundwater policies in the world put emphasis on the process of registration of wells. This stands to reason because no informed policy is possible if abstraction points are not known. However, the registration of wells has been found globally to be more problematic than expected, most especially in areas with diffuse groundwater use for irrigation (Molle and Closas, 2017).

In Jordan, registration of wells is actually mandatory since 1961 (for abstraction over 5m^3/day). A drilling ban was decreed in 1992 and in 2002 the Groundwater Bylaw established precise and stringent rules for all aspects of well drilling and use. Because of the slack enforcement of the law during the preceding four decades, Jordan faced the necessity to register hundreds of wells that had been drilled directly by landowners, without paying heed to existing regulations.

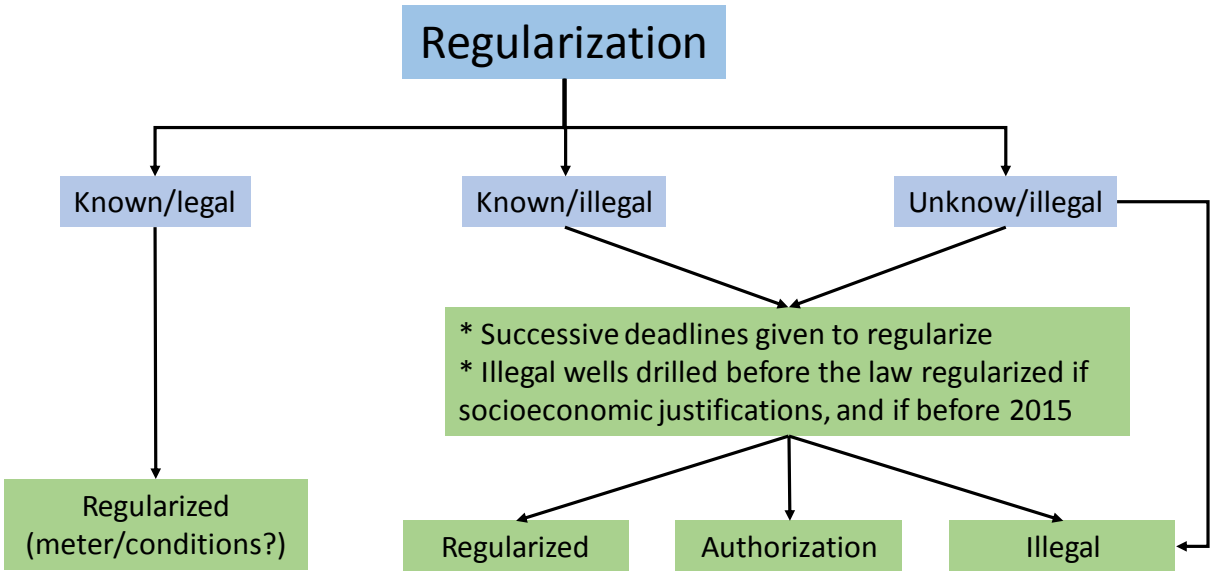
In 2002 the Bylaw initially gave owners of illegal wells six months to regularize their situation, should they be in a position to justify the socio-economic importance of their use of groundwater for their livelihoods. In 2003, an amendment gave another year, and in 2007 the possibility was restricted to wells drilled before 2005 and waiting for a land settlement to legalize their land. Eventually, in 2014, all wells older than 2005 were considered illegal and liable to be backfilled (Al Naber and Molle 2017a). But Jordan put in place an uncommon distinction when in the late 1990s it decided to start granting temporary 'permits' to unlicensed wells that came to be identified and inventoried. The 2002 Bylaw gave legal existence to this intermediary status.

The Bylaw implicitly establishes several categories of wells (Figure 3):

- Legal wells with a license (*rukhsa*) obtained before 2002, or later on if a process of regularization has been initiated by the owner between 2002 and 2005, and if legal requirements are eventually met.
- Wells with no license prior to 2002 but which can be (temporarily) authorized if there are "economic or social factors justifying continuation of water extraction", in which case the owner receives a permit (*ijaza*), usually valid for three years, with a maximum amount he can use (in general 25,000 or 50,000 m^3). These permitted wells are formally considered illegal but are often classified (for example in WAJ's statistics) together with legal wells.
- Illegal wells without licenses or permits but registered in WAJ's database. Before their situation is settled (in theory they should be closed down), they are subject to a very discouraging block tariff.
- Illegal wells not registered in WAJ's database, whether known by WAJ field staff or not, which escape taxation but have a higher risk of being the target of well sealing campaigns.
- In addition of these 'legal' categories, the Bylaw singles out Azraq as a region where illegal expansion should be addressed with tougher measures, both on account of the fact that groundwater is still relatively shallow and that WAJ's well field which extracts 25 Mm^3 yearly must be preserved and protected.

Illegal wells are mostly to be found in areas where the land tenure status is unclear, notably Azraq, Jafr and Maan, and where therefore wells cannot be made legal. In contrast, in Mafraq and more generally the AZB, farms have been developed on regularized land (with land titles) and 95% of the wells are licensed. This also reflects the extremely high cost of drilling wells in this region, and the reluctance by landowners to engage in such investments without having administrative security. The number of illegal wells, beyond the 3138 inventoried by WAJ, is unknown but probably under 1000. A recent (partial) survey identified a percentage of illegal wells of around 15% (USAID 2014), but higher in Azraq area, where illegal drilling is continuing (Al Naber and Molle 2017a). These are in principle manageable numbers compared with many other countries, as commented upon earlier.

Figure 3. The regularization conundrum



2.2.1.2 Drillers and drilling

Aside from the pressure on landowners willing to drill wells Jordan has also considered, very early on, regulating drilling professionals. Licenses are needed to establish oneself as a driller (1974 and later texts), but also to own or use rigs (with associated fees), and even to transfer them. Fees are associated with all these modalities.

But the sector has been found to be difficult to regulate, with a large proportion of drillers coming from Syria since early days. The government launched a campaign against illegal drilling in 2013 and two years later was boasting the confiscation of 150 drilling rigs (JT, June, 6 2015).

The first sanctions for illegal drilling or violating license terms first appeared in the 1988 Law, which determined that "any user or owner who does not follow the established provisions for obtaining a well license, rules for drilling or replacing, cleaning or deepening a well will be facing prison (for a period of time of no less than a year and not more than three) and have to pay a fine between 1,000 JD and 5,000 JD". In 2014, these penalties have been redefined as one to five years in prison and a payment of not less than 2,000 JD and not more than 7,000 JD for illegal drilling. These penalties, at the moment, seem to be rather used as threats in the context of negotiations rather than applied across the board.

2.2.1.3 Drilling ban and back-filling of wells

In 1992 a decree froze well-drilling for agriculture in all overexploited areas. Although it did not confirm the freezing, the 2002 bylaw established strict procedures for authorizations and the government extended the official ban.

Limiting the number of wells may also include the more radical measure of back-filling illegal wells, or those not respecting the clauses of their licenses. Although already featuring in the 2002 Bylaw this measure has not been implemented for working wells because of its social/political implications. The 2014 amendment reinforced the apparent commitment of the WAJ to close illegal wells. 237 wells have been backfilled prior to 2007, and an average of 35/year in following years, until 2013, with a record of 141 wells (MWI, 2013). Since it launched

a crackdown on illegal wells in 2013, the government is claiming to have seized 60 rigs and closed 800 wells (Ammonnews 2017), but these were reportedly either unused, saline or dry.

2.2.1.4 Other tools

The 2002 Bylaw also includes the necessity to get authorizations for all well maintenance operations (deepening, cleaning, replacing), under some conditionalities. This constrains the renewal of wells and contributes to their abandon. Lately in 2015, the free abstraction block of licensed wells was changed from 150,000 to 75,000 m^3/yr for any well deepened or drilled to replace an old well.

Another tool to discourage new wells is to make the connection to the electricity grid conditional upon having a license. With the increasing price of gas and diesel which makes pumping costly (especially where groundwater is deep), accessing electricity is an important aspect of the sustainability of some farms.

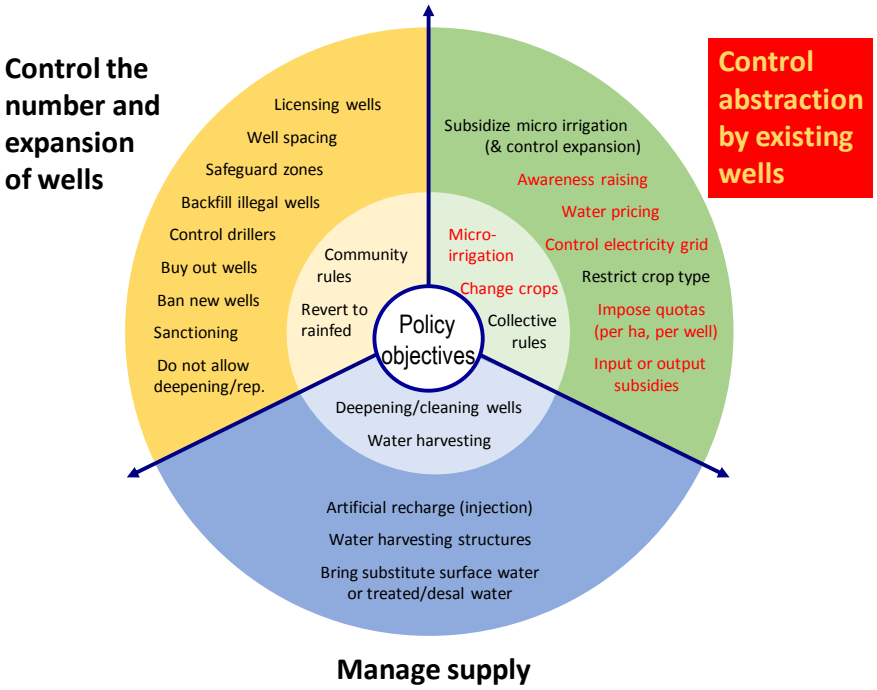
The buyback option has also been considered by the government of Jordan (Chebaane et al. 2004). A survey found out that 50 percent of farmers were in favor of such measure (Chebaane et al. 2004). The government, however, is not inclined to considering such an option, most especially for illegal wells, since it would belie the principle that water resources belong to the state and would reward violators of the law.

The MWI is also using satellite imagery to identify land with irrigation and locate illegal wells.

2.2.2 Controlling abstraction in existing wells

Along with controlling the number of wells, the second main policy objective is to control or *reduce abstraction by existing wells*. Most common tools include setting up quotas or water tariffs, changing the price of input or output factors, water-saving technology, and raising awareness of users (Figure 4).

Figure 4. Policy tools to control abstraction in existing wells implemented in Jordan



2.2.2.1 Metering, quotas and pricing

In 1966, the maximum abstraction volume was to be specified for each registered well, but this was only partly implemented. In 1973, the principle of systematic metering was adopted and in 1984, with the establishment of the WAJ, the licenses delivered by WAJ came to indicate a maximum annual volume of 50,000 or 75,000 m^3 (in some cases 100,000 m^3, after 1990), based on the size of the farm area.

Use in excess of the maximum discharge defined was supposed to be taxed after 1973. But both the limit and the tax remained dormant for agricultural users. For other uses, meters were supposed to be installed on licensed wells as early as 1974 and volumetric tariffs were defined in 1978. The 1988 Law already provides the possibility to estimate water use based on proxies, in case meters are absent or not functioning.

In 2002, the Bylaw brought together quotas and water tariffs and established a block tariff system, distinguishing between wells with licenses/permits, illegal wells, and wells in Azraq. The former were granted a generous free block of 150,000 m^3/year, a threshold that was hard fought for by farmers, against the ministry which wanted much lower thresholds. Wells in Azraq were taxed at higher rates (on account of the shallow aquifer and the need to protect abstraction for domestic supply). Illegal wells were charged from the first cubic meter, but at a relatively innocuous rate (Venot and Molle 2007). The evolution of the price for water in different situations is given in appendix. An amendment raised water tariffs the following year (2003) but this raise faced stiff social opposition and another amendment in 2004 cancelled it.

During 10 years water prices remained at the same level, but recent policy changes in 2014 included a drastic increase in the price of water for non licensed wells, as well as a (not yet implemented) intent to reduce the 'free block' from 150,000 to 75,000 m^3. The 2014 amendment raised water prices to €0.15/m^3 for the first 10,000 m^3, €0.25/m^3 until 30,000 m^3 and €0.5/m^3 beyond this (see appendix). The price of water for illegal wells is now so high that it basically makes agriculture unprofitable, except for greenhouses.

Because of the difficulties to impose systematic metering, the 1988 Law already validates the possible use of indirect means, such as using cropping-patterns and theoretical water requirements, or satellite imagery. Recent studies using satellite images suggest that actual groundwater abstraction in the Highlands of Mafraq and Azraq, as estimated from land-use maps, is between 2 to 3 times higher than per official data (Al-Bakri 2015).

2.2.2.2 Indirect and other tools

Jordan offers a very interesting illustration of how actions on other sectors can be used to instill changes in the groundwater economy. First, the well needs to be legal for the farmer to obtain a connection to the electricity grid. But farming in the deserts of Jordan is also based on the hiring of foreign labor (mostly from Egypt), through permits to 'import' laborers. Attaching this possibility to the compliance with specific legal requirements, such as having a legal well, is now increasingly used to control the expansion of groundwater-based agriculture in Jordan. The number of workers allowed has also been drastically reduced to avoid a 'windfall effect', whereby landowners are paid for releasing their (excess) workers to the construction sector. The Ministry has also stopped giving agricultural loans or credits to illegal well owners, and starting cutting off the electricity supply to farms with illegal wells.

More recently, the Ministry of water resources and irrigation has developed and other means of action allowed by the interconnection of various state administrations through a computerized system. People needing/willing to go through an official procedure, for example to renew a passport, issue a driving license, or buy a house, will see their request denied if they have not

paid their water bills, for example. With people not paying their bills now being barred from accessing other state services or obtaining official documents, this double pressure sends a strong signal about the growing resolve of the ministry. These measures are quite original and seemingly have great potential, but no information is yet available to assess them in more detail.

It must be noted that the government, contrary to countries in Northern Africa, has not subsidized micro-irrigation, in an attempt to elicit water savings. This reflects the fact that, because of the nature of the soils in the highlands but also of the type of intensive agriculture, most of the farms have been set up with drip irrigation technology from the onset. Exceptions include small farms in Azraq and a few others, which have in most cases either shifted to drip or disappeared, or farms irrigating crops such as alfalfa (in general by sprinklers or pivot).

2.2.2.3 Awareness raising

Many programs to raise the awareness of the population about water scarcity and water problems in Jordan have been supported by donors since the 1990s. For example, a 5 year Water Efficiency and Public Information for Action (WEPIA) programme has been funded by USAID in 2001 (Zietlow et al. 2016), using religion as a basis to raise awareness about water conservation, building on the facts that "Saving water is a very important topic in the Holy Koran" and seeking to train "religious leaders, both Muslim as well as Christians, about the urgent need to conserve water so that they will in turn disseminate this information in their respective communities" (Jordan Times, 17 Jan 2001).

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). Awareness raising activities have also been directed towards imams, judges and the Jordanian Parliament (Committee on water resources). The ministry has also and is intensively using the media to publicize actions against offenders, such as seizing rigs and other equipments, freezing assets, publicizing cases of interventions on fixtures found in mains, and publishing lists of people with outstanding unpaid water fees (*naming and blaming*).

2.2.3 Co-management options

Jordan has also experimented with co-management of aquifers. Because of the iconic dimension of the Azraq wetland, the basin has been the beneficiary of various local, regional and international initiatives to promote sustainable water management and preserve groundwater resources, including the UNDP supported Azraq Oasis Conservation Project in the 1990s, the Azraq National Dialogue Initiative steered by IUCN/ InWEnt in the late 2000s, and the Highland Water Forum (HWF), a GIZ-funded project which ran from 2010 to 2013. This project established a multi-stakeholder forum in the Azraq Basin, bringing water users across multiple scales together with the aim "to bring the conflicting water users, particularly the water-governing authorities and the agricultural community, to agreement regarding the causes for dwindling groundwater resources, and to collectively think of creative solutions".[1] The process to develop an action plan followed several meetings with different actors in the basin, from the lowest to the highest level.

The action plan was presented to the Minister of Water and Irrigation in 2013 and included the following issues: revision of the 2002 bylaw with, in particular, a fair and transparent water pricing system; improving access of well-owners to clear procedures and regulations related to wells; cross-sector coordination, with in particular, a joint national water and agriculture strategy; setting up a reliable repository of data and information; institutionalizing the Highland

[1] Source: https://highlandwaterforum.wordpress.com/about/.

Water Forum as a consultative entity and a strategic partner to MWI; allocating water by sector; finding cropping patterns that reduce water demand; improving the efficiency of irrigation at farm-level; promoting reuse of grey water; establishing a compensation mechanism to buy out wells on a voluntary basis; developing alternative income resource to replace agriculture (energy farming, salt-industry, tourism, etc); awareness programs; rainwater harvesting programs, etc.

Farmers who were very optimistic at the beginning of the forum were disappointed after two years of meetings as the produced action plan did not go as far as expected and its implementation is delayed. The elaboration of the action plan was also constrained by the necessity to make it compatible with the National Water Strategy. At the end of the support by GIZ, the HWF has been institutionalized and now appears in the organization chart of the ministry. Studies have recently been carried out to find ways to generate a steady and secured financial resource for the Forum, but the dominant feeling of most stakeholders is that the Forum's role is likely to remain limited largely due to a lack of empowerment. It is apparent from interviews with forum members that the Ministry largely saw the Forum as a means of mediating its reforms, while farmers saw it as a means of claiming benefits.

3 Groundwater use and management in Azraq

3.1 Azraq setting

The Azraq groundwater basin is located 120 km northeast of Amman with an area of 12,710 km^2. The largest part of the catchment (94%) is in Jordan, with smaller parts in Syria (5%) and Saudi Arabia (1%). The basin covers three Jordanian governorates: Zarqa governorate represented by Azraq district; Mafraq governorate represented mainly by a part of North Badia district; and Amman Capital governorate represented mainly by a part of Al Jiza district. We focus here on the situation in Azraq oasis and surrounding areas, with additional references to North Badia in Al Mafraq (According to the Ministry of agriculture there are about 104,285 dunum (du) of land cultivated in Azraq district, the main crops being winter vegetables, clover (*bersim*), fruit trees, grape and olive trees (MoA 2010). The government's well field abstracts about 23 MCM every year, while agriculture abstracts around 28 MCM, nearly the equivalent of the basin's safe yield (24 MCM per year) (MWI 2009). Nowadays all shallow wells have been closed or turned into boreholes. The number of working wells in 2015 reached 420 (a majority of which only have permits and are subjected to higher tariffs), to which should be added unregistered/unknown illegal wells.

Figure 5).

The Azraq river basin largely corresponds to its groundwater basin and surface water and groundwater naturally flow to a central wetland (or oasis), a Ramsar site of major importance. The Azraq basin's safe yield has been established at 24 Mm^3 per year (MWI, 2009). The main recharge of the upper aquifer system originates from infiltration of high rainfall in Jabal Al Arab in southern Syria. Intensive thunderstorms and flash floods in the Azraq basin are also minor contributors to groundwater recharge. The estimated total recharge is about 34 Mm^3/year (Bajjali 1990; MWI 2013).

The diversion of spring water from Azraq for urban purposes began in 1963, when the government decided to transfer water to Irbid (UNDP, 1966), and then to Amman in 1980. In 1981/82 the Water Authority of Jordan drilled fifteen wells northwest of the Northern Azraq springs. As a result, in 1987 the springs of North Azraq dried up and so did those of Azraq South in the early 1990s. The water table dropped by 0.3-0.8 m/year (Mesnil and Habjoka 2012) and the depth of groundwater in the usable aquifer now varies from 20 m in the center of Azraq

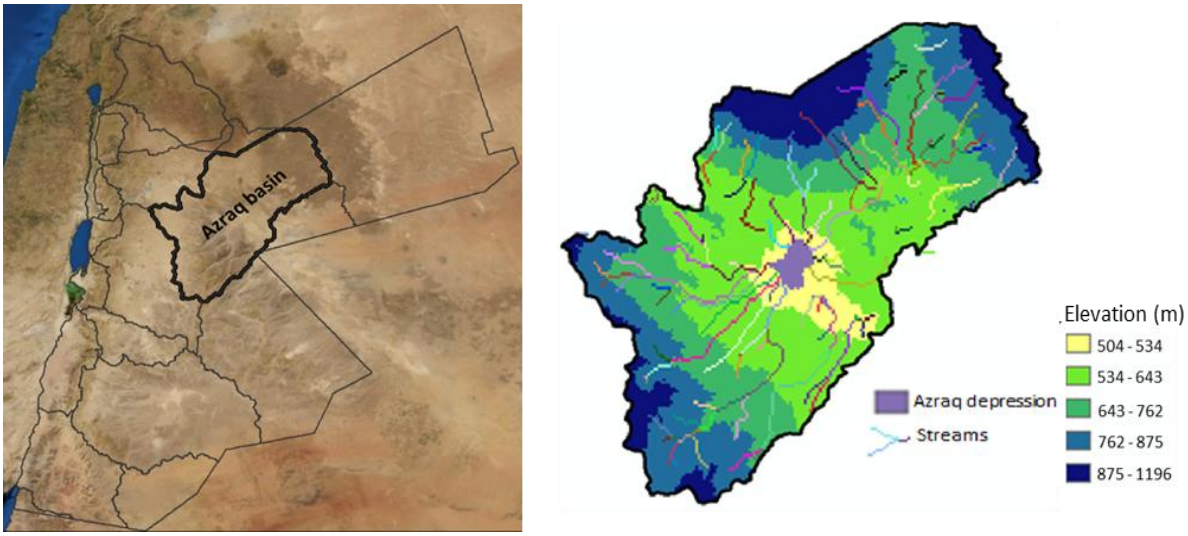
Oasis to 350 m in North Badia. The wetland, now reduced to 10% of its original area, is sustained with (public) well water.

According to the WAJ well database, water salinity in the Azraq basin ranges between 100 and 7,000 ppm. However, the most frequent (206 wells out of 225 wells) range is 500–2500 ppm, with a few cases were salinity concentrations are above 4,000 ppm found in Azraq south area.

The Azraq area is part of the Zarqa governorate and has a population of around 15,000 distributed over 8 districts (Figure 6). The area is home to two major tribes (Beni Sakhr and Al Sarhan) and to Chechen and Druze minorities (Mesnil and Habjouka 2012).

According to the Ministry of agriculture there are about 104,285 dunum (du) of land cultivated in Azraq district, the main crops being winter vegetables, clover (*bersim*), fruit trees, grape and olive trees (MoA 2010). The government's well field abstracts about 23 MCM every year[2], while agriculture abstracts around 28 MCM, nearly the equivalent of the basin's safe yield (24 MCM per year) (MWI 2009). Nowadays all shallow wells have been closed or turned into boreholes. The number of working wells in 2015 reached 420 (a majority of which only have permits and are subjected to higher tariffs), to which should be added unregistered/unknown illegal wells.

Figure 5. Azraq Basin location, elevation and streams (Al Naber and Molle 2017b)



3.2 Agricultural development in Azraq

- Early state support

In the early 1960s, the government launched development programs aimed at settling Bedouins in the Eastern Desert area of the Amman-Zarqa basin (AZB). In the late 1970s, the Badia development Program provided Bedouins with job opportunities and infrastructures (including water supply, roads, schools, hospitals and other public services). Irrigation for agriculture was developed as an additional source of income and the government granted well licenses and low interest loans (Chebaane et al. 2004).

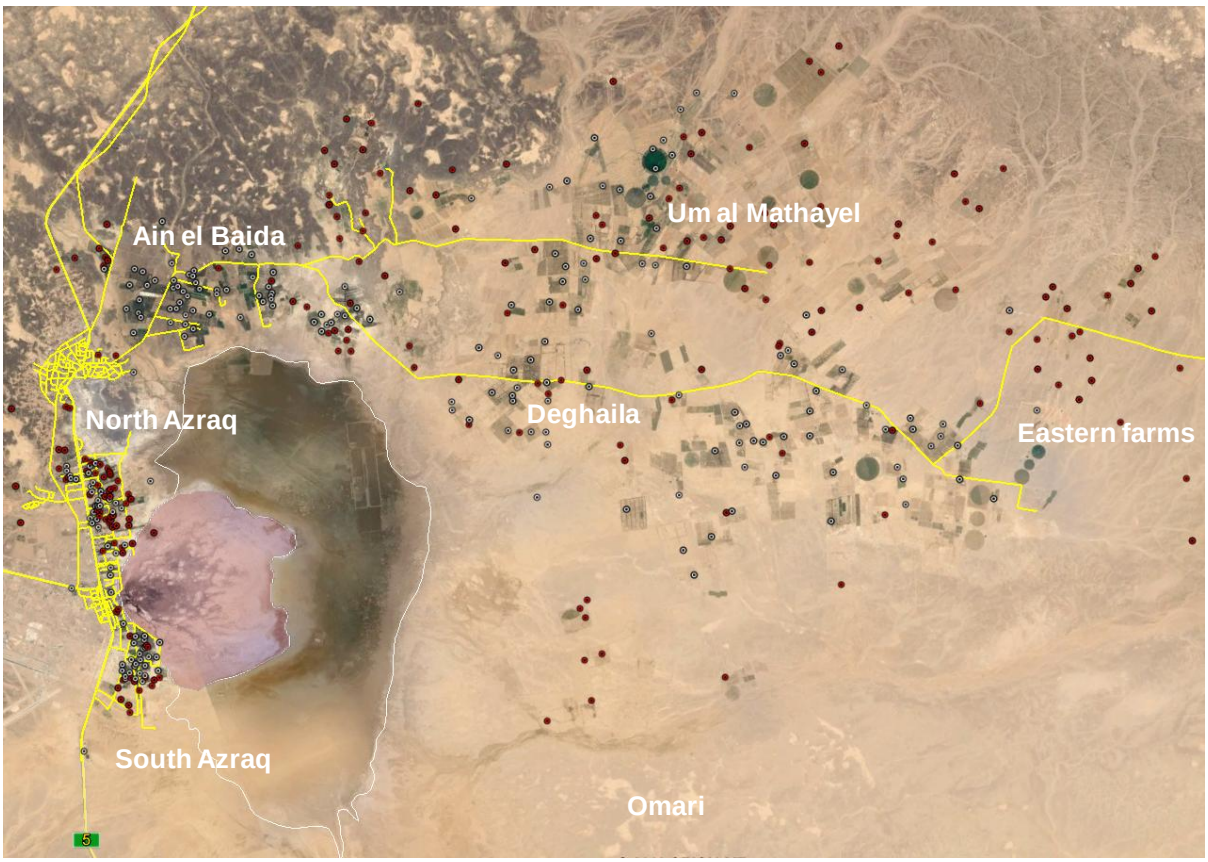
In the 1970s and 1989s, agriculture appeared as a profitable venture and huge private investments were made in the Highlands on large farms of about 20 to 25 hectares, despite apparent unfavorable conditions (aridity, high temperatures in summer, frost in winter, wind

[2] A number contested by farmers, who think abstraction by the state is voluntarily minimized.

and dust). The new bonanza attracted in particular investors from the Jordan valley, many of them Palestinian, government or Army officials and other urbanites. Several factors contributed to making agriculture possible and attractive: modern production techniques for vegetables and fruits tested in the Jordan Valley, good market prices and export markets to Gulf countries or Lebanon, low land prices, availability of good quality groundwater (most especially in Azraq area where water was very shallow), fertile soils with no trace of fungus, nematodes or bacteria, and easy to reclaim (flat topography, deep and well drained soils), lower incidence of theft of production, and the possibility to rotate plots or expand to neighboring land in order to avoid soil contamination, as is common with some vegetables such as tomato or water melon. Expansion was also boosted by government interventions in the market (limitations on import of fruits and flowers, tax exemptions, etc.) (Qasem et al. 1993). As farms expanded in size and number, labor became scarce but the highlands tapped into and benefitted from the large influx of Egyptian workers from the mid-1970s onwards.

Agriculture first started in Azraq around the oasis, based on the spring water and shallow dug wells: South Azraq was home to, and farmed by, Chechens, while North Azraq was farmed by the Druze community. It then expanded to Ain el Baida and eastern Azraq (and also in the north of the groundwater basin, in Mafraq) (Figure 6).

Figure 6. Azraq district, roads (yellow), former wetland (pink) and wells (incomplete)



- The land conundrum

But attractive gains from agriculture do not fully account for agricultural development in Azraq. Expansion is also largely fuelled by land speculation and land tenure issues. Desert land in Jordan is officially under state control and theoretical 'ownership', but is also claimed by Bedouin tribes

who refer to traditional land arrangements between tribes, and sometimes to oral or written agreements with Ottoman, or later British, authorities as to which area would be under control and part of their tribal land (*wajihat al ashira*). Bare soil in the desert is valueless but adding water transforms it into cash flow, especially if it can be legalized, that is, transformed into private property with a legal title deed (*qushan*) (Al Naber and Molle 2016).

State land can be privatized through different means, including the settlement (*taswiye*) procedure of the 1952 Land and Water Settlement Law, which regularizes existing use under certain conditions. The delegation of land (*tafwid*) allows people, private or public companies to rent Treasury land in order to build, cultivate or make a project on it and, with time, to have ownership established in their name. In practice investors generally go through negotiations with tribal leaders and obtain a *hijjeh* (unofficial proof that will be exhibited at time of settlement or in case of conflict). Land settlements are of course prone to conflicts and generate endless additional claims, reasons for which they have been discontinued in the late 2000s (Al Naber and Molle 2016).

- Trends and prospects

During the mid-2000s the decline in water table levels, the decrease in well productivity, and a (localized) increase in water salinity affected farming, with a number of farms being abandoned, especially in south Azraq area, which is underlain by a saline aquifer. Nevertheless agricultural expansion continued in Azraq north and the eastern area, with the introduction of new cash crops such as alfalfa, reaching about 114,000 du in 2011, according to the Ministry of Agriculture. All wells dug after 2005 are considered as illegal and are now the object of increasingly strict measures (see Al Naber and Molle 2017a).

3.3 Groundwater policy in action in Azraq

Official numbers from 2013 (El Hadidi, 2015) point to a total of 329 legal wells and 524 illegal wells but also large rates of non-working wells (117 and 316 for these two categories, respectively). As for the 420 working wells, legal wells are believed to abstract 16.5 Mm^3, against 10.7 Mm^3 for illegal wells, but USAID (2014), based on field visits, estimated the total yearly abstraction at 51.8 Mm^3 (double the official amount). Most 'legal wells' in Azraq only have permits (not licenses) and are subjected to a lower free block (often 25,000 m^3) and a tougher block tariff table (see Appendix).

- Public policies on the ground[3]

Fieldwork in Azraq and interviews with varied actors in Amman have provided insights on the gap between formal policy measures, on paper, and the reality on the ground (Al Naber 2016).

The ban on well drilling is circumvented in different ways. Some farmers apply for a well for domestic or industrial use and use it for agriculture; or for a well cleaning license but instead deepen the well to get more water; they may dig a new well, make it look old, and pretend it dates back to before 2005. 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, and open it again after WAJ's inspection and a replacement license is approved.

Metering is also bedeviled by different types of problems. Most farmers interviewed by Chebaane et al. (2004) claimed that metering is not a reliable tool for monitoring and control of groundwater pumping as tampering and vandalism is common. In eastern Jordan, whenever wells are licensed, owners "tamper with the meters and do not report the exact amounts of

[3] See Al-Naber and Molle (2017) for more details.

water consumed" (Barham 2012).[4] In Azraq some farmers use a driller to rewind the meter backwards, or bypass the meter with a parallel derivation pipe, so that not all the water pumped is metered. Reading of meters involves field staff who can be bribed or intimidated into reporting lower volumes.

The constraints on using the well (no more than one extraction license for one plot of land, no transfer possible) are evaded through dividing the land between sons or relatives, and transfers of water by pipe to distant areas are not uncommon.

A remark is needed regarding energy prices. Because of growing energy costs (unrelated to a decision to use them as a policy tool), pumping with diesel in Azraq (often in farms distant from the wetland and the electricity grid, and therefore with higher pumping depths and costs) has virtually made crops such as olive unprofitable. Diesel costs are around 0.12 JD/m^3, 8 times more than with electricity (0.015) and almost as much as electricity in Mafraq (0.142 JD/m^3). Solar energy is now proving to be extremely cost-effective and could be a game changer in that it reduces energy costs[5] and frees farmers from the constraint of obtaining an electric connection, boosting illegal expansion at the very moment diesel prices were jeopardizing it.

- Recent 'stick' measures

Although water tariffs are effective since 2003, few farmers paid their water bills until 2010 (in Mafraq in 2006 only 25% of farmers were doing so, according to Ramirez et al. 2007). Bills with arrears were sent again in 2010 and various mechanisms to force payment by farmers were gradually put in place. Negotiations (and realism), however, led to a wholesale reduction of these arrears to 30% of their value, according to one MWI official.

Azraq has the highest number and percentage of illegal wells concerned by the hike in tariffs. It remains to be seen how this pricing policy will be enforced in the long run, if it is tantamount to bankruptcy for farms with illegal wells.

As for illegal (unregistered) wells, since 2013 the government has stepped up its policy to crack down on illegal well drilling, seizing drilling equipment, and backfilling (or blasting) wells (so far mostly unused wells) (Addustour 2013). Some interviewees reported that drillers had become more sophisticated and had developed more discrete drilling equipment that can be transported on pickup trucks.

The government has also sought to curtail the windfall benefits associated with land and labor speculation. Land settlements have been discontinued and the number of foreign laborers who can be hired has been reduced (one per 50 du, against 10 du in the past).

4 Assessing governance options in the face of current dynamics

Jordan's experience stands out, at a global level, given the large array of policy tools mobilized to regulate the use of groundwater. We briefly comment on some of its major features based on international experience (Molle and Closas 2017), and then turn to assessing current and potential moves forward.

[4] Quoting a water expert, former employee of the Ministry of Water.

[5] One farmer in Azraq was reported to have imported 96 panels from China at a cost of 30,000 JD and to be able to irrigate 400 du with one well (75 JD/du), which is less than the annual electricity cost for diesel (120 JD/du) and (only) around three times that of electricity (22 JD/du) (Al Naber and Molle 2017b)!

4.1 Examining Current Practices against International Experience

Jordan's groundwater policy must be understood through a number of key contextual features:

- Jordan's policy is giving priority to domestic use and is geared towards *reducing* agriculture in the highlands (in contrast with most countries in the MENA region which, explicitly or not, do support its expansion).
- As a result, and considering the disappointing outcomes of 15 years of attempts at comanagement in Azraq, the government has deliberately chosen to use almost exclusively '*stick' policies*. Policies are therefore entirely top-down and rely on the assumption that the enforcement power of the state will be sufficient to deal with the problem.
- The relatively limited number of wells, around 3,100 with perhaps an additional ~1,000 illegal unknown wells and two third of them for agriculture, may entertain the hope that they are '*manageable*'.
- Well drilling, except in the Jordan Valley, is costly. *Raising the risk* of drilling an illegal well (through different sanctions) is therefore a sound policy that has some likelihood to be effective.
- The overall resource is limited by low aquifer recharge and limited rainfall.

4.1.1 Illegal drilling

Since 2013, the Ministry has seized numerous drilling rigs, and these actions have been repeatedly publicized in the newspapers. They are a necessary action to make drilling more dangerous and difficult but it is not clear, though, how much of a deterrent to illegal well drilling they are since similar announces were also made in 2003 in the wake of the bylaw.

Illegal drilling is also made more risky for landowners, as the government increases its means to spot them on the ground (through remote sensing) and shows an increasingly strong resolve to backfill illegal wells. Numerous reports in the press and television channels certainly contribute to creating a feeling of uncertainty and risk for would-be drillers.

Closing wells that are being used to irrigate, however, is politically problematic. And indeed, with a few exceptions (e.g. wells drilled on state land or impacting a public domestic well) no country in the world has been able to do this in a systematic way. Destruction of crops or plantations is a much less attractive and politically rewarding headline for governments, especially when this can be seen as antagonizing the survival efforts of small farm holders. Indeed, the government has so far focused on backfilling unused wells (dry, saline or abandoned). This can probably explain why it has decided to deal with illegal wells through the indirect tool of water pricing.

4.1.2 Metering

International experience has it that when meters start to indicate volumes that result in damageable costs or penalties, they invariably tend to be tampered with or are found 'out of order'. A survey in the Amman-Zarqa Basin in Jordan in 2004, two years after the implementation of the bylaw and even though hardly any farmer had yet paid for water, found that only 61% of the meters installed in the past 10 years were still working (Chebaane et al.

2004). In Azraq for example, 192 water meters were reported to be working but 136 had not been installed (out of a total of 334 wells surveyed) (IRG 2014).[6]

It is also unclear whether the meters that have been found to be working are being tampered with (e.g. rewinded), or partly by-passed. Meter reading has also globally extensively been found to be prone to bribing and to invite corruption. All these factors together probably explain why recent studies have estimated groundwater abstraction to be much higher than officially recorded.[7]

Estimating groundwater use through cropping areas, in particular with the help of remote sensing, is probably an idea that has to be pursued more systematically because it lends itself to the particular conditions of Jordan's Highlands, which are basically desert and make the identification of irrigated areas much easier that in other settings. Using this proxy, rather than meter readings, does not completely suppress the need for ground truth and visits but make them less frequent.

4.1.3 Volumetric pricing

While water pricing has potential for reducing water consumption in urban settings, its use in agriculture is problematic, especially in surface irrigation schemes where the monitoring of volumetric individual consumption is very rare. With groundwater, however, there is the possibility through direct metering or indirect means (as discussed above) to price water volumetrically. Unfortunately, since pumping is usually private and individual there is no service that the state can charge for (except some relatively minor charges for resource management or environmental considerations, as sometimes found in Europe). As a result, very few countries with numerous and disperse agricultural wells actually charge for groundwater. And when they do in theory, like in Morocco, these fees are often not collected (doing so would in general actually cost more than the revenue thereof). because there is no service to be charged for, this also means that it is politically unacceptable to charge water fees that would elicit water savings, since such fees are invariably found to substantially dent incomes (see Molle and Berkoff 2007). Administered prices are therefore not a viable tool to reduce water use. This is exactly what has been found for Jordan, where groundwater fees have been found to have minimal financial impact (Venot and Molle 2007, Demillecamps 2010), and where *legal* well owners have consistently negotiated comfortable free blocks and resisted hikes in tariffs.

However, these limitations do not apply to *illegal* wells (deprived of licenses and permits) because illegality prevents the owners of those wells to protest: as violators of the law they are in a weak bargaining position which the government has made use of to attack them through very high tariffs (rather than through problematic direct action in the fields, as commented above). We are not aware of a similar situation in any other country, which makes this initiative rather original.[8] However, there are two problems associated with this policy: first, it makes clear to prospective well drillers that they have to remain hidden at any cost, and discourage them to declare or register their wells in the future for any reason. Second, instead of raising prices gradually, the government has chosen to brandish a very 'big stick' by raising prices to extremely high levels, to the point that very few farmers will be able to pay. As a result, the government has undermined the credibility of the measure, has been forced into negotiation, and has made

[6] According to the results of this survey, Azraq is the basin in Jordan with the highest number of non-installed meters, other basins such as Mafraq have 8 non-installed meters (out of 298 wells), Deir Alla has 52 (out of 110 wells) (IRG 2014).

[7] Although there is a lot of uncertainty as to how to calculate crop water requirements in the Highlands.

[8] Note that this is only possible if illegal wells are known and registered. This does not apply to unknown illegal wells.

its decision vulnerable to being overturned on the next occasion, when political pressure will be put on the government for any reason.

4.1.4 Indirect measures

The interconnection of public data, and making any governmental procedure (purchase transaction, passport or driving license request, etc.) conditional upon records showing due payment of water bills, is the most original measure. It is being reinforced by a *naming and blaming* policy that exposes offenders in the media. It is hard to measure the impact of this policy, and to what extent it is also partly watered down by influence and power relations, but it has the potential to discourage farmers with little-productive farms, as well as investors willing to drill new wells and reluctant to run the risk of illegality.

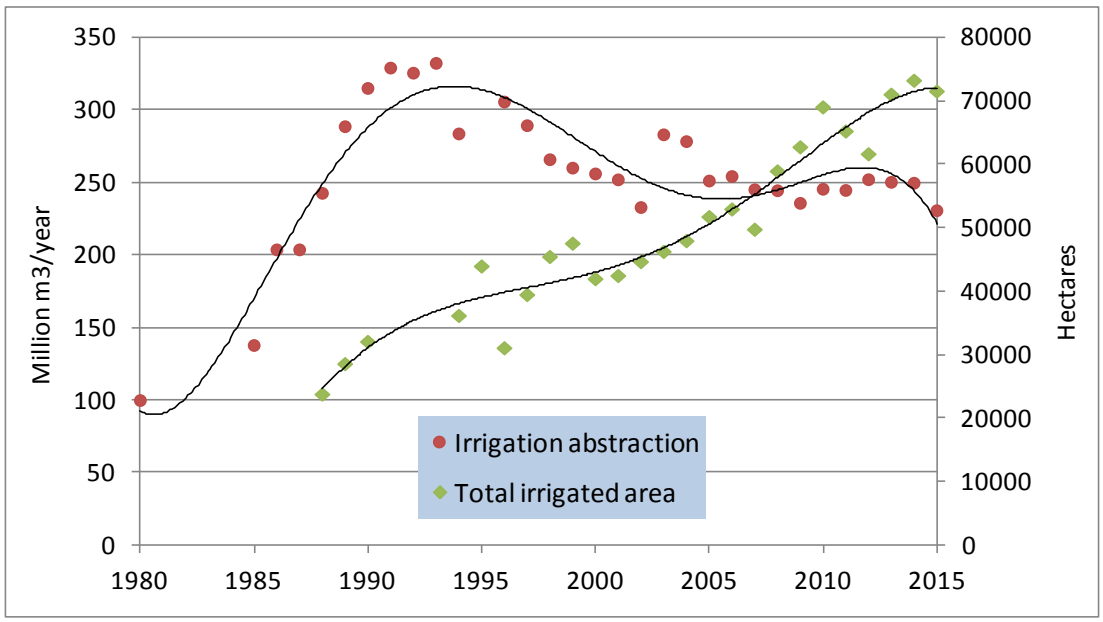
4.1.5 Validity of data

The difficulty to maintain an exhaustive register of wells, and even more so to monitor their actual groundwater abstraction, has already been commented upon. The result is that official data do not offer a good view of reality on the ground. The pressure to demonstrate an impact of policies may also have influenced the production of data. Several declarations linking the 2002 Bylaw and its pricing policy to alleged reductions in abstraction were common in the 2000s, although farmers only started to pay (partially) at the end of the decade, and although economic studies do not support this.

Figure 7 shows official data on groundwater abstraction for irrigation and indicates that abstraction has decreased in the late 1990s and then levelled off at around 250 Mm^3/year. Figure 7 also displays the total irrigated area on the Highlands (Department of statistics), which is clearly very hard to reconcile with official data on abstraction.[9] It is unclear how reliable are the statistics on cropping areas. However, using satellite images Al-Bakri (2015) has shown that substantial expansion of irrigated areas took place in Azraq and Mafraq areas during 1990-2014. The irrigated areas were only 17,000 and 36,000 du in 1990 for Azraq and Mafraq, respectively. Both figures increased to 35,000 and 107,000 du in 2002 in Azraq and Mafraq, respectively; and then 46,000 and 134,000 du in the 2013/2014 season. This growth is consistent with the general trend shown on the Figure. Tremendous pressure exerted on staff to show policy results may have distorted data reporting.

[9] AFD and CMI (2011) also note that recorded water abstraction for agriculture amounted to only 56% of the value theoretical based on crop water requirements.

Figure 7. Official data on groundwater abstraction for irrigation* and total irrigated area in the highlands (Al-Karablieh and Salman 2016)



*Note: Abstraction for irrigation refers to the whole country but only a small part corresponds to the south of the Jordan valley.

Other instances of standard official statements denying reality include the oft-repeated statement in the 2000s that 95% of wells were equipped with meters, despite evidence to the contrary (e.g. Fitch 2001).

4.2 Policy opportunities and constraints

Jordan's groundwater policy is at a crossroads. The government has aptly built a message of urgency which is being forcefully disseminated to all segments of society and is starting to percolate (as judged, for example, from a change of attitude in the Parliament). It has invested considerable political capital in passing and enforcing extremely stringent measures. By doing so, it has fully embarked in an '*all-stick policy*' and put aside other approaches that would include '*carrots*' or deliberative processes.

At this point the message is clear and no 'retreat' is possible. Slack enforcement would not only nullify all the efforts made but also send the signal that tough policies should not be taken seriously because they are likely to be eroded in no time. The question remains, however, as to whether the strong resolve manifested at the top of the Ministry pyramid is passed down to lower levels. In other words, one should not overestimate the power of the state to act in a top-down manner down to the local level. Pressure at the well/well owner level has been smoothened by friendly reporting from field staff, in particular regarding metering of abstraction (a logical conclusion of Al-Bakri's (2014) and Al Naber's (2016) studies. This can be explained by bribing, intimidation, and the social proximity of local staff with farmers. It is a well recognized feature of paid-for registration/licensing and groundwater use to invite corruption (Molle and Closas 2017).

The common complaint by farmers about unequal treatment depending on one's social power (Al Naber, 2016) has been aptly countered by publicizing cases of powerful persons having been heavily fined, prevented from leaving the country, or who have seen their assets frozen because of unpaid water bills or illegal fixtures on water mains.

The most aggressive measures are directed at illegal wells and their expansion is likely to be affected. But the question of the current overdraft remains and appears to be even more challenging. Whether we consider official numbers or estimates from recent studies (Al-Bakri 2015; USAID 2014), actual abstraction in major basins (AZB, Yarmouk, Azraq, Dead Sea) is anywhere between 2 and 3 times the officially stated safe yields. Reducing this abstraction to sustainable levels constitutes a formidable challenge and nowhere in the world has this been possible through the mere use of policy instruments.

The government, as well as international donors, have long vested undue hope in water pricing as a means of reducing abstraction. As we have seen above, this is extremely difficult to achieve for legal wells for various reasons. Illegal wells are heavily targeted but the new fees are so high that they look like a death sentence and therefore lack credibility, eventually facing the same kind of obstacles that constrain the backfilling of wells. Too high water fees will translate into more defaulting (the debt from fines from illegal groundwater abstraction by farmers exceeds JD24 million[10]).

The situation of overdraft is such that the ministry did not accept the idea of freezing well drilling against the regularization of existing wells, including those declared as illegal, a bargain that is often offered by governments. Officials argue that this would reward violators of the law and is therefore out of question, but the underlying concern is more likely to be the fear to send the message that any illegal well yet to be drilled will one day be regularized.

Last, the exceptional resolve shown by the Ministry, irrespective of the factors that limit the effectiveness of policies on the ground, might be hard to sustain. The policy might in particular come under fire from opposition groups. Even though the bargaining power of investors has been reduced and politicians have become aware of what is at stake for the country, political volatility may well affect the staffing and policy line of the MWI. Although the current Minister has now been acting for over 4 years, historical records show that a much higher turnover used to be the norm in the past.

The future of groundwater resources in Jordan is therefore uncertain. The most likely scenario includes a slowdown or leveling-off of the rate of the expansion of groundwater-based agriculture and a decrease in the illegal drilling of wells. However policies are unlikely to suffice to balance supply and actual uses and water tables will continue to fall, even though at lower rates. This will result in increasing pumping costs and capital needs for (illegal) deepening of wells, growing average salinity of groundwater, and in some places drying up of wells (Fitch 2001; Rosenberg 2012), with a growing proportion of farmers getting out of business because of saline water and/or dubious profitability (e.g. olive trees) in the face of rising costs. Only the most technically efficient growers of cash crops taping export markets or temporary niches such as alfalfa will survive, on the model of Mafraq. This would particularly affect small local farmers and would encourage further migration to the city. At some point, the state might be forced to offer both compensations/subsidies ('carrots') and alternative economic opportunities.

This scenario might well be accelerated by extreme events such as severe droughts, which would exert excessive pressure on groundwater, adding to the impact of the current Syrian crisis.

[10] At the current currency exchange rate (August 2015), JD24 million correspond to around USD 34 million. The Jordan Times 2014, www.jordantimes.com/news/local/farmers-should-seal-illegal-agricultural-wells-year-end-%E2%80%94-water-ministry (Accessed 17th August 2015).

5 Conclusions

The case of Jordan's groundwater policy is of particular interest for practitioners and academics alike because of the large array of policy tools and measures that have been implemented in the past three decades. Jordan is also characterized by low per capita water endowments and a strategic reliance on groundwater for domestic use that translates in a policy to control and reduce abstraction by agriculture. This situation is amplified by the emergency and humanitarian crisis experienced by Jordan with the wave of refugees from neighboring Syria, adding further pressure on the country's overstretched water resources. Needless to say, this refugee crisis has been used to emphasize the critical situation Jordan is facing with regards to water scarcity and appeal to the international community for further international aid and funds.

Unwilling to extend 'carrots' in favor of agriculture, and unconvinced by the results of 20 years of attempts at co-management in the Azraq basin, the government has adopted a to-down 'stick-only policy', despite a lack of evidence of success. Enforcement problems have weakened these policies and (illegal) well drilling has continued in several regions. At the end of last decade, and more forcefully since 2013, the Ministry has exerted spectacular pressure on illegal wells and water bill defaulters. The media has echoed crack-down operations and published the names of offenders. The rules of the game have been rather clearly defined and enforcement is the big challenge. As a result, the main conclusions of our analysis are qualitative rather than engaging with the *nature* of the policies in place.

- The measure taken in 2014 to raise water prices for illegal wells is extremely brutal. Too big a 'stick' may therefore not be credible and/or invite defaulting. The objective may have been to force people into negotiation, which is what actually happened (people being given more time to pay arrears and their values being slashed by 30%). Yet, it remains that farmers are likely to keep defaulting rather than declare themselves bankrupt and the question of whether and how to be more coercive will be raised again. A more gradual, yet substantial, increase might have been preferable.
- Rising diesel prices have now turned pumping for olive trees basically unprofitable. But solar energy is emerging as a very cost-effective solution that needs to be monitored by the government, since it might boost illegal expansion at the very moment diesel prices were jeopardizing it in remote areas.
- Another effect of political pressure might well have been to generate distortion in data reporting. At least the difference between data on irrigated areas and abstraction for irrigation cannot be reconciled without questioning these data. The result is that the Ministry may have become blind to actual dynamics on the ground.
- Jordan has deployed very original indirect tools to enforce the law, including the interconnection of ministerial computer systems, the reduction of the incentives to speculation on land and labor, the discontinuing of agricultural loans or credits to illegal well owners, the cutting off of the electricity supply, or *naming and blaming* actions. It is not possible to measure their respective impact but they clearly depart from the 'lack of political will' situation observed in most countries in the MENA region. They also signal a weakening of policy analyses focused on inaction as a reflect of the balancing act of the Hashemite regime towards Bedouins (York 2013; Zeitoun et al. 2011).
- Raining awareness in all segments of the population, including judges, imams and MPs, is proving to be important in the long term (Zietlow et al. 2016).

- Estimating groundwater use through cropping areas, in particular with the help of remote sensing, is probably an idea that has to be pursued more systematically because it lends itself to the particular conditions of Jordan's Highlands, which are basically desert and make the identification of irrigated areas much easier that in other settings. Using this proxy, rather than meter readings, does not completely suppress the need for ground truth and field visits but make them less frequent.
- Despite all the commendable political capital engaged in current policy implementation, there is little likelihood that overexploitation trends can be reversed before a large number of farmers are forced to exit the groundwater economy due to local exhaustion of the resource. This scenario might well be accelerated by possible severe droughts.
- 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; and also remains exposed to being overturned at any time by political volatility.

6 Appendix

Table 5. General tariff for wells with licenses or permits (in fils/m^3)

Quantity of water (block)	*Water price Bylaw 2002*	*Water price (amend. 2003)*	*Water price (amend. 2004)*	*Water price (draft amend. 2010)*	*Water price (amend. 2014)*
0 – 50,000 m^3	Free	Free	free	Free	free
50,000 – 150,000 m^3	Free	Free	free	10	free
150,000 – 200,000 m^3	5	25	5	10	5
More than 200,000 m^3	60	60	60	100	60

*The value of 25K for the free block was also discussed. Later, after the amendment was given up, a value of 75K was envisaged.

Table 6. Special water tariff for wells with permits in Azraq area (as amended in 2003, Bylaw 85-2002)

2003 to 2005 and after 2012		*Between 2005 and 2012*		*Draft 2010*
Quantity of water	*Water price*	*Quantity of water*	*Water price*	*Permitted amount 25K*
0 to permitted amount*	Free	0 to permitted amount	Free	Free
Permitted amount to 100,000 m^3	20	Beyond permitted amount	60	10
More than 100,000 m^3	60			100

*50,000 m^3 or 250 m^3/du for a farm smaller than 200 du

Table 7. Water tariff for illegal wells as amended in 2003 and 2014 (Bylaw 85-2002)

2003		2010 draft	2014	
Quantity of water	*Water price (fils/m^3)*	*Water price (fils/m^3)*	*Quantity of water*	*Water price (fils/m^3)*
0 – 100,000 m^3	25	50	0 – 10,000 m^3	150
100,000 – 150,000 m^3	30	70	10,000 – 30,000 m^3	250
150,000 – 200,000 m^3	35	100	More than 30,000 m^3	500
More than 200,000 m^3	70	100		

7 References

Addustour. 2013. Illegal driller was detained in Mafraq (in Arabic). www.addustour.com/17800/.

AFD and CMI. 2011. Jordan water demand management study. Prepared for MWI and AFD.

Al-Karablieh E and Salman A. 2017. Water and groundwater in Jordan – resources and management. Groundwater governance in the Arab World: Taking stock and addressing the challenges. Report submitted to the project. Groundwater Governance in the Arab World. School of Agriculture. The University of Jordan, Amman, Jordan.

Al Naber, M. 2016. Jordan – Azraq Basin Case Study. Groundwater governance in the Arab World. IWMI Project Publication. Report no.11.

Al Naber, M. and Molle, F. 2016. The politics of accessing desert land in Jordan. Land Use Policy 59: 492–503.

Al Naber, M. and Molle, F. 2017a. Controlling groundwater overabstraction: policies vs. local practices in Jordan Highlands. Water Policy (in press).

Al Naber, M. and Molle, F. 2017b. Water and sand: is groundwater-based farming in Jordan's desert sustainable? Groundwater for Sustainable Development (forthcoming)

Al-Bakri, J. T. 2015. Crop mapping and validation of ALEXI-ET in Azraq and Mafraq areas. A report for Regional Coordination on Improved Water Resources Management and Capacity Building, Ministry of Water and Irrigation, Amman, Jordan.

Al-Hadidi, K. 2015. Groundwater legislation framework in Jordan. Presentation at the 5th ACWUA conference, Muscat, Oman.

Ammonnews. 2017. الناصر: وقف ٦٥ حفارة وردم ٨٠٠ بئر مخالف http://www.ammonnews.net/article/305848. 19-03-2017.

Bajjali, W. 1990. Isotopic and Hydrochemical Characteristics of Precipitation in Jordan. M.Sc. Thesis, Jordan University, Amman-Jordan.

Barham, N. 2014. The sociopolitical aspects of water scarcity in Jordan, Conference on 'Social water studies in the MENA region – State of the art and perspectives', German Jordanian University Campus, 28-29 September 2014, Madaba, Jordan.

Chebanne, M., El-Naser, H., Fitch, J. Hijazi, A. & Jabarin, A. 2004. Participatory groundwater management in Jordan: development and analysis of options. Hydrogeology Journal, 12, 14-32.

Closas, A. and Molle, F. 2016. Groundwater governance in the Middle-East and Northern-Africa region. Report submitted to USAID (vol. 1). IWMI.

Demilcamps, C. 2010. Farming in the desert: analysis of the agricultural situation in Azraq Basin.

Fitch, J. 2001. Curtailment of Groundwater Use for Irrigated Agriculture in the Amman-Zarqa Basin Uplands: An Economic Analysis. Fitch & Marshall, Inc. Yakima, WA, USA.

Mesnil, A. and Habjoka, N. 2012. The Azraq-dilemma. Past, present and future groundwater management. Amman: GIZ.

Molle, F. and Closas, A. 2017. Groundwater governance: a synthesis. Report submitted to USAID (vol. 6). IWMI.

Molle, F., Berkoff, J. (eds.) 2007. Irrigation water pricing: the gap between theory and practice. CABI: Wallingford, UK and Cambridge, MA, USA.
www.iwmi.cgiar.org/Publications/CABI_Publications/CA_CABI_Series/Water_Pricing/protected/index.htm

MWI. 2009-2015. Annual Report. Ministry of Water and Irrigation, Amman, Jordan.

MWI. 2004. The national Water Master Plan of Jordan. MWRI/GTZ.

Qasem, S.; Wir, A. and Shatanawi, M. 1993. Jordan Agricultural Sector Review: Irrigated Agriculture. APAP II, Technical Report No. 132, Volume IV, Prepared for Agricultural Policy Analysis Project, Phase II (APAP II) and USAID/Amman.

Subeh, A. 2006. Water in Jordan: water security and protection. Presentation at the "Water security and protection workshop", June, 2006.

UNDP. 1996. The Azraq Oasis Conservation Project: JOR/1992/G31.

USAID. 2014. Socio-Economic Analysis Report Impact Assessment of Groundwater Wells in Jordan. Institutional Support and Strengthening Program. USAID, Amman, Jordan.

USAID. 2001. Options for artificial groundwater recharge with reclaimed water in the Amman-Zarqa Basin & Jordan Valley. USAID/MWI.

Venot, J. and Molle F. 2007. Irrigate Agriculture, Water Pricing and Water Savings in the Lower Jordan River Basin (in Jordan). Research Report 18. Comprehensive Assessment of Water Management on Agriculture. IWMI.

Yorke, V. 2013. Politics matter: Jordan's path to water security lies through political reforms and regional cooperation. NCCR TRADE Working Paper No 2013/19.

Zeitoun, M., Allan, T., Al Aulaqi, N., Jabarin, A. & Laamrani, H. 2011. Water demand management in Yemen and Jordan: addressing power and interest. *The Geographical Journal*, 178(1): 54-66.

Zietlow, K.J.; Michalscheck, M. and Weltin, M. 2016. Water conservation under scarcity conditions: testing the long-run effectiveness of a water conservation awareness campaign in Jordan. *International Journal of Water Resources Development*, 32(6): 997–1009.