JORDAN – AZRAQ BASIN CASE STUDY

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Groundwater governance in the Arab World

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Summary

Groundwater in Jordan has been used since the early 1960s by several sectors for different purposes: domestic, industrial, agriculture and environmental use. Irrigated agriculture is the major consumer of groundwater in Jordan, especially in the Highlands, one of the main agricultural areas in the country after the Jordan valley. This report highlights the existing agricultural activities and farming practices in the Highlands, taking the Azraq basin as a case study.

In Azraq, the development of modern groundwater-fed agriculture over the years was 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 agriculture the first investment option in the Azraq basin. Such expansion was also fuelled by the government who freely awarded licenses for wells in the 1980s and early 1990s. Even though investors and farmers enjoyed the economic revenues from these activities, in the early 1990s the government, sensing the increase in groundwater use in the area, tried to control abstraction by introducing well metering in most wells 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 recognized Azraq wetland.

The measures aimed at monitoring groundwater abstraction and reducing over-abstraction limits were not respected and the number of illegal wells increased 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, caused the deterioration of water quality and quantity. The lowering of the water table in the basin encouraged deeper well drilling, new well locations and new wells, contributing even further to the degradation and over-abstraction of the resource, while increasing salinity and degradation of water quality. As the number of functioning deep wells has been increasing, groundwater abstraction has also been on the rise, causing a decrease in water table levels by about 25 meters during the last 28 years. Even though fluctuations of the groundwater table due to recharge events caused by rainfall may be observed, they are not enough to cover the gap between abstraction and recharge, the former being estimated at somewhere between two and three times the estimated safe yield.

This report begins by giving an overview of Jordan's water resources, focusing on Azraq basin as a case study. It then provides a detailed description of the basin in terms of its hydro-geology and hydro-chemistry in a historical context. The main objective of the report is to emphasize the driving forces behind the development of agriculture in the Azraq basin. The report focuses further on the issues of land tenure, as profits generated from groundwater-based irrigated agriculture have created a demand for land causing the expansion of irrigated agriculture area. The report then provides a summary of the evolution of Jordan's main historical water policy developments, describing the different policy tools used in groundwater policy and the elasticity of law enforcement, and how farmers in the Azraq basin have responded to these policy and regulatory measures. The report 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.

The last part of the report presents the farm typology identified and characterized following fieldwork between 2013 and 2014. This section also compares this report's farm typology to previous studies showing the level of consistency and variations in agricultural practices over the past decade in Azraq. The result of this work was based on field visits, and multi-scale interviews with different stakeholders such as policy-makers, government bodies, local groundwater users, farms owners and managers.

Currently, as this report shows, land speculation, weak law enforcement, control and monitoring create a fertile ground for the continuation of extensive farming and irrigation in the basin by locals, Bedouins and investors. But new policies have the potential to constrain expansion: the combination of heavy water prices for illegal wells, estimating use through remote sensing or electricity consumption without resorting to meters, constraining the granting of labor permits, and the interconnection of public data (as a means of enforcing payment) may discourage farmers with little productive farms, or investors willing to drill new wells.

The future of agriculture in Azraq is therefore uncertain. One scenario contemplates a continuation of current trends, with a large proportion of farmers getting out of business because of saline water and/or dubious profitability (olive trees) in the face of rising costs, and only the most technically efficient growers of cash crops taping export markets or temporary niches such as alfalfa surviving, on the model of Mafraq. This would in particular affect some local small farmers and would encourage further migration to the city. Another scenario includes a leveling off and stabilization of the cultivated area, the gradual retirement of some farms faced with adverse increases in input prices, or the offer of both compensations and alternative economic opportunities by the state. It may well be, also, that extreme events such as severe drought, a continued Syrian crisis, political changes, or upheavals in some input or output markets determine the course of things.

1 Jordan overview

1.1 Country overview

Jordan is a country located 80 kilometres off the eastern coast of the Mediterranean Sea, covering an area of about 89,000 km^2. The country is bordered by Saudi Arabia to the south and east, Iraq to the north-east, Syria to the north, and Palestine and Israel to the west. Jordan is in a semi- arid area with a climatic condition characterized by cold winter and hot summer. Average minimum annual temperatures are recorded in January (5°C), while the average highest temperature is recorded in August (35°C). Precipitation in Jordan varies from less than 50 millimetres per year (mm/yr) in the south-eastern desert area of the country to more than 650 mm/yr in the highlands and northern mountains (JMD, 2011).

The main environmental challenge that Jordan faces nowadays is water scarcity. Jordan is one of the countries with the scarcest water resources worldwide, with its groundwater resources abstracted beyond the aquifers' safe yield, surface water resources almost fully diverted, and precipitation fluctuations (Courcier et al., 2005). The gap between water demand and supply is increasing in parallel with population growth combined with a massive influx of refugees. In 2004, the population in the country was estimated as 5.1 million, a number reaching 10 million people in 2015. Of those 10 million, 6.7 million are Jordanian and 2.8 million are refugees (Jordanzad, 2015). This increase in population caused a direct increase on water demand, which in return increases the pressure on the country's limited resources.

Jordan is divided into twelve provinces; Ajlun, Amman, Aqaba, Balqa, Irbid, Jarash, Karak, Ma'an, Madaba, Mafraq, Tafilah and Zarqa. Table 1 shows the population by governorate according to the official data in 2012 with the area of each governorate (DoS, 2012).

Table 1. Populations, population density and governorate area (DoS, 2012)

Governorate	Population*	Area		Population Density
		Km^2	%	
Amman	2,473,400	7,579	8.54	326.3
Balqa	428,000	1,120	1.26	382.0
Zarqa	951,800	4,761	5.36	199.9
Madaba	159,700	940	1.06	170.0
Irbid	***1,137,100***	***1,572***	***1.77***	***723.4***
Mafraq	300,300	26,551	29.90	11.3
Jarash	191,700	410	0.46	467.8
Ajloun	146,900	420	0.47	350.1
Karak	249,100	3,495	3.94	71.3
Tafelieh	89,400	2,209	2.49	40.5
Maán	121,400	32,832	36.98	3.7
Aqaba	139,200	6,905	7.78	20.2
Total	***6,388,000***	***88,794***	***100***	***71.9***

1.2 Overview of global challenges

1.2.1 Refugees influx

Jordan has observed endless waves of refugees (Druze, Chechens, Armenian, Circassian, Palestinian, Iraqi, and lately Syrian) since the early 1900s till nowadays. The registered number of Palestinian refugees in 2004 (mainly from either the 1948 Arab-Israeli War or the occupation of the West Bank in 1967), is 1.7 million but unofficial surveys suggest that the number exceeds 3.2 million (FRD, 2006). The number of registered Syrian refugees is 2.7 million (Jordanzad, 2015). In addition, 58,000 Iraqis were spread between refugee camps and their number is also increasing. Relative to Jordan's population size, this refugee flux makes Jordan the largest refugee-hosting country in the world since the end of the Second World War (JMI, 2014).

The influx of refugees and the sudden and rapid increase of population have had a negative impact in all sectors in the country (e.g. education, health, security, infrastructure, public services, labour market, and natural resources), with of course an impact also on the country's annual budget, debt, and balance of payments.

1.2.2 Food production

The total agricultural area in Jordan is about 9.7 million dunum (du) (or 970,000 ha), 60% of the total cultivable area, representing only 3.3 % of Jordan's total land area (4.791 million dunum). Of the total cultivable area, 49% is cultivated with crops, while fruit trees represent about 3.6 million dunum and vegetables 1.4 million dunum (37% and 14% each respectively) (MoA, 2010). Since 80% of the cultivated area in Jordan is rainfed, the agricultural sector is characterized by unstable production (FRD, 2006). The most profitable crops are citrus, stone fruit trees and vegetables (tomatoes, eggplants, cucumbers, cauliflowers, cabbage). The country is completely dependent on cereal imports. Agricultural products represent 17.6% and 16% of the total national exports and imports respectively (MoA, 2010). Jordan is self-sufficient in potatoes, olive, olive oil and lemon production, and has a surplus in tomato production (MoA, 2010).

1.2.3 Energy

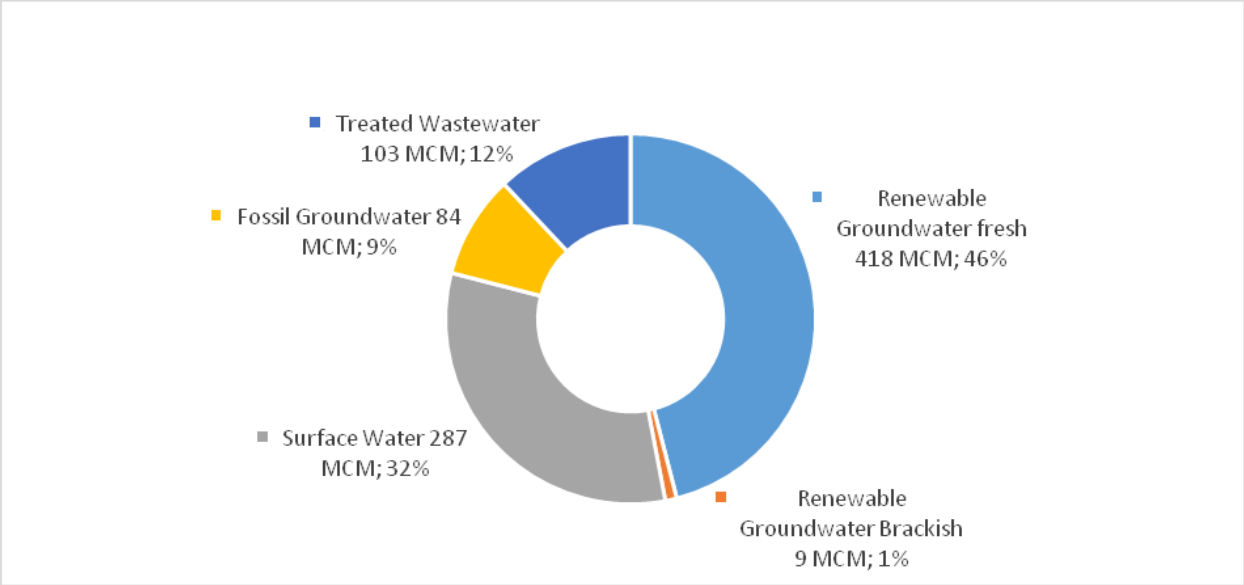
Jordan's 95% of energy is imported from Saudi Arabia, Kuwait and the United Arab Emirates (Dos, 2014). The lack of energy resources and the growth of Jordan's economy in recent years have led to an increase in energy demand causing a load on the national economy and a budget deficit due to the high cost of importing energy. For this reason, the country started to shift its energy production strategy towards the use of renewable energies (wind and solar for electricity generation and biomass energy) by 2020. In addition, the development of natural gas, shale gas, biogas and hydropower (along the Red Sea-Dead Sea canal project) as local energy sources to cover the country's future energy needs have also been envisaged.

1.3 Surface and groundwater resources in Jordan

Jordan's water sources are divided into surface water basins, groundwater basins and recycled water. The total annual water supply average from all water sources (surface, groundwater, and recycled water) is between 800 and 900 MCM over the past 15 years (Humpal et al., 2012; MWI, 2013). In Jordan, 56% of water is drawn from renewable and non-renewable groundwater aquifers

(Figure 1), the rest comes mainly from the Yarmouk River with some additional contribution from lateral wadis along the Jordan Valley (Humpal et al., 2012). Jordan has ten surface basins and twelve groundwater basins, some of the basins boundaries are located inside the country while other are shared with neighbouring countries (Figure 2 and Figure 3).

Figure 1. Total Jordan water resources in 2010 (Humpal, 2012)



The total quantity of groundwater available in Jordan is 511 MCM, of which 427 MCM are renewable and 84 MCM are non-renewable (MWI, 2013). The agricultural sector uses about 46.2% of all groundwater use in Jordan, followed by the municipal sector with 47.6% of groundwater, and the remaining 6.2% is used for industrial activities (DoS, 2014). It is important to note that the current use of groundwater exceeds available renewable supplies in many aquifers, and non-renewable water is being abstracted from the Disi aquifer in the south. Groundwater development in Jordan was rapid in the 1980s and early 1990s as successive governments freely awarded licenses for tube-wells (MWI, 1998), which led to the abstraction of about 250 MCM for agriculture use (MWI, 2013).

Over-abstraction is evident in six of the twelve Jordanian basins as the aquifers are being over pumped at rates varying from 146 to 235% of its safe yield (Table 2) (MWI, 2013). Water quality continues to decline in some over-pumped aquifers as older saline water moves in to replace the fresh water that has been pumped from the aquifers (USGS, 1998). It is feared that some aquifers will be depleted or will be highly contaminated with saline water if not properly managed.

Figure 2. Surface water basins (USGS, 1998)

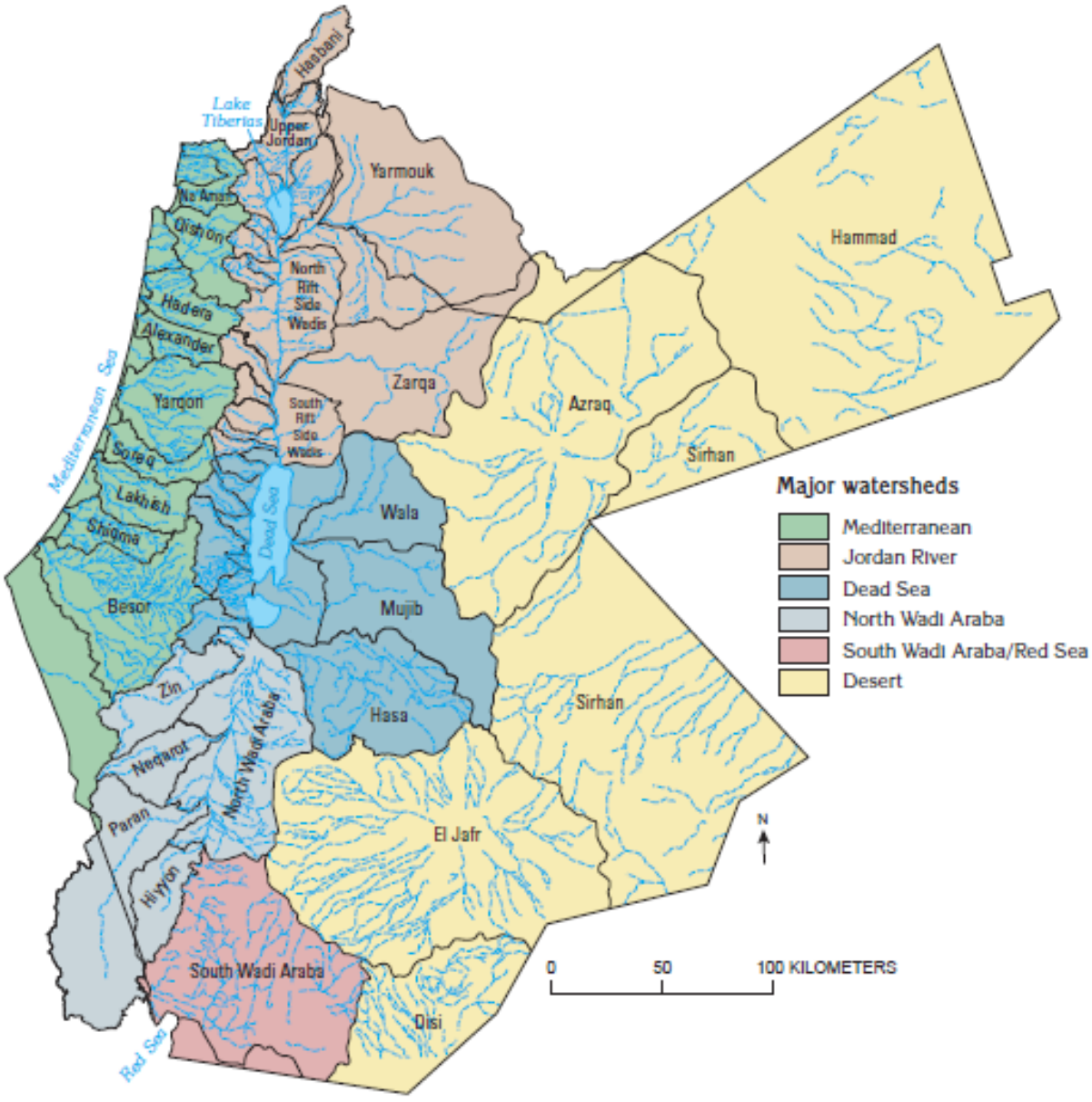


Figure 3. Groundwater basins (USGS, 1998)

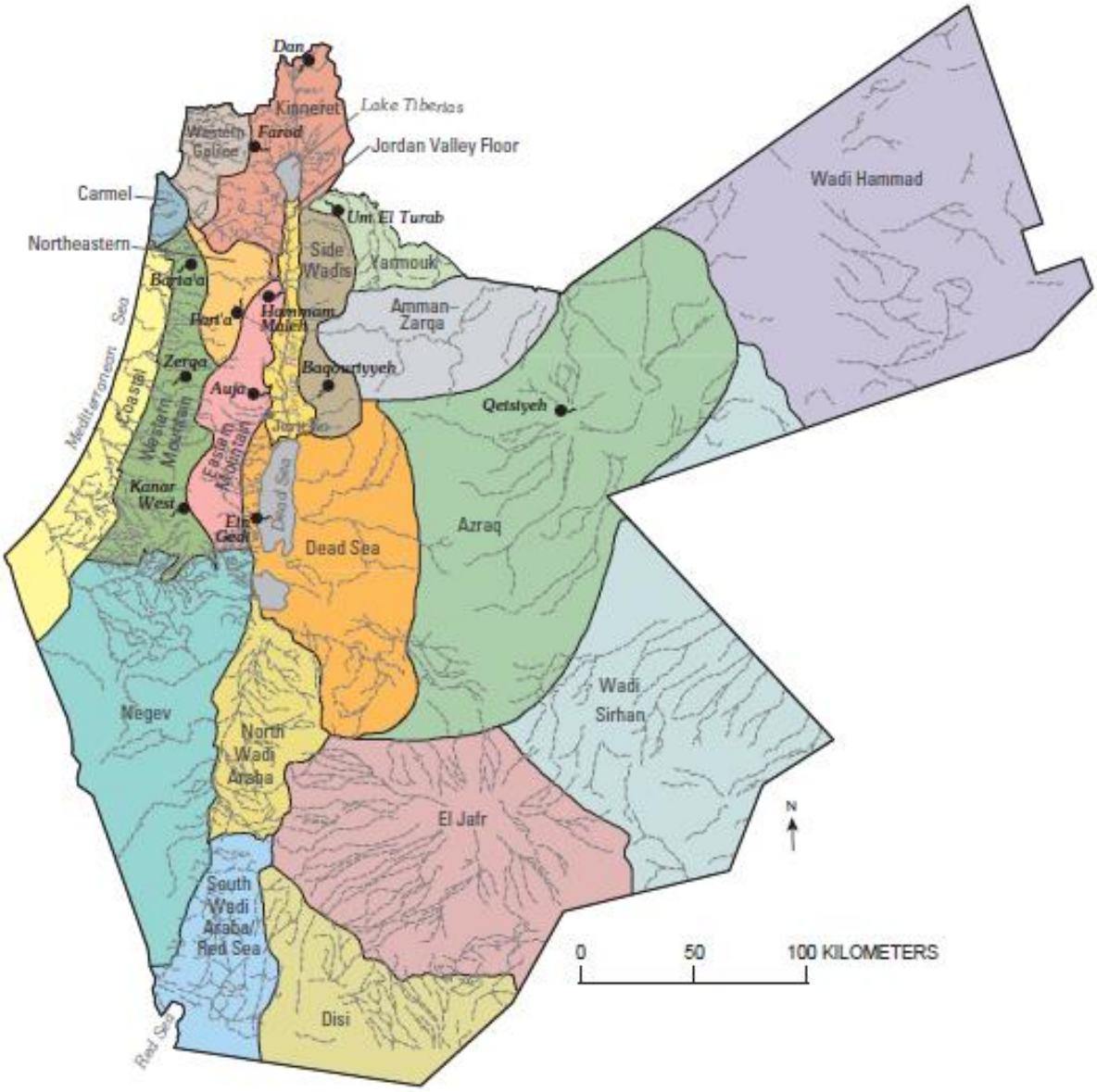


Table 2. Groundwater basins safe yield and balance (MWI, 2009)

Groundwater basin	Safe yield	Total extraction (MCM)	Balance (MCM/year)	% of safe yield abstracted
Yarmouk basin	40	55	-15	137
Side Wadis basin	15	12	3	80
Jordan Valley basin	21	38	-17	181
Amman Zarqa basin	87	138	-51	159
Dead Sea basin	57	85	-28	149
Northern Wadi Araba basin	4	4	0	100
Southern Wadi Araba basin	6	5	1	83
Al Jafer basin	9	23	-14	256
Azraq basin	24	56	-32	233
Al Sarhan basin	5	1.5	3.5	30
Al Hammad basin	8	1.3	6.7	16
Disi	Fossil	65		

Groundwater resources in Jordan are concentrated mainly in the Yarmouk, Azraq, Amman-Zarqa and Dead Sea basins (El Naqa et al., 2007). The most important non-renewable groundwater resources are the Disi and Jafr fossil aquifers. Disi aquifer was used to supply the city of Aqaba for domestic purposes until 2013, but now groundwater is transferred to Amman in order to supplement the capital's drinking and domestic water needs. As it appears from the previous table, the Amman-Zarqa basin and Azraq basin are the most over-abstracted aquifers in Jordan, with 176% and 215% of the safe yield abstracted respectively. As we will see later, these official figures likely underestimate actual overdraft.

The Amman-Zarqa Basin is one of the most important groundwater basins in Jordan. It covers a total area of 4,586 km^2, with 4,074 km^2 in Jordan and 512 km^2 in Syria. The average annual precipitation in the basin is around 600 mm in Jebel Arab, 400 mm in western Amman, and less than 100 mm towards the desert. The Amman-Zarqa basin has the highest groundwater recharge in Jordan (88 MCM/yr) (Al-Qaisi, 2010; Goode et al., 2013). Aquifer depth in the basin varies from 300 to 400 meters in the North Badia area, to 50 to 100 meters in the Dulayl and Hashmiya areas. The development of agriculture in the Jordanian highlands started in the early 1960s with groundwater from the Amman-Zarqa basin. In 1965 there were only about 25 wells, but by 1980 the number of wells had seriously increased and the Amman-Zarqa Basin had become a land of orchard gardens and vegetable farms (Chebaane et al., 2003). As irrigated agriculture expanded in the basin, so did municipal and industrial activities, resulting in significant water shortage and salinity increase, especially in shallow aquifer areas. Other impacts included the drying up of springs near Zarqa and the decline of water levels and water quality deterioration in parts of North Badia. Continued over-pumping will further deplete groundwater resources and represents a threat not only to domestic water supply in Zarqa and parts of Amman, but also to the socio-economic development and stability of the country.

2 The Azraq Basin

2.1 Geographical location

The Azraq Basin is located in the North-eastern part of the country with an area of 12,710 km^2 (Figure 4). The largest part of the catchment (94%) is in Jordan with smaller parts in Syria (5%) and Saudi Arabia (1%) (Shahbaz and Sunna, 2000; Al Raggad and Jasem, 2010; Addamat et al., 2006; Halah, 2007). 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 (Figure 4 and Table 3) (DoS, 2008). This report covers the area of Al Zarqa Governorate (Azraq area) and part of Al Mafraq governorate (North Badia).

Figure 4. Azraq basin location and governorate inside the basin

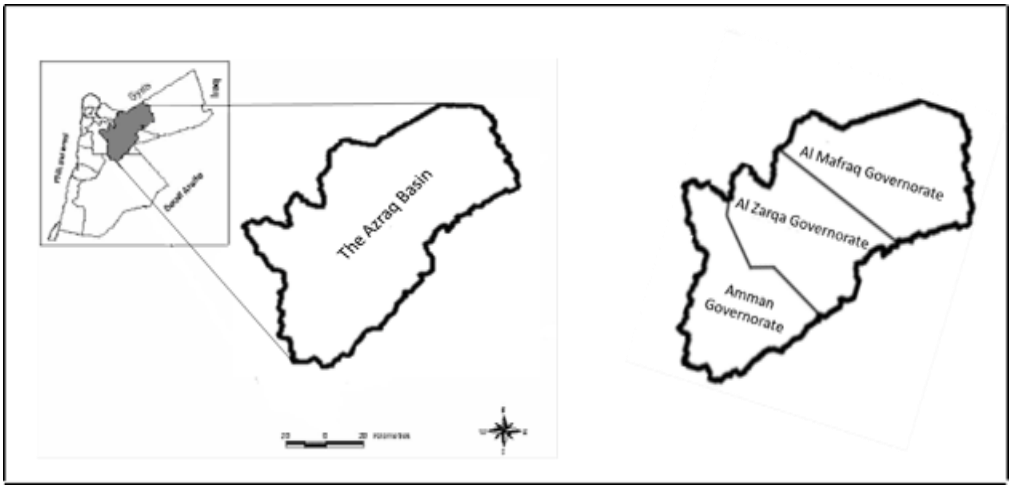


Table 3. Total population of the three governorates located in the basin (DoS, 2008)

Governorate: District	Total Population
Al Mafraq: North Badia*[1]	**84420**
Al Zarqa: Al Azraq	**12200**
Amman: Al Jiza*	**49050**

The Azraq area which is part of the Zarqa governorate includes eight districts: South Azraq; North Azraq; Omari; Ein Al Baida; Eastern Farms area; Um Al Mathayel; Degaileh; and the air force base (Figure 5). The total population of Azraq district is estimated at around 12,000 inhabitants (IUCN et al. 2007).

[1] * Only a portion of these districts located inside Azraq basin

Figure 5. Azraq district and roads

2.2 Basin physical properties

The Azraq basin is a semi desert area characterized by hot and dry summers and fairly wet and cold winters. The mean annual rainfall ranges from 50 mm/year in the Azraq Oasis area to 500 mm/year in Jabal Al Arab area (Hydrology of the Azraq Basin

The Azraq basin consists of three aquifer systems hydraulically connected in certain parts; upper, middle and deeper aquifer systems. The upper aquifer is exposed in the entire basin and consists of four major water-bearing formations: B4, B5, the Basalt (Ba) and the Quaternary formation. The basalt extends from the centre of the basin to the north and ends up in the highlands of Syria (Joudeh and Abu Taha, 1978). Groundwater flows from south Syria towards Jordan from high to lower elevations (1,200 m above sea level (ASL) to 500 m ASL) towards the Azraq depression (Figure 8). Topographically, the basin is concave with the Azraq oasis as a large fertile mudflat in the central and lowest part of the basin. The depth of groundwater in the upper aquifer varies from a few meters in the centre of the Azraq oasis to 400 m due to the topography in the northern catchment area. The middle aquifer system (B2/A7 formation overlain by B3 aquitard) is considered as a confined aquifer throughout the basin, and it is recharged mainly from the Jabal Al Arab (also known as Jabal Al Duruz) recharge area in the north of the basin (check 2.3.1). The deeper aquifer system has a formation between B2/A7 and Kurnub Sandstone aquifer, this aquifer (saline aquifer) has low yield and poor water quality (Figure 7).

Figure 6). The average precipitation for the entire basin is 87 mm/year, occurring between January and March. Annual rainfall patterns in the Jordanian part of the basin vary between 100-150 mm in the west and north of the basin, 50-100 mm in the centre, and less than 50 mm in the south and east of the basin (JMD, 2011). The mean daily temperature in winter is less than 10^{o}C and the maximum temperature is 45^{o}C. 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. Soils are primarily composed of limestone or covered by basalt boulders that resulted from volcanic out crossing centred on Jabal Al Arab (DLU, 1994).

2.3 Hydrology of the Azraq Basin

The Azraq basin consists of three aquifer systems hydraulically connected in certain parts; upper, middle and deeper aquifer systems. The upper aquifer is exposed in the entire basin and consists of four major water-bearing formations: B4, B5, the Basalt (Ba) and the Quaternary formation. The basalt extends from the centre of the basin to the north and ends up in the highlands of Syria (Joudeh and Abu Taha, 1978). Groundwater flows from south Syria towards Jordan from high to lower elevations (1,200 m above sea level (ASL) to 500 m ASL) towards the Azraq depression (Figure 8). Topographically, the basin is concave with the Azraq oasis as a large fertile mudflat in the central and lowest part of the basin. The depth of groundwater in the upper aquifer varies from a few meters in the centre of the Azraq oasis to 400 m due to the topography in the northern catchment area. The middle aquifer system (B2/A7 formation overlain by B3 aquitard) is considered as a confined aquifer throughout the basin, and it is recharged mainly from the Jabal Al Arab (also known as Jabal Al Duruz) recharge area in the north of the basin (check 2.3.1). The deeper aquifer system has a formation between B2/A7 and Kurnub Sandstone aquifer, this aquifer (saline aquifer) has low yield and poor water quality (Figure 7).

Figure 6. Mean annual temperature in C (left) and annual precipitation in mm (right) in Azraq basin (Al Naber, 2012)

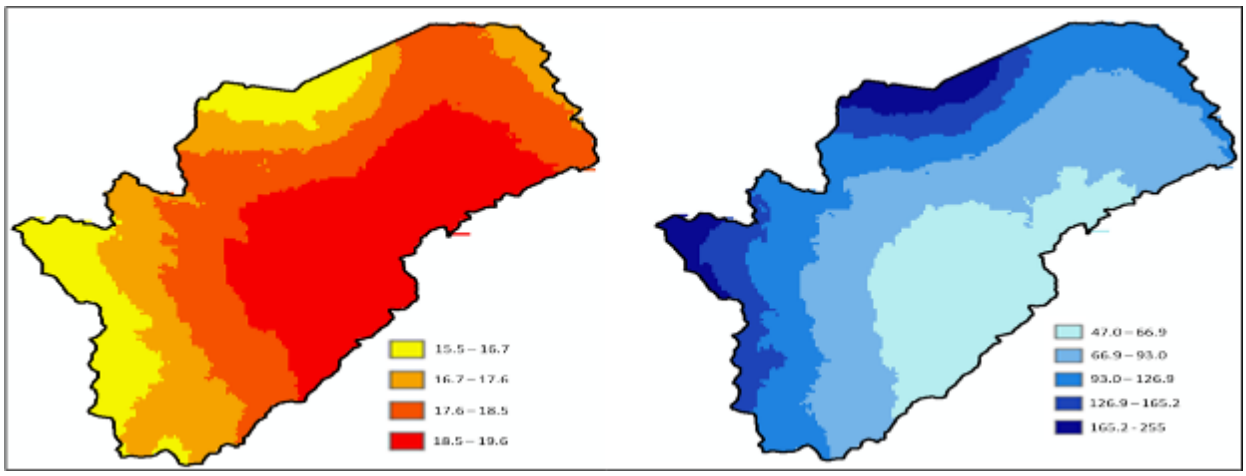
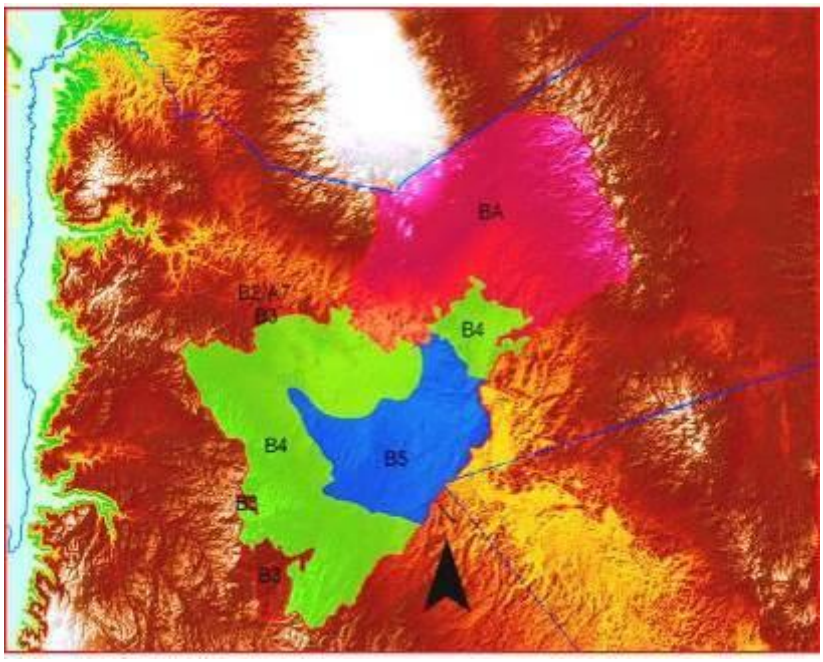


Figure 7. Azraq basin hydrogeology (Sahawneh, 1996)



2.4 Recharge and safe yield

The Azraq basin's safe yield has been established at 20 MCM in 1987 and later modified to 24 MCM per year (GIZ, 2010; Jones, 1990; Al Raggad and Jassem, 2010; MWI, 2009). The main recharge of the upper aquifer system originates from infiltration through the basalt layers from high rainfall areas at 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 MCM/year (Bajjali, 1990; MWI, 2013).[2] The age of groundwater ranges between 4,000 and 20,000 years (BGR and WAJ, 1994). Groundwater flow moves from the north east and south west of the basin to the Qa'a area in its centre (Figure 8). When rainfall occurs, water flows from Azraq wadis to reach the Qa'a, accumulating there and recharging the aquifer while decreasing salinity levels in the aquifer (Figure 9).

[2] This consists of 20 MCM/yr recharge from Jabal Al Arab + groundwater sub flow of 10 MCM/yr + recharge from eastern-western south wadis of 4 MCM/yr (Bajjali, 1990; MWI, 2013).

Figure 8. Azraq basin elevation and streams flow (Al Naber, 2012)

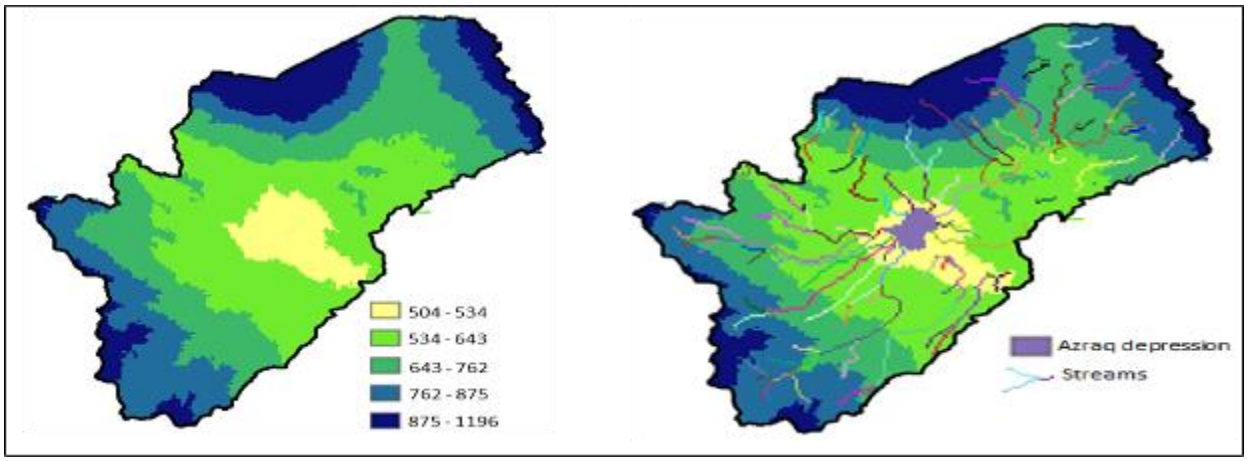
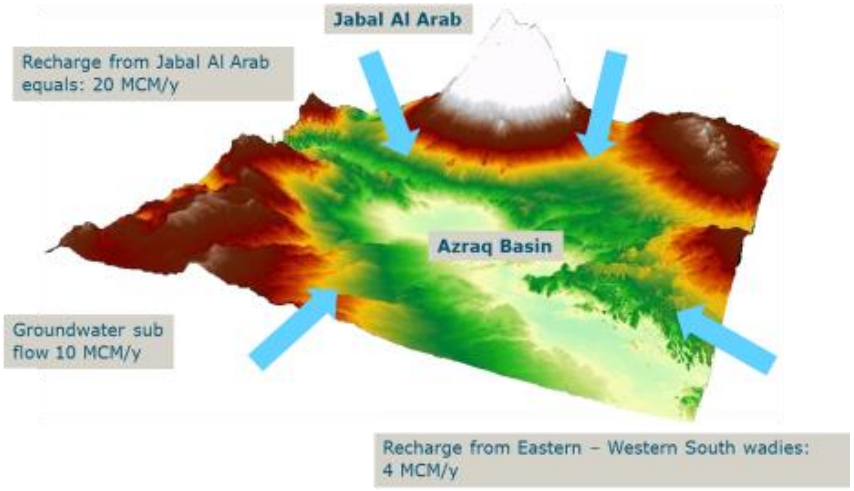


Figure 9. Azraq basin recharge scheme (Al Raggad, 2015).



2.5 Azraq basin communities

Three main communities are found in the Azraq basin: Bedouins, Chechens and Druze. The major Bedouin tribes living in Azraq are the Bani Sakher, Al Sarhan and Rtemeh from the Abad tribe, and the Al Massaid (located in Mafraq). Even though Bedouins were mostly pastoralists, some of them started farming when agriculture boomed in the basin. Others preferred to work as land brokers. The Chechen were re-settled by the Ottomans in 1902 as they were fleeing from the Russian army, while the Druze came in 1920 from Jabal Al Arab, after confrontation with the French (GIZ, 2010; IUCN, 2007). Chechen and Druze settled in the city centre. The Chechen stayed in the south of the city, known as Azraq Al Chechen, while the Druze stayed in the north of Azraq city (Azraq Al Druze). Chechens were normally farmers, preferring to live near water points, but agriculture was not productive since their lands were located near the Qa'a, an area where water is more saline. The Druze worked in salt production then switched to agriculture after the Azraq salt industry closed (see Section 2.7) (Interview 1., 15 august 2013; Interview 2., 6 June 2013).

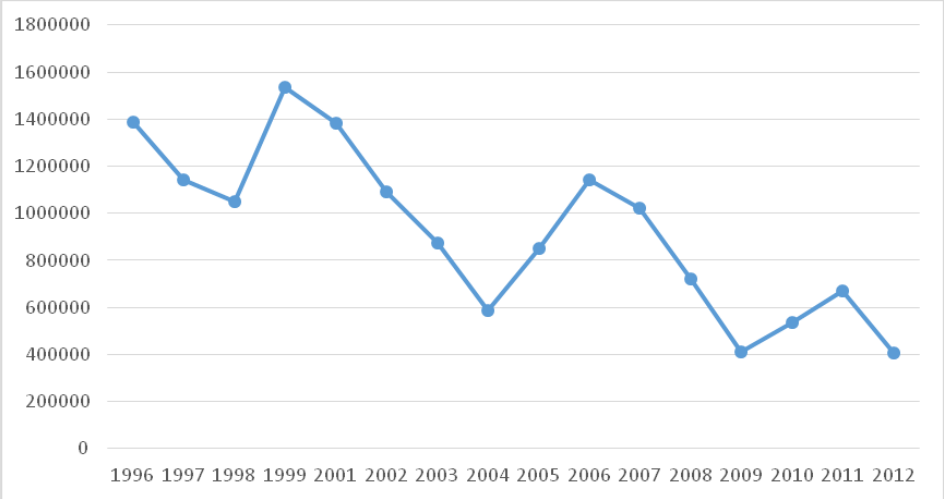
2.6 The Azraq Oasis: between past and present

The Azraq Oasis (or Azraq wetland) is located in the central part of the Azraq basin with a naturally flooded area of 12 km^2. In 1977, the Azraq Wetland and the mudflat (Qa'a) were declared an international Ramsar site. Until the mid-1990s, the Azraq Oasis was ranked as an outstanding example of a wetland in the desert (Al-Eisawi, 2012). It was also an important reserve for migratory birds, with up to one million birds migrating to the oasis in spring season, and a breeding site for about 70 bird species. The oasis hosts a rich flora, fauna, aquatic and terrestrial species, including the special Azraq *sirhani* fish, which only exists in Azraq (Halah, 2007; IUCN, 2007). This diversity attracted a multiplicity of organisms that are extremely tolerant to desert conditions, forming one of the most unusual ecosystems in the world (Scates, 1966; Jones, 2010).

The oasis was formed from the discharge of four main springs in Azraq, until 1992 when they dried out due to extensive pumping and use from different users (agriculture and drinking water supply to Amman). Two springs were found in Azraq South (Al Soda and Al Qaisia), and the other two were discharging from Azraq North (Aura and Mostademeh) (Daoud et al., 2006). The North Azraq springs used to recharge the wetland until 1987, while the South springs flowed until early 1992 (GIZ, 2010; IUCN 2007; Daoud et al., 2006; RSCN, 2013). In 1980, discharged water from springs into the wetland was estimated at 10.49 MCM, decreasing dramatically in 1991 to 300-400,000 m^3, before stopping completely in 1992. The drying up of springs caused a deterioration of the wetland and the decrease of the flooded area, leading to an environmental catastrophe for the wetland ecosystem and a reduction of the site's touristic potential were visitors used to come to observe the bird migration season and enjoy the wetland as a unique RAMSAR site.

The director of the Azraq wetland highlighted that in 1994 the Jordanian government through the RSCN (Royal Society for the Conservation of Nature) and with international support from the United Nations Development Programme (UNDP), initiated a project to rehabilitate the oasis by artificially pumping 1.5-2.5 MCM/yr of groundwater into the wetland. The project lasted for four years and the RSCN succeeded to recover 10% of the oasis' original size (Interview 3., 30 Jan. 2013). Until today the oasis continues to be artificially replenished with groundwater from public wells (500,000 m^3/yr) (Figure 10) (Hresha, 2013). As a result of these actions, Al Sarhani fish species still exist in the oasis. Birds continue to migrate to the oasis but in smaller numbers. The Azraq wetland reserve has an important social and economic role for the local community, as it provides a permanent source of income for 40 locals employed by the park.

Figure 10. Artificial filling of the wetland in MCM/yr (RSCN, 2013)



2.7 The Azraq salt Industry

The Azraq salt industry was established in 1986 and was one of the most lucrative economic activities in the basin (KREBS SWISS, 1996; Interview 1., 15 Aug. 2013). The factory was mainly managed by the Druze through the Azraq cooperative Society, formed to control the production and distribution of salt inside and outside the country (Ronay, 1993; Ramsar, 1990; KREBS SWISS, 1996; Interview 1., 15 Aug. 2013). 97% of the cooperative members were Druze while only 3% were from the Chechens (Ronay, 1993). It was known that only the cooperative members and their sons could work on salt production in Azraq (Ronay, 1993; Interview 1., 15 Aug. 2013). The presence of the factory in the basin helped the local families directly by providing job opportunities (mainly for Druze members) and indirectly by decreasing the salinity ratio in the aquifer by 20% (Interview 1., 15 Aug. 2013 and Interview 18., 4 June, 2013).

Saline water was pumped to the surface between June and August through small electric pumps. It was then left in a pond for 24 hrs. Allowing silt to settle down, the salted water was then piped to large shallow beds (8*50*1m) directly exposed to the sunlight (Ronay, 1993; Ramsar, 1990). Water evaporated, and residual dry crystallized salt was scooped up and trucked to the salt factory for processing (Ronay, 1993; Ramsar, 1990). Afterward it was distributed throughout Jordan and exported to Gulf countries under the name of "Azraq Salt". The average total annual salt production was 40,000 ton/year (Interview 1., 15 Aug. 2013). The Azraq refinery contributed to achieving Jordan's self-sufficiency in salt and to a small export market to Iraq (Ramsar, 1990).

In 1996 a new salt industry was established in Jordan: the "Safi Salt Company", producing salt from the Dead Sea. The new industry was built with a budget of 17 million euro and produces about 1.2 million tons of industrial salt per year compared to 40,000 ton/year in Azraq. The presence of a new competitor in the salt production business affected Azraq's salt industry negatively, as production costs of "Safi Salt" were lower than "Azraq Salt" (since water in Azraq is pumped through wells, which incurs additional energy costs). Also, the quality of Safi salt is better than Azraq salt due to the high sulphate concentration in Azraq salt. Consequently the market for Azraq salt decreased and the factory closed up in 2006 (Ronay, 1993; Ramsar, 1990; KREBS SWISS, 1996; Interview 1., 15 Aug. 2013). Figure 11 shows people working in salt production in Azraq.

Figure 11. Azraq salt production (Azraq wetland reserve, 2015)

3 Azraq and its water

3.1 The water situation: quantity and quality

Groundwater in Azraq has been used since the early 1960s by several sectors for different purposes: domestic, industrial, agriculture and environmental use. Groundwater in the Azraq basin is a major source for drinking water for the cities of Amman, Irbid and Zarqa as well as 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). Irrigated agriculture is the major consumer of water in the basin with an estimated abstraction volume of 28 MCM of water per year, nearly the equivalent of the basin's safe yield (24 MCM per year) (MWI, 2009) (Table 4).

Table 4. Groundwater usage in Azraq basin from the registered legal and illegal wells in 2009 (MWI, 2009)

	Abstraction rate MCM (2009)	*Safe yield MCM*	*Abstraction rate %*
Private drinking wells	0.32		
Governmental drinking wells	22.9		
Industrial purpose	0.35		
Agricultural purpose	28		
Rural area	0.09		
Total	51.66	24	215%

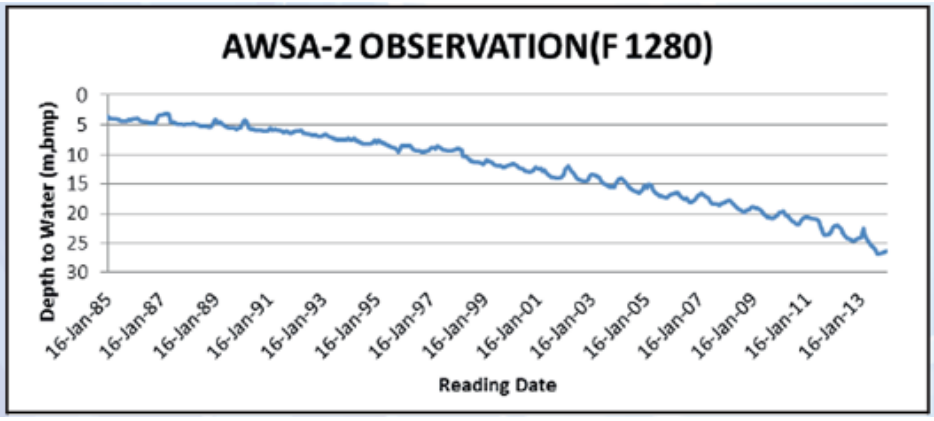
Modern groundwater-fed agriculture was developed in the 1970s with the introduction of the diesel engine (IUCN, 2007; Venot and Molle, 2007) and the availability of modern irrigation techniques such as drip and sprinkler irrigation systems (Al-Jaloudy, 2001; MWI, 2015). Before that, users depended on traditional surface irrigation techniques and traditional shallow wells with low

abstraction rates for subsistence agriculture. Modern irrigation techniques first spread in the Jordan Valley when agriculture was still incipient in the highlands (especially Azraq). When modern irrigation techniques extended to the highlands, well-drilling techniques had also improved and energy costs had been lowered, while land was cheap and easy to access (see section 4.1) and water quality was still good (Halah, 2007; IUCN, 2007; USAID, 2014). All these factors helped make agriculture the first investment option in Azraq. Such expansion was also fuelled by the government who freely awarded licenses for wells in the 1980s and early 1990s (MWI, 1998), causing agriculture to dramatically expand in the highlands.

Even though investors and farmers enjoyed the economic revenue from these activities, in the early 1990s the government, sensing the increase in groundwater use, tried to control abstraction by introducing well metering in most wells in the highlands. This measure was aiming at monitoring water abstraction and reducing over-pumping. However, abstraction limits have not been respected and the number of illegal wells increased due to a weak monitoring system of actual use on the ground. The mismanagement of groundwater use by both the government, through its lack of control, and private users caused a large deterioration of water quality and quantity. The lowering of the water table in the basin encouraged deeper well drilling, contributing even further to the degradation and over-abstraction of the resource, while increasing salinity and degradation of water quality. This caused an environmental catastrophe in the wetland's ecosystem, with farmers abandoning unproductive lands, increasing in the salt content of the aquifer, and reduced tourism potential.

In order to monitor groundwater table and water quality following extensive groundwater use, the Water Authority of Jordan (WAJ) dug sixteen monitoring wells in a preserved area in Azraq (AWSA field). As the number of functioning deep wells has been increasing, the abstracted amount has also been increasing, causing a decrease in water table levels by about 25 meters during the last 28 years (Figure 12). Fluctuations that can be observed in the groundwater table are due to recharge events caused by rainfall but these are not enough to cover the gap between discharge and recharge.

Figure 12. Fluctuation in groundwater level (MWI, 2013)



3.2 Agriculture in Azraq

In the 1970s agriculture was concentrated around Azraq city (Azraq north and south). In the beginning of 1990s it expanded to eastern Azraq (farm area) and Mafraq. The farms east of Azraq

are traditionally considered by Bedouins as their tribal land (section 4.1), and some of them found in agriculture a good investment (Interview 5., 24 Apr. 2014; Interview 4.,9 March 2015; Interview 8., 23 May, 2013). Others sold their land to investors who came from Amman, the Gulf, Iraq and Palestine.

One of the drivers of the expansion of land cultivation in Azraq is land control and speculation. Farmers willing to own land would cultivate it illegally (without a property deed) and would later claim ownership with the administration. This caused an increase in the number of illegal wells since the WAJ cannot issue well licences without having a legal land property deed. This category of potential land owner tends to cultivate olive trees, as they need less labour and capital for their cultivation during the required period of time (at least ten years) before they can possibly claim to own the land.

The expansion of agricultural land continued in the 1990s with the introduction of new cropping patterns in Azraq, e.g. grapes, and pomegranates later in the early 2000s, diversifying away from olive trees. More recently, farmers have attempted to cultivate alfalfa due to its high yield and high revenue, despite its high water consumption. It was found during fieldwork between 2013 and 2014 that alfalfa cultivation in Azraq area is mainly dependent on illegal wells, or on wells without meter, so that farmers can avoid paying water consumption fees.

The increasing trend in groundwater abstraction was reduced during the mid-2000s due to the decline in water table levels, the decrease in well productivity, and an increase in water salinity. Accordingly, a number of farms were abandoned, especially in south Azraq area which is underlain by a saline aquifer. Nevertheless, agricultural expansion continued in Azraq north and eastern farm area with the introduction of new crops such as alfalfa. According to the Ministry of Agriculture, cultivated land surface increased between 2005 and 2011 from 61,195 dunum to 114,325 dunum (MoA, 2012) (Figure 15 and Figure 16).

Agriculture in Mafraq is located under north Badia area were cultivation is mainly concentrated in stone fruit tree and vegetables. According to an NDVI "Normalized Difference Vegetation Index" analysis in the basin, these activities occur mainly in the northeast of the city (Al Naber, 2012) (Figure 13 and Figure 14).

Figure 13. NDVI map for Azraq basin and reflection on agriculture land (Al Naber, 2012)

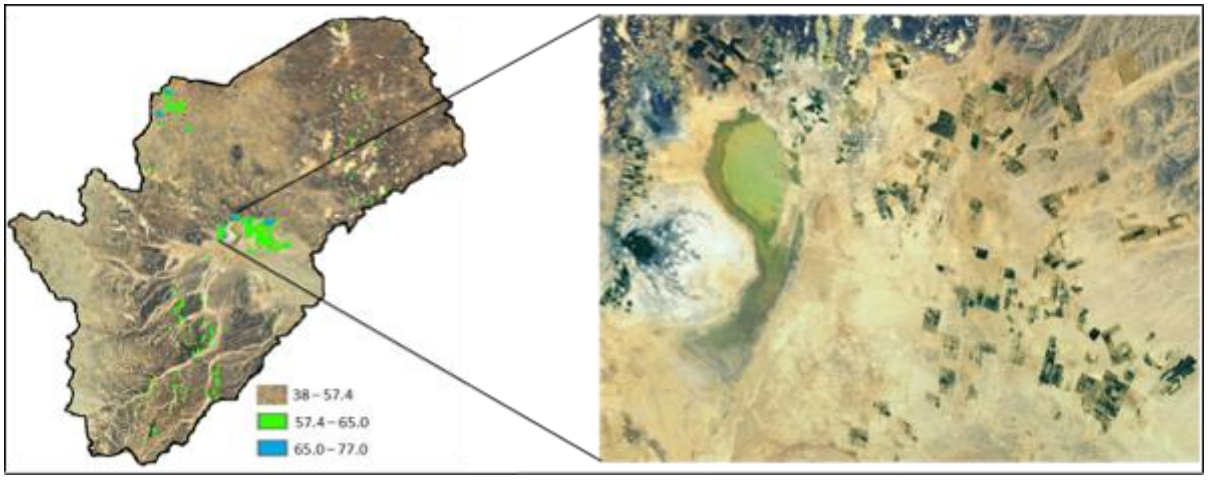


Figure 14. Agriculture activity in Mafraq/ Azraq basin

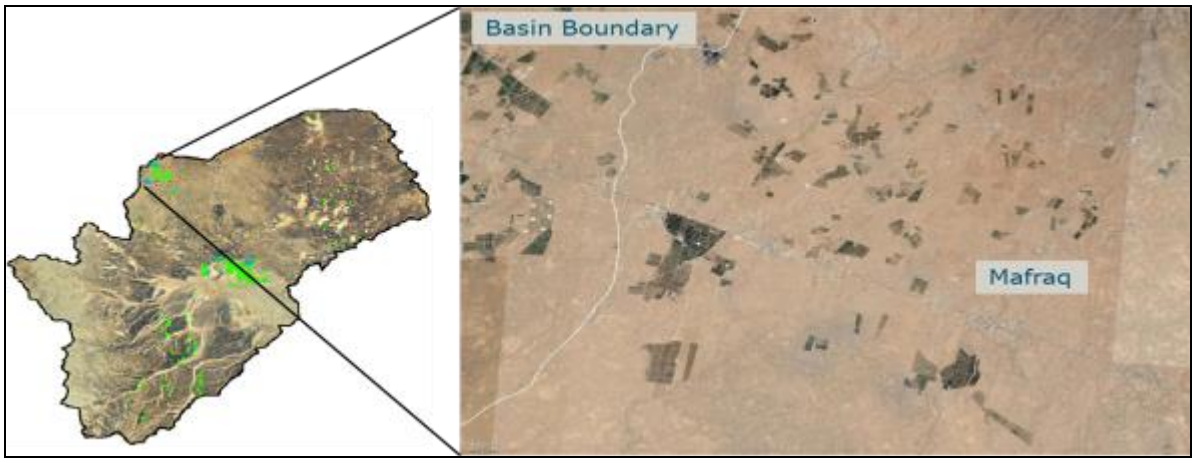


Figure 15. Cultivated area in Azraq (2005-2011) (MoA, 2012)

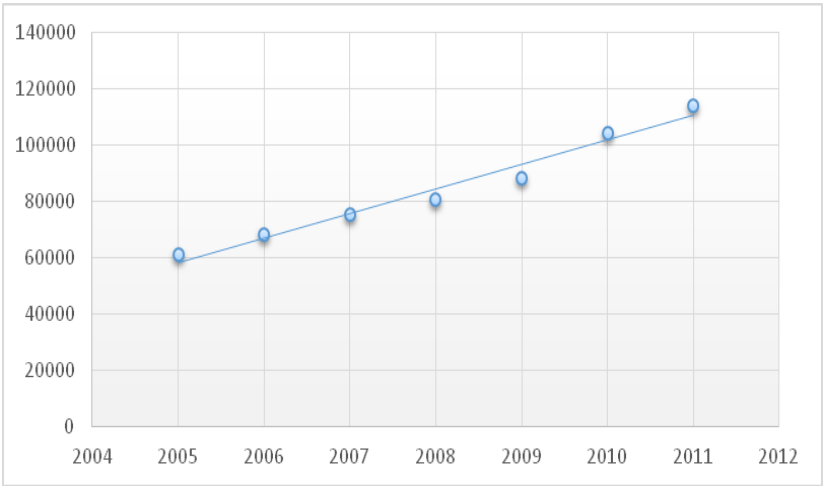
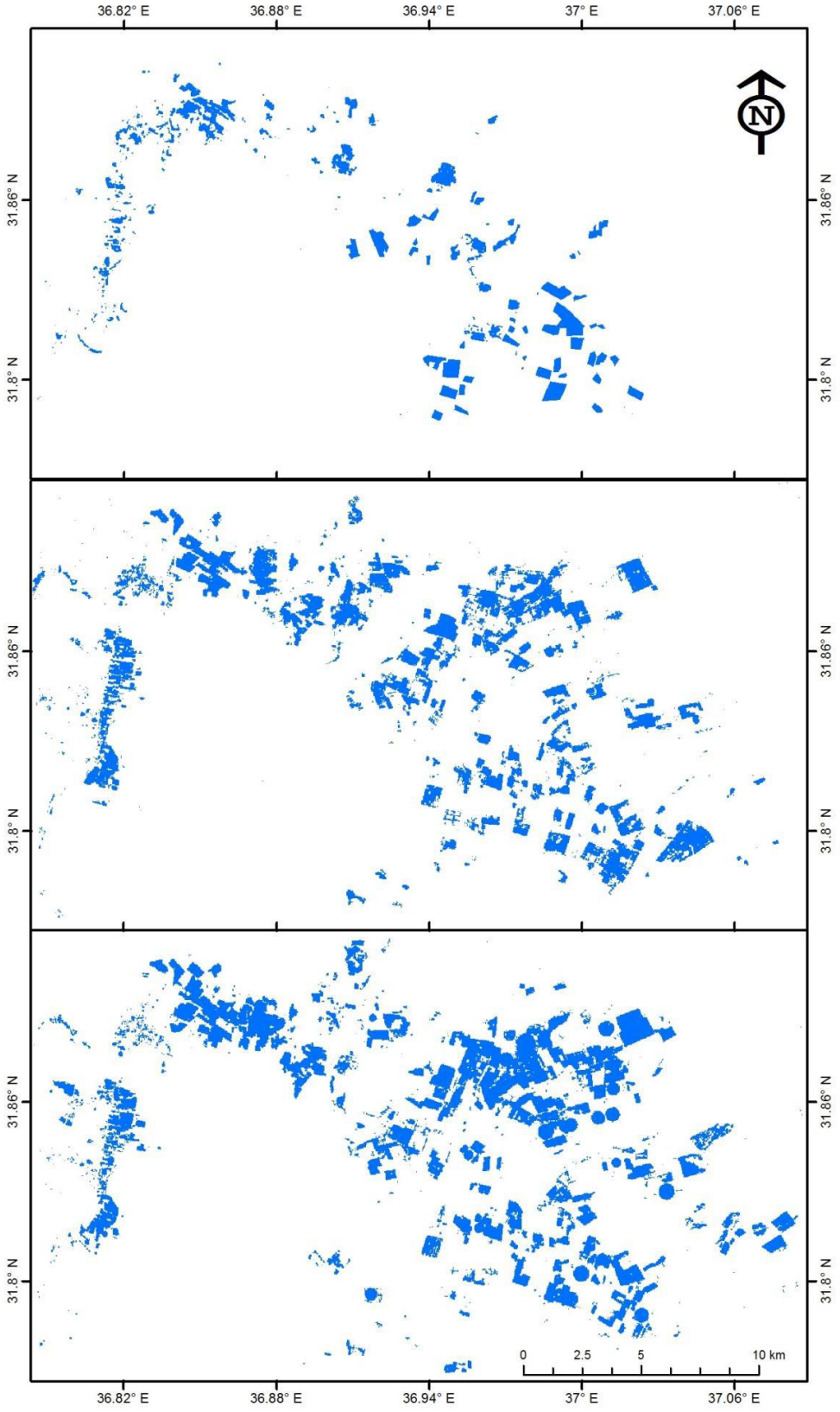


Figure 16. Expansion in agriculture area in Azraq in 1990, 2002 and 2014 (Al Bakri, 2015)



3.3 Agricultural well types and characterization

When agriculture first started in Azraq well licenses did not exist. With the introduction of groundwater laws and water prices, farmers were forced to obtain licenses for their wells. Wells in Azraq are divided into three types depending on their legal status; 1) legal well (well drilled with a *licence* from the WAJ); 2) registered illegal well (well with a *permit* registered in the WAJ database) and; 3) not registered illegal well (well drilled illegally and not declared by the owner, which is either known to the WAJ or not) (Table 5).

Table 5. Well typology

<table>
<tr><th>Type of well</th><th colspan="3">Type of license</th></tr>
<tr><td>Legal well</td><td colspan="3">With license (roukhsa) from WAJ (land registered)</td></tr>
<tr><td rowspan="3">Illegal well</td><td rowspan="2">Registered well</td><td colspan="2">Registered well with ijaza, permit from WAJ (land not registered yet)</td></tr>
<tr><td colspan="2">Registered well with kushan (land registered)</td></tr>
<tr><td rowspan="2">Non-registered well</td><td>known by the Ministry</td><td>Subject to water bill</td></tr>
<tr><td>Not known by the Ministry</td><td></td></tr>
</table>

Illegal registered wells are in general drilled on land without an official title deed. Each well status has its own water tariff and abstraction quota (see Section 3.4). Some farmers obtained licenses easily, as they own the land officially. However, as mentioned earlier, one of the main drivers for the spread of agriculture in Azraq is land speculation as settlers cultivate land in order to access to its ownership. Well owners without an official land deed cannot get a license. A well drilled on 'illegal land' (land occupied without title deed) may have been given a *permit* (*ijaza*) instead of a *license* (*roukhsa*), until the land issue is solved.

Well drilling is normally done by licensed drillers with rotary-drilling machines that are registered in the database of the WAJ. The depth and well location is approved by the WAJ and written in the well license. Almost all functioning wells in the basin are drilled wells, while in the past they were dug wells. Wells have a depth between 30 m and 350 m, depending on the area and the water table. The installation of casing and a screen is needed in order to prevent the inflow of sediment and the collapse of the well. Pumps are installed with different capacity according to the needed discharge. The average total cost for drilling a licensed well by a licensed driller amounts to 60,000 JD for an average depth of 55 m. There are also unlicensed drillers working in the basin, and drilling unlicensed wells costs twice as much as a licensed well (to account for the risk and the illegality).

Given the fact that groundwater is the only source of water in Azraq, the number of wells has increased over the years following the expansion of land cultivation and agricultural activities. Official abstraction rates are calculated based on meter readings of legal and illegal registered wells, and estimated based on the cultivated area and cropping patterns in un-metered wells. In the

1970s there were only 54 private irrigation wells abstracting no more than 2 MCM/yr. By 1984 the number of wells had increased to 254 dug (shallow) wells and 73 boreholes wells, abstracting in total around 8 MCM/yr (GIZ, 2010). Nowadays, all shallow wells have been closed or turned into boreholes wells. According to official statistics, the number of wells reached 1,316 in 2009 and abstraction volumes reached around 51 MCM, 28 MCM of which for agriculture (Table 6 and Figure 17). Several recent surveys conducted in the Azraq basin have found that actual groundwater use for agriculture in the basin exceeds three times the official recorded data (Al Bakri, 2015; USAID, 2014).

Illegal wells affect the basin negatively, as it has been established that users abstract via illegal wells almost one and a half times more than what legal wells are licensed for (Figure 17). Abstraction from legal wells seemingly decreased after 2005 (Figure 17) possibility due to the new water tariff and the enforcement of bill payments which had been neglected before 2004. Accordingly, farmers have tended to increase groundwater abstraction via illegal wells to avoid paying the water price.

Table 6. Number of wells in the basin (MWI, 2011)

	Years			
	2009 (Azraq)	2009 (North Badia)	Total 2009	2010
Type of well	**Total number of wells**			
Legal agricultural well	304	350	654	318
Illegal agriculture well	561	6	567	548
Private governmental well	13	11	24	14
Governmental well for drinking water	20	1	21	20
Wells for herds in remote areas	11	13	24	11
Wells for factories, universities, productive wells	0	26	26	26
Total	909	407	1316	937

Figure 17. Abstraction from agriculture wells in m3/yr (MWI, 2010)

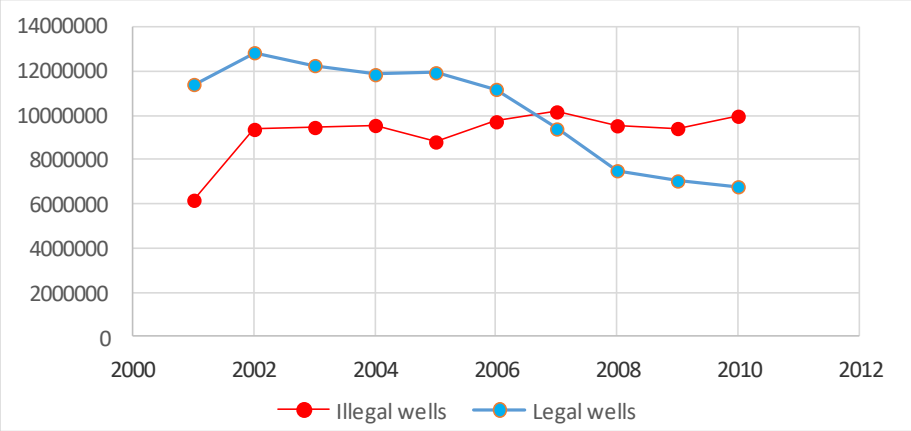
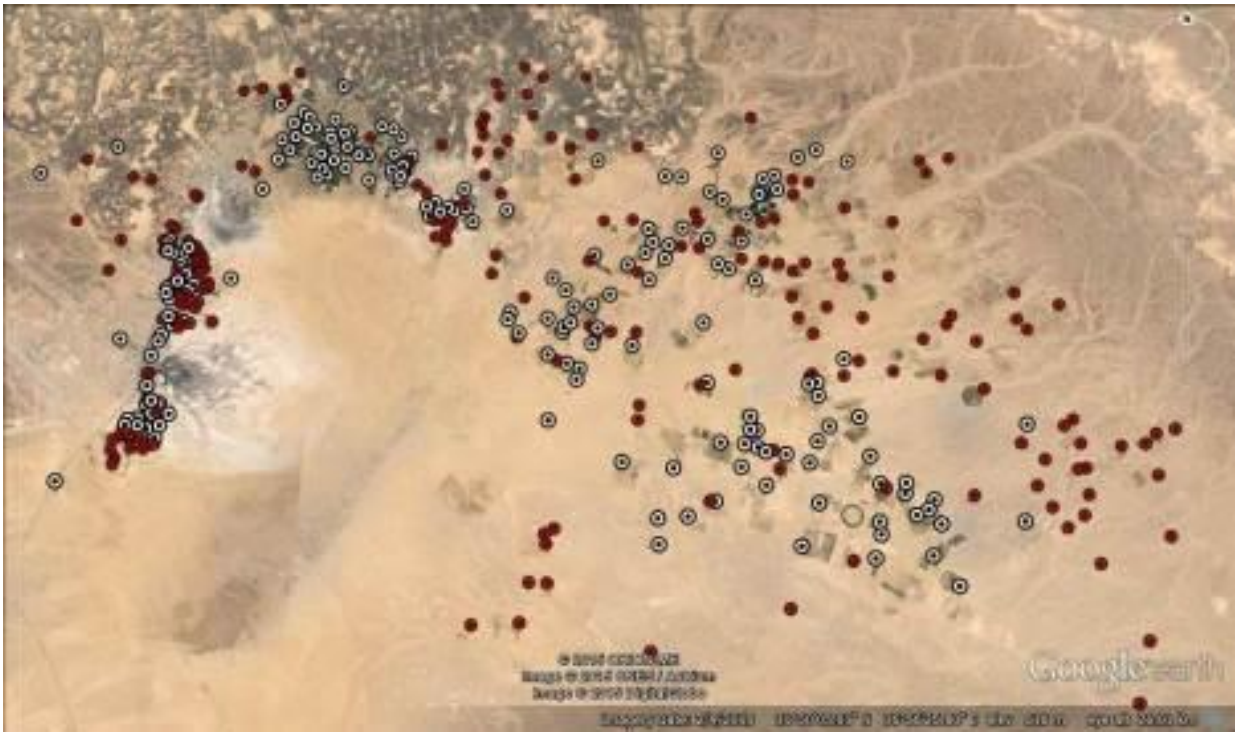


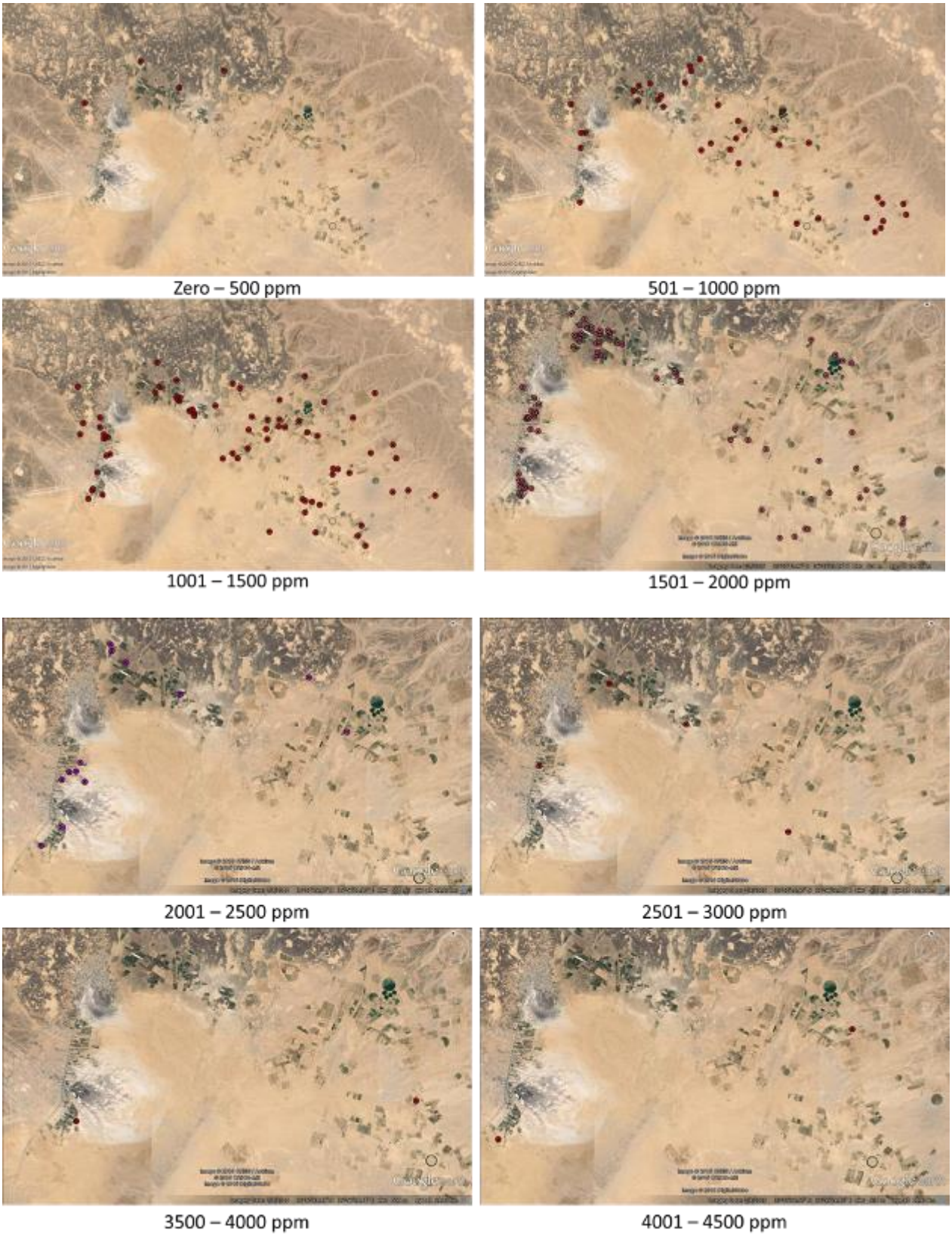
Figure 18 shows the location of both legal and illegal wells.[3] As it appears, some illegal wells are spread along the basin boundaries, in remote farms in the east but also in the basaltic area to the north. It is also possible to observe a higher concentration of illegal wells near the city of Azraq. It would also appear that Azraq South has a lower concentration of illegal wells, due to the deterioration in water quality in that area, which make the area less favorable for cultivation either legally or illegally. 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 a sample of 225 wells) range of salinity is 500–2500 ppm, with a few cases were salinity concentrations are above 4,000 ppm (found in Azraq south area due to high water salinity in the aquifer and the Qa'a) (Figure 19).

Figure 18. Legal (white dots) and illegal (red dots) wells in the basin



[3] According to WAJ database.

Figure 19. Salinity in the Basin (WAJ, 2010)



3.4 Springs in Azraq, location, and discharge

As mentioned in Section 2.5.1, the Azraq basin is recharged from the streams coming mainly from Jabal Al Arab in Syria. Historically there were four main springs in Azraq, two located in Azraq South (Al Soda spring and Al Qaisia spring), and the other two located in Azraq North (Al Aura spring and Al Mostademeh spring) (Figure 21). These springs were the major water source for the wetland (Daoud et al., 2006; IUCN, 2007; Nelson 1973; UNDP, 1966; Haleh, 2007).Springs discharge was studied by several international initiatives since late 1950s, indicating that Azraq is a suitable area for agriculture due to spring and groundwater availability (Baker, 1956; UNDP, 1966). The diversion of spring water from Azraq for urban purposes began in 1963, when the government decided to transfer water to Irbid (UNDP, 1966; Nelson, 1973). A system of pumping stations and a pipeline were built in order to carry water more than 125 km to the northwest of Azraq. Later, in 1980, the government also began to convey water to Amman from Azraq (through direct spring intake) at an average rate of 900 m3/h, which amounts to around 75% of the total spring discharge. A year later, in 1981, the Water Authority of Jordan drilled fifteen artesian wells northwest of the Northern Azraq springs, replacing direct spring intake with well abstraction, directly and dramatically affecting spring discharge (IUCN, 2007). Later in 1987, only the springs of South Azraq were still flowing, while those in North Azraq had dried up as a result of the lowering of the water table (Table 7 and Figure 20) (RSCN, 1990).

Table 7. Estimated withdrawals from groundwater wells with spring discharge (RSCN, 1990)

Year	*Withdrawal from government wells*	*Estimated withdrawal from private wells*	*Spring discharge*
1981	-	1.50	10.49
1982	9.50	1.50	8.35
1983	12.31	1.50	6.60
1984	14.36	2.00	6.04
1985	15.64	3.50	5.27
1986	13.72	4.50	3.57
1987	14.00	8.00	4.11
1988	19.64	12.00	2.15 [4]
1989	16.92	12.00	1.96 [5]

3.5 Dams and wadis

Despite Azraq's climatic conditions, characterized by hot summers and cold winters with low rainfall frequency, precipitation events can be of high intensity causing floods from wadis to the Qa'a area, where water accumulates. As mentioned before, the Qa'a area has a highly saline soil and is located above a saline aquifer. Water harvesting is one of the options that the Ministry of Agriculture in cooperation with the WAJ has introduced in order to collect flood water and prevent surface water recharge coming from wadis to reach the Qa'a and mix with the saline water. Since three dams and several infiltration systems were built in different location in Azraq, the amount of water reaching

[4] Only Azraq South springs were flowing.

[5] Only Azraq South springs were flowing.

the Qa'a has decreased accordingly, but has also had a negative effect on the wetland itself, since flood water was also recharging the wetland (Figure 21).

Figure 20. Estimated withdrawals from groundwater wells with springs discharge (RSCN, 1990)

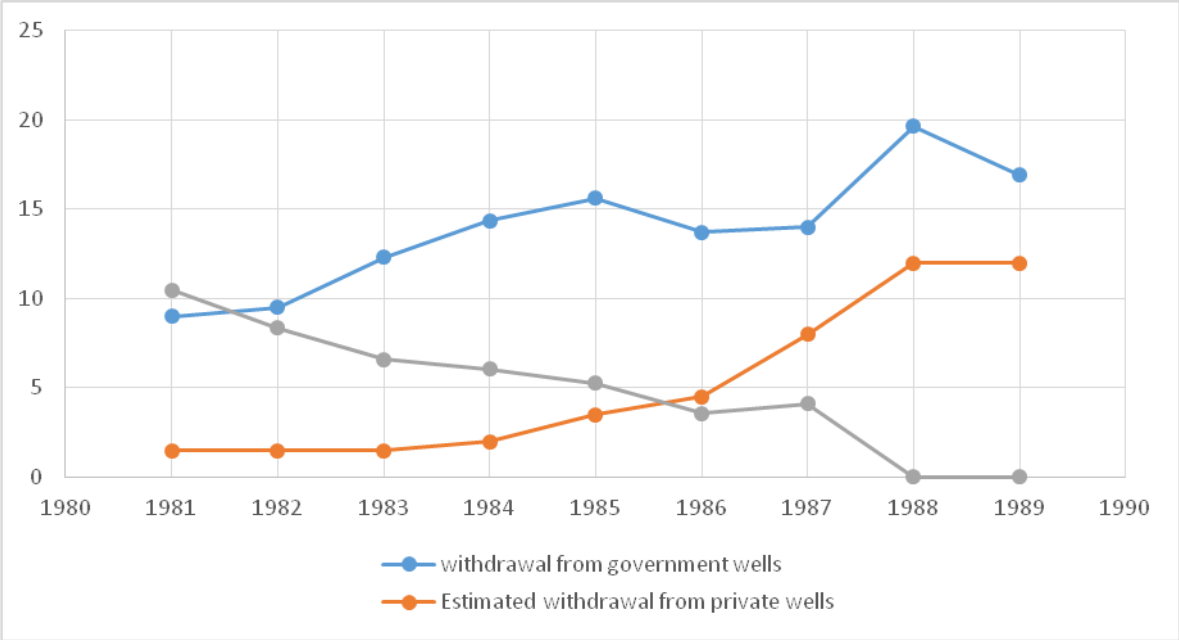
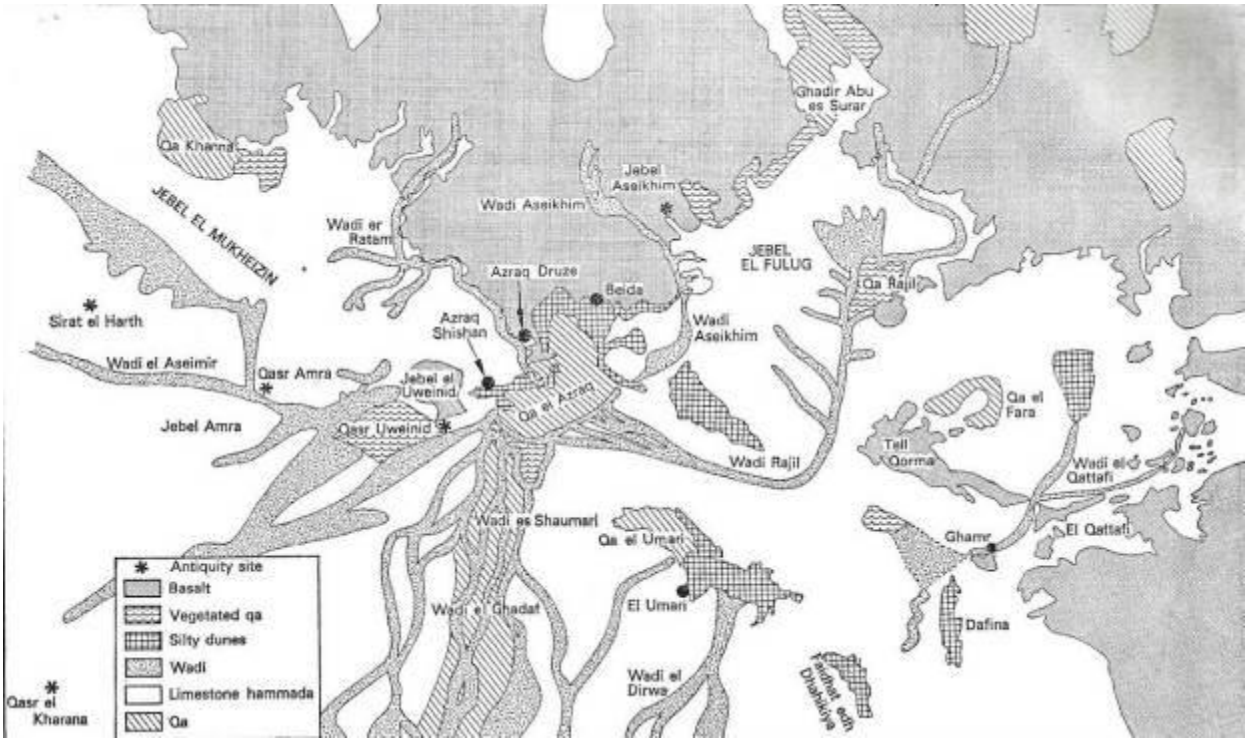


Figure 21. Wadis and springs in Azraq (Nelson, 1973).



4 Agriculture in the Azraq basin[6]

4.1 Land ownership and access

Three main types of land ownership are to be found in Azraq: 1) state land; 2) lands owned by the state (*miri*); and 3) *milk* land (i.e. land that has a private owner). State lands are officially under the custody of the state but are traditionally known to be 'owned' and claimed by tribes, but without a legal deed from the Department of Land and Survey (DLS). Tribes and settlers used to live, and some still live, in that type of land when Jordan was known as Transjordan. There are three main mechanisms to transform public land into private land*: taswiye, tafweed* and land dedication.

4.1.1 Taswiye

The land settlement procedure largely follows the land settlement rules and procedures carried out by the British between 1930 and 1950, and later enshrined in the 1952 Land and Water Settlement Law. A group of persons can request the opening of a *taswiye* process if they together claim an area of no less than 6,000 dunum. The request is first reviewed by the Governorate and then by the Department of Land Survey (DLS), which checks the status of the claimed land and the conformity of the request, and forwards it to the prime minister for approval. The settlement must be announced in the newspapers and in public places and starts by a survey of the area and the attribution of numbers to all plots and *hawds* ('basins'), and by listing present persons using/claiming the land in a 'field book'.

All documents provided by claimants are important, and people keep all kinds of official bills (water, electricity, tax, etc.) or documents to prove some occupation of the land. Although not recognized officially, the *hijjeh* ('proof') is a key document. The *hijjeh* is signed by an authoritative person of the tribe claiming historical rights to the land in question, and two to three witnesses (who certify that the land belongs to, or was reclaimed by, the person 'selling' the land). The 'buyer' can use this paper to sell his land thereafter, but without any protection from possible frauds (e.g. several *hijjeh* issued by different sheikhs, or fake ones).

A first 'table of claims' is published in public places, with the names of claimants and corresponding plots, for a period of one month during which people can raise objections. In the absence of contestation names are moved to the final 'table of rights' and the new 'owners' receive a *qushan* (land deed) that officializes their private ownership of the land (Interview 16, April, 2015).

4.1.2 Tafwid

The 'delegation' of land (*tafwid*) is ruled by Law No. 17 of 1974 and Law No. 53 of 1977. Individuals, private or public companies can rent state land from the government in order to build, cultivate or make a project on it. Would-be renters should present their project through an application directly

[6] The data and information used and analysed in this section have been gathered in the Azraq basin (Azraq area and North Badia area/Mafraq) as part of a PhD program. The fieldwork was based on multiscale farmers' questionnaires (see annexes) to investors, past farmers and present local small farmers. The questionnaires were designed to gather data on several aspects such as: land status; farm characteristics; water source; irrigation techniques; water abstraction; water bills and payments; labour; animal breeding; and socio-economic aspects of farms and farming practices. Difficulties arose when gathering information related to the economic aspects of groundwater-fed agriculture, possible illegality, and the accuracy of water consumption data in some farms. The reason is that these issues are very critical and farmers tend to keep this information, especially since the increase in monitoring from the Ministry of Water.

to the DLS director. If the land is 'delegated' for agricultural purpose it should be rented for a minimum of five years before it may be registered legally under the beneficiary's name, although the latter cannot buy or sell it during the following ten years after its registration (Al Khatabeh, 2006).[7] The maximum area that can be delegated varies according to the location of the land and can be up to 500 dunum in desert lands in the east. Tribes and settlers take advantage of this law to occupy land, reclaim and cultivate it, and then claim it officially.

Two points should be noted here: in practice, farmers seldom go to DLS with a project and, rather, start cultivation outright, in general drilling an illegal well at the same time, in order to be able to irrigate. They also notify the Ministry of Agriculture, which, through its regional directorate, is in charge of checking farming activities and register the area and the type of crop. This will be needed to consider the application of the farmer to obtain permits for foreign agricultural labor, for example. After cultivation is established, they initiate the DLS procedure.

4.1.3 Land dedication (اهداء الاراضي)

In other instances, the state can decide to distribute land from the treasury, through a grant from the King through the Royal Court (*makrama malikiye*). Since a ministry or a municipality cannot legally sell or distribute land to private persons, the land is first given to the Royal Court and then the King distributes it. This option has frequently been resorted to for the allocation of housing plots to some categories of civil servants or specific constituencies, or for political purposes. For example, King Abdallah II has granted land plots to employees from the DLS, the Ministry of finance, Jordan Audit Bureau, the Royal Court, teachers, former ministers, and judges, like in 2006 when 598 judges obtained land in Amman, Yajouz, Tabarbour and Marka (Al Khatatbeh, 2006). The land is then allocated through a tafwid process.

In the aftermath of the Arab Spring and due to the volatile political situation that prevailed hitherto, land bequeaths to tribes and poor constituencies have been heavily resorted to, most notably in Ma'an.

4.1.4 Land access in Azraq

As explained above, Azraq's main settlers are Bedouins (mostly from the Bani Sakher and Sarhan tribes), Chechens and Druze. These settlers claimed and occupied land and started agriculture with groundwater as their main source of income, with in some cases the idea to later claim land ownership through *taswiye* or *tafweed*. Accordingly, agriculture activities in the basin can be divided into two main kinds according to the purpose:

> Cultivation in order to claim land (with the objective to sell it later at a high price). Normally Bedouin and locals do that and it is mainly concentrated in Azraq area, where starting agriculture needs less capital since water table is near the surface and little energy is needed to abstract it.
>
> Agriculture activity as an investment. Outsider investors will seek areas where land ownership is legal (and also wells) to invest into intensive agriculture. A first sub-type includes investors specialized in intensive agriculture; a second includes rich/powerful

[7] Following this process, the potential owner can get its land registered after 5 years of use but that does not give him the right to buy or sell it until ten years after its registration have passed.

people who want to have a villa in the countryside and hire a manager to take care of agricultural operations.

Agriculture was started by settlers when they arrived as a source of livelihood. The survey carried out for this research showed that the Druze community (settled in Azraq North) is more involved into agriculture than the Chechens (settled in Azraq South), maybe as a result of the better soil and water conditions in Azraq North. Initially, Druze and Chechen started with small-scale agriculture for family consumption and they were also involved in the salt production industry and commercial activities. However, with the deterioration of the oasis and increasing water salinity, a lot of Chechens moved from Azraq to Amman, while some Druze moved into larger-scale agriculture, some legally but the majority illegally. These farmers claimed state lands and cultivated them, combining olive tree plantations and vegetable production and also land trading.

Most Bedouins live outside municipal boundaries in the eastern part of Azraq, where they claim large areas of state land as their own tribal land. Bedouins are in general involved in extensive agriculture (olive trees and alfalfa for their animals), as a means to occupy and claim the land, and later generating revenue from land trading. According to a DLS officer, Bedouins are "not attached to the land, they keep moving, and look down at farmers as if they were slaves". An investor feels that "Bedouins do not like agriculture that much, they prefer to sell land and take money since they are not traditionally oriented in farming activity" (Interview 5., 24 April, 2014). But tribal members sometimes do indulge in intensive farming. For example in Mafraq, an Al Sirhan sheikh underlined that "a lot of tribe members sell a part of their land in order to succeed in agriculture because they need money to invest" (Interview 5., 24 April, 2014, interview 11., 3 May, 2014, interview 10., 10 Sep. 2013 and interview 12., 19 June 2013). Accordingly, it is worth mentioning that some Bedouins switch to intensive agriculture when they see the good return of this activity.

Most professional farms in Azraq are investors, of which around 90% reside in Amman or other large cities, or even in foreign countries (Iraq, Kuwait). Many are from Palestinian origin, and also frequently have other farms in the Jordan Valley or Mafraq. Investors normally bought the land from Bedouins or settlers with a legal deed ("*qushan*") so that their investment will not be at risk or, and this seems to be a recent trend, will be renting it. They were attracted to Azraq by cheap land prices and water availability, since the water table is only between 10-20 m below the surface (compared with over 150 m in Mafraq). Despite these conditions, investing in a farm that uses one (or several wells) means mobilizing several hundred thousand JD, which is quite considerable – but much less than in Mafraq though, where water is far deeper.

One Sheikh mentioned that he came to Azraq to invest in the late sixties because he used to go there as a child but also because with the wave of Palestinian refugees after 1967 many people expected that a refugee camp would be established in Azraq, which illustrate speculative strategies linked to expectations about the changing importance of the area in the future (a refugee camp did open, but in 2013, for Syrians).

4.1.5 Relationships between Azraq communities

According to our interviewees, the relationships between Chechen, Druze and Bedouins are considered to be good. Despite this, the fieldwork for this research uncovered instances of conflicts, such as for example a disputed land between Chechen and Bedouin along the road to Amman, and also one instance of death of a Druze at the hand of a Al-Sarhan member in a land-related conflict.

Both Al Sarhan and Bani Sakher tribes reported that they had a document from Ottoman times stating their rights to the land, and how traditional tribal boundaries were defined. It is common among Bedouin Sheikhs to emphasize that "each tribe has its own specific control area. Each tribe knows where its land area is." It is however difficult to substantiate these claims, which are contradicted by instances of conflict, and by several past documents clarifying and establishing tribal boundaries, as shown by a document in the hands of a sheikh of the Al Sarhan tribe. The document, dated 5th of January 1934, was signed by a Druze Sheikh named Muhammad Atieh (Abu Sharash), a Chechen leader and Saleh Al Sarhan, in the presence of M. Saleh, Member of Parliament for Azraq. The agreement defines the demarcations between the tribes: "Sarhan tribes' boundaries are located between the old Sarhan's house to the north, to the old Sarhan's graves to the south, and from the old mountain in the east of Qaisie spring to the old castle and palm trees to the west. Any member from each of the three tribes who claims others land boundaries will have to pay 300 (geneh) and will go to prison for 3 years".

Relationships between investors and local settlers are said to be good but this partly reflects a clear intent to avoid referring to conflicts in a context where power relations are often lopsided (Interview 1., 15 Aug, 2013; Interview 14., 10 Sep, 2013; Interview 15., 30 April 2014; Interview 5., 24 April, 2014). One Palestinian investor for example, while claiming that he had excellent relations with all Bedouins and frequently demonstrated that by helping them in different ways, such as transportation to the hospital, gift of fruits or other products, admitted that some of them were considering themselves above the law, and liked to display an implicit power of intimidation or subjection (Interview 4. 9 March, 2015). Another Palestinian investor in Mafraq was forced by his neighbor to deliver water to his fields which, even though he paid for the associated energy costs, is clearly prohibited and punished by law. He felt he had no other solution than complying, for fear to see his vehicles or trees damaged.

The principal cause for disagreement *within* tribes is associated with the way tribal land has been partitioned between tribe members. When asked according to what criteria tribal land was divided between its members, one member answered "according to the influence and power", while stressing that his father not only distributed land equally, 400 dunum to each family member, whether sheikh or 'herder', but also to people "outside the tribe". In contrast an Al Zubi sheikh was reported to have taken all the land for himself. In another case "the sheikh got 400 dunum while the 'herder' got 4 dunum". One of the Bani Sakher sheikhs in east Azraq reportedly claimed 6,000 dunum for himself and distributed the rest between his brothers, sisters and children.

4.1.6 Legal vs illegal land

With the option to legalize land, people are trying to occupy and claim more state land. The DLS tried, and is still trying, to control the encroachment through state land patrols. Patrols used to visit state lands, record and destroy any illegal construction on the field (cultivation, buildings, caravans, green houses, etc.). One Palestinian investor is cultivating three plots of land, one bought from a Chechen, another bought from a Bedouin, both with a *hijjeh* in 1953; but the third plot is on state land and he is cultivating it illegally, expecting the patrol to come anytime to destroy his cultivation, but yet preferring "to deal with that risk since in the meantime [he] can obtain profit rather than stopping cultivation or waiting for a loss if the plot is destroyed". One of the Palestinians who have been interviewed bought the land from a Druze family through *hijjeh* in 1999 and then regularized the land after 3 years, when the DLS opened a settlement procedure. But after registering the land

he extended his cultivation illegally. The government spotted his land, recorded his infringement of the law and sent the case to court.

Based on fieldwork observations, it is apparent that whether or not the state intervenes is strongly related to the social power of the owner of the farm, with Bani Sakher sheikh's social power widely reported in different ways by farmers to be "much stronger that the DLS patrol" (interview 7., 2 Oct, 2013), especially with elements of the tribe in the parliament and influent positions in the government.

It is hard to establish exactly when settlement operations have been carried out in Azraq, over which surface area, and for how many beneficiaries. The first reason is that the DLS does not divulgate such data, for fear that other tribes in other areas of the country would demand equivalent land allocations. Second, a *taswiye* process unfolds over several years and farmers remember the year in which they have received their property title (*qushan*) rather than the year or the period of the process itself. Many properties are registered but the final delivery of the *qushan* is put on hold because the property contains a non-registered well, which entails that the processes of registration and officialization of land and water (wells) are intertwined. With this uncertainty in mind, we have nevertheless identified settlement calls by the DLS in 1972, 1980, 1987, 1994, 1998, 2000, 2002.

The period of land regularization opened in Azraq in 2000 was part of the "un-surveyed land project", where 17,839 dunum from *hawd* no. 3 and 4 in Azraq south were registered in people's name, while 21,082 dunum of land were rented from the state by local people for agricultural purposes and a period of 5 years, after which the lands might be delegated to their users (Al Khatatbeh, 2006). Beneficiaries of land settlement had to pay a minor fee corresponding to 0.016% of the actual market price.

An influential Chechen resident indicated that a royal grant (*makrama malakiye*) was announced in 2006 after a visit by the King to Azraq, dedicating one dunum of land to each (new) family in Azraq so they could build a house. The allocation concerned lands along Azraq's main road, near the city, and was mostly targeted at Chechen and Druze. Bedouins however also largely benefited from this grant because of the greater number of families, something that Chechen and Druze resented because they consider themselves as the first people to have settled in what is now Azraq city, unlike the Bedouins who, they stress, "keep traveling between Azraq and Saudi Arabia or Iraq"(interview 5, 24 april, 2014). A total of 70,000 dunum were eventually distributed in 2009, at a nominal price of 30 JD/du (8% of the estimated land value of 350 JD/du, price for bare soil).

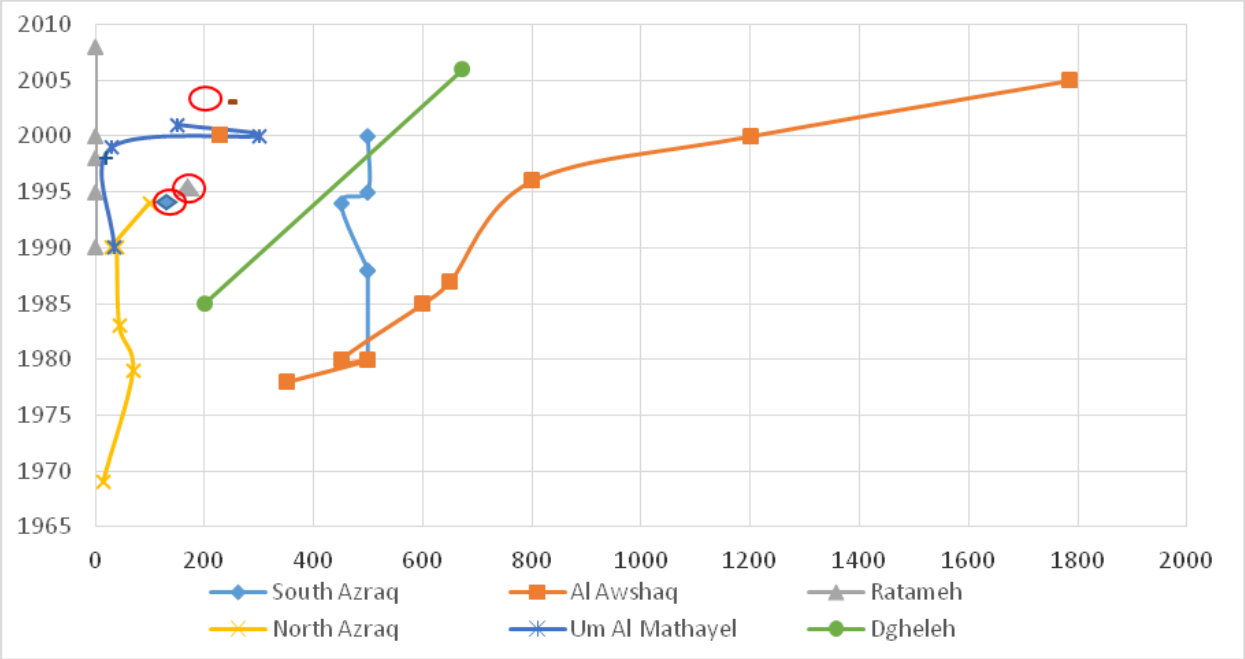
Out of the 54 farmers interviewed in Azraq, 41 (75%) claimed to have official private land deeds (*qushan*), while out of the 13 remaining cultivating land illegally, five (10%) reported to have *hijjeh*, and the remaining eight (15%) cultivate state land without permission. However, because of the sensitivity of the issue it can be hypothesized that some farmers cultivating land illegally reported to have legal documents. It must also be noted that our survey tended to pick up farms with reasonable access (and farmers who were known and could be contacted), which has probably introduced a bias in the sample in favor of "official" farmers. The much higher percentage of illegal wells suggests that illegal land is more common than suggested by our figure (25%). From the interviews it can be noticed that, on average, farmers cultivate and occupy land illegally for 16 years before initiating the process to legalize it.

4.1.7 Land prices

The evolution of land prices in Azraq reflects the evolution of the land market in Jordan in general, with some additional local characteristics. Figure 22 shows the differences in land prices according to the area and year in Azraq region, based on transactions recorded during field work. Note that prices have now notably increased, with current land prices in Azraq Chechen at around 4,500-5,000 JD/du (Al Naber and Molle, 2015).

It is important to note that the prices shown in the figure originate from direct interviews with farmers in Azraq, and reflect the price that was paid by them when they purchased the land. There are a number of farms 'owned' and cultivated illegally where, as a result, the owner did not pay anything for the land. It is however difficult to compare prices because it is influenced by whether the land was private property (*qushan*) or not (*hijjeh*), whether it already included a well or not (which would increase the sale price), whether this well was legal or not, what was its discharge and the quality of water, and whether electricity from the grid was available. The data as shown on the chart refers to legal land (with some additional unconnected isolated points in red circle corresponding to *hijjeh* transactions).

Figure 22. Reported prices of land transaction (in JD) according to place and time



As seen above, North Azraq farmers are mainly Druze, while South Azraq is home to the Chechen. Land prices have been quite low and stable on account of the fact that their lands were regularized at their request by the DLS against the payment of 0.016% of the actual land value (as an administrative fee to register the land in *taswiye*). Also, farms in the area are small in size (typically 20 du) which makes them unattractive to investors. In addition, the situation in South Azraq has notably deteriorated due to the over abstraction and the increase in groundwater salinity, which explains why land prices are much lower than in North Azraq. Land transactions are limited in number and prices are stable (Al Naber and Molle, 2015).

In Ratameh, located in east Azraq, and Al Awshaq in the North east, conditions are favorable for investment. Vast swathes of good quality land are available for large-scale farming, water is less saline compared to South Azraq, and land ownership has already been regularized by the DLS, allowing investors to buy land with a deed and avoid the uncertainty inherent in the *hijjeh.* In these areas, some investors also rent the land directly from the government for agriculture. Since the land is registered it can benefit from municipal services (e.g. electricity, piped water). It is clear from the figure that land prices in both areas are the highest, compared to other areas in Azraq. The land market is also very active in both areas, with most recent prices ranging between 2,000 and 4,000 JD/du, while some investors recall that in the 70s land in this area could be obtained for 1JD/du. The two points in the graph which are disconnected from the other points refer to lands bought by *hijjeh* in both areas. It is clear in the graph that *hijjeh* prices are much lower than with deeds, as one would expect.

In Mafraq, one dunum of land which was sold at 30 JD in 1995 is now being sold at 1,000 JD (in 2015). One landowner recalled that his father was a land trader and bought at the time 20,000 dunum. It seems that the land was divided up among the big families and sheikhs, who then parceled it out; it is not clear whether the *taswiye* occurred before or after that. An influential Srour Sheikh (from the border area with Syria) was given land by King Hussein in 1964. As a member of parliament with good relations with the King, he obtained the Jordanian Nationality for 5,000 of his people as well as 200,000 dunum in Mafraq area to be distributed among them (despite the opposition of the Bani Hassan tribe) (Interview 13., 25 April, 2014).

Cultivation has also expanded eastward, to areas known as Um Al Mathayel, Degaileh or Hora (Figure 5). Eastern farm lands are normally state land, occupied - legally or not - by Bedouins (notably from the Khuraysha clan) who claim it as their tribal land, and also by investors who have either bought land through *hijjeh* at their own risk (with prices around or under 500 JD/du), or through a *qushan*, when the land had already been regularized. Roads are not paved, and electricity and other services absent. Energy is sometimes sourced from solar panels (Al Naber and Molle, 2015).

It is also interesting to note a trend regarding land renting, often on a yearly basis (also observed in Mafraq with, in particular, Syrian refugees as rentees). This reduces or even cancels the risk for the person willing to invest in cultivation, whether the land is officially registered on not. This is also a way for Bedouins who have to keep large plots of land under cultivation to do away with the burden of cultivating them, while ensuring steady revenue and waiting for future *taswiye* operations. A well supplying groundwater to fields between 200 and 500 du is rented 20,000 to 30,000 JD/year (10,000-12,000 JD/100 du, that is, 1/20th of the price of land, as an order of magnitude).

4.2 Implementation of water policy in Jordan

The modern management and organization of water affairs in Jordan started in the late 1950s with the establishment of the National Authority for Natural Resources (predecessor of the WAJ).[8] The authority had the responsibility to manage all natural resources, including groundwater. It was also the only legal entity that provided land owners and drill owners with drilling permits. In 1968, the

[8] WAJ and the national authority for natural resources are different and they are not related to the same entity. Water management was in 50s controlled by the natural authority while it transferred to MWI as WAJ later.

National Authority implemented a new law (Law No. 12) to manage natural resources. The law however was too general and did not help in conserving groundwater. As groundwater for agriculture began to be abstracted, irrigated agriculture came to be encouraged by the government in the early 1970s, following the vision of a green Jordan, and also as it provided a reliable source of income that would improve social welfare, stability and security (UNDP, 2013).

The development of groundwater-fed irrigation was done by granting licenses and soft loans to users through the agricultural credit corporation for drilling private wells. The licenses indicated a limitation to abstract groundwater at rates of 50,000, 75,000 or 100,000 m^3/year. These volumes where however not respected due to the poor monitoring of groundwater, weak laws and an absence of metering system (Chebaane et al., 2004). Consequently, the highlands became one of the most important regions in Jordan for agriculture, with olives, grape, vegetable and fruit trees (MoA, 2010).

In the early 1980s the peak of agriculture production was reached in Jordan. During this period, the control of groundwater resources remained with the National Authority for Natural Resources until 1984, when it was transferred to the WAJ/Ministry of Water and Irrigation (established in 1988). The Water Authority used two main laws to govern groundwater: Law No. 18 from 1988, and the Water By-law No. 85 from 2002 to monitor groundwater systems.

4.2.1 Law 18 from 1988 and its amendments

The main purposes of Law No. 18 were:

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

Law No. 18 from 1988 was the first piece of legislation that introduced penalties for illegal well drilling, as well as illegal use: imprisonment for no less than six months and no more than two years, with a bail of no less than 1,000 JD and no more than 5,000 JD. Since its enactment in 1988, there have been two main amendments to this law, the first in 2004 and the second in 2014.

As part of the first amendment in 2004, two new articles were added to the law, the first addressing the need to set a strategic plan to design and develop a series of programs for the implementation of water policies for all water users including domestic, municipal, agriculture and sanitation, and the need to set control measures to monitor groundwater abstraction and well drilling. The second article gave the authority to the WAJ to request the support of the army (if needed) in order to control any illegal activity related to groundwater (e.g. inspect and destroy any illegal well drilling and/or cleaning and well deepening or replacement and each of these processes requires technically a specific license).

In 2014 a new amendment was added to the law which included five new articles:

- In order to control groundwater bill payments, the government linked all the ministries together with one single computer system. As a result, farmers cannot initiate or

request anything from the administration until all due bills are paid. One article was added indicating that any land with a drilled well cannot be transferred to a new owner if there are any pending bills for water usage.

- 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 3) and have to pay a fine between 1,000 JD and 5,000 JD.
- Given the fact that the enforcement of penalties did not dissuade groundwater users (as the number of illegal wells continued to increase according to WAJ), the ministry changed the initial penalty from 6 months to two years in prison to one to five years, and the payment of 2,000 to 7,000 JD.
- Any illegal drilling will be stopped by the WAJ with help from the army (if needed) and the perpetrator (and not the government) will pay for the removal of the equipment.
- Water consumption from illegal abstraction will be estimated according to the cultivated area, cropping pattern, energy consumption, satellite image and remote sensing image.

This last amendment reinforced the apparent commitment of the WAJ to close illegal wells given the fact that enforcement was not effective before 2013. The ministry surveyed all wells and announced closing procedures for the illegal not registered and un-productive wells, with the help from the army if needed, as written officially in the 2004 and 2014 amendments. Table 8 shows the number of illegal wells backfilled (MWI, 2013). Illegal well *permits* are renewed each 3 years; WAJ has the right to renew or decline the permit. This higher uncertainty/risk, together with different tariffs, mark the difference with *licensed* (legal) wells. It must be noted however, that the wells that have so far been backfilled or destroyed were either unused or dry.

Table 8. Number of backfilled illegal wells (MWI, 2013)

Year	*Number of wells*
Before 2007	235
2007	26
2008	45
2009	46
2010	57
2011	29
2012	19
2013	141

4.2.2 The Water Bylaw of 2002

The Water Bylaw No. 85 from 2002 was mainly promulgated to control private groundwater abstraction in agriculture. It also re-emphasized that all groundwater resources are owned and

controlled by the government and that land ownership does not entail ownership of groundwater extracted in the property.

The bylaw indicated that the ministry is the only entity responsible for managing and monitoring water resources. The ministry is also charged with defining the annual allowable groundwater abstraction in all Jordanian basins. To ensure the sustainability of groundwater-fed agriculture, it is expected that, at least on paper, cooperation between the Ministry of Water and Irrigation and the Ministry of Agriculture will be implemented actively under this by-law. The Ministry of water and irrigation will define the safe yield of each aquifer and the Ministry of Agriculture will define the arable area and its water consumption needs according to the cropping pattern, while respecting the safe yield (Bylaw, 2002).

According to the by-law, the WAJ is the only entity allowed to issue drilling licenses to users. Licenses are valid for one year and can be renewed by applying to the WAJ with a cost of 500 JD. Legal well owners have to renew the abstraction licenses yearly by paying 50 JD. Normally this amount is added automatically to the groundwater bill. Licenses specify the type of use and the surface of land to be irrigated (it is illegal to irrigate more than one land plot or property with one well license). In order to obtain a license, the land area to be irrigated has to be more than 100 dunum and the minimum distance between wells has to be 1 km. After obtaining the license and having drilled the well, a discharge test has to be done in the well within 6 months in order to specify the annual allowable abstraction volume for the well. If the owner fails to carry out the test, the authority has the right to backfill the well.

Also according to this bylaw, it is forbidden to sell any abstracted groundwater as drinking water without a special permit. The authority shall close any well not fulfilling this condition. The wells also can be backfilled in case: 1) a well is drilled without obtaining a license (for legal wells) or permit (for registered illegal wells); 2) the well owner does not comply with the terms of licenses/permits granted.

After a well has been drilled and is producing water, the owner can do maintenance on it by applying for a permit for cleaning, deepening and/or change of location. These changes can be done if some conditions are met, such as in the case where the original well is legal and not backfilled but has a technical problem (rather than a productivity problem). Accordingly the license for the new well is given and the original well backfilled. Following the by-law, each well has to have a metering device and the well owner should inform the WAJ within 48 hours if the meter stops working.

The Bylaw No. 85 also introduced a fixed free groundwater abstraction volume based on the safe yield of each basin and an abstraction quotas combined with taxation of exceeding use. The bylaw also established a system to account for groundwater abstraction if a well has no meter and/or if the meter is not working correctly, users should report it to the WAJ all metering problems and it is expected that the WAJ will visit the field every 3 months. The abstracted amount is estimated according to the irrigated area, cropping patterns and energy consumption of the pump (if any electric connection). The Ministry also uses remote sensing satellite imagery to control land use and irrigation expansion (introduced by the second amendment to Law No. 18 of 1988).

4.2.3 Amendments to the 2002 Water Bylaw

Several amendments have been made to the Water Bylaw in 2003, 2004, 2007, 2013 and lastly in 2014.9 In 2003 the WAJ introduced a water tariff system according to different abstraction quotas as explained in details in the tables below (Table 10 to Table 14) (depending on the well status; legal, illegal with a permit, illegal without a permit). Also, the ministry established variable abstraction quotas depending on water quality (for saline water). All regions in Jordan have the same free quota as agriculture (established at 150,000 m3/year for agriculture use). The Azraq area was however treated as a special area since the water table was near the surface and farms were expanding so the government sought to control consumption by limiting the free extraction 'block' (and raising the water tariff). The limited free quota is 250 m3/du but not exceeding 50,000 m3/year. In other words, the free quota benefits farms with an area not exceeding 200 dunum and using only 250 m3/du or less, a case that hardly exists in Azraq (due to the size of the farms and also to the basin's hot climatic conditions).

Table 9. Licences and permited wells for agriculture tariff (Bylaw 85-2002)

Quantity of water	*Water price (Amendment 2003)*	*Water price (amendment 2004)*
0 – 150,000 m^3	Free	free
150,000 – 200,000m^3	25 fils/m^3	5 fils/m^3
More than 200,000 m^3	60 fils/m^3	60 fils/m^3

The 2003 bylaw amendment also introduced new fees for renewing licenses for well replacement (at 200 JD/well) and also for well maintenance (for cleaning and deepening wells, these were set at 100 JD per well per operation). The prices of licenses for cleaning, deepening and replacing wells in the bylaw 2002 were set as 300, 500 and 750 JD respectively.

The establishment of a rule with water tariffs and quotas was, and still is, very optimistic as paying for water had never been done in Jordan before 2004. Up to recently farmers tend not to pay their bills and regulation is not enforced as it should be: some wells have meters installed by the WAJ but others do not; farmers tamper with meter reading and the authority estimate the consumed water for a non-metered wells using satellite imagery and by estimating the crop water requirement according to the cultivated area; bribing distorts the consumption figures collected on the ground.

After introducing the water tariff for legal wells in the 2003 amendment, farmers raised a lot of complaints and tried to exert political pressure to reduce the tariff of the second 'block' from 25 fils/m3 to 5 fils/m3. In the end they succeeded, with the help of members in parliament who used political pressure on the minister of water, as a water expert indicated (Al Zyoud, 2015), and the WAJ changed it in the 2004 amendment (Addustour, 2004). The water tariff for illegal unregistered wells was later promulgated in the 2014 bylaw amendment (as they were not charged). Then, the WAJ tried to control illegality by increasing water tariff dramatically, as shown in Table 13.

[9] There were two amendments done in 2014, one to the Water Law from 1998 and one for the Water By-Law from 2002.

In July 2005 the ministry banned all new well drilling and stopped giving new well licenses. Permits given to wells after 2005 to old illegal but registered wells could often not be transformed into licenses due to problems related with land ownership (see Section 4.1). An important article was added to the Bylaw in the 2014 amendment indicating that all unlicensed and not registered wells in use drilled illegally after July 2005 (and whose owners had not asked for any settlement with the WAJ to correct and legalized there wells) should be closed by their owners, otherwise the WAJ would close them (with army support if necessary). Farmers should also install metering systems and new quotas and fee tables were issued for farmers with illegal but registered wells. In 2014 the WAJ started closing illegal wells, focusing however on the non-working or unproductive wells. By mid-2015, the ministry had closed 648 wells in Jordan (Interview 16., 9 Sep, 2015).

Table 10. Licences and permited wells for agriculture tariff (Bylaw 85-2002)

Quantity of water	*Water price (Amendment 2003)*	*Water price (amendment 2004)*
0 – 150,000 m^3	Free	free
150,000 – 200,000m^3	25 fils/m^3	5 fils/m^3
More than 200,000 m^3	60 fils/m^3	60 fils/m^3

Table 11. Water tariffs for saline wells as amended in 2003 (Bylaw 85-2002)

Quantity of water	*Salinity ratio (ppm)*	*Water Prices (fils/m^3)*[10]
0 – 150,000 m^3		Free
More than 150,000 m^3	From 135 – 1,500	15 fils/^{m3}
	1,500 – 2,000	10 fils/^{m3}
	More than 2,000	5 fils/^{m3}

Table 12. Water tariff for wells with licenses and permits in Azraq area (as amended in 2003, Bylaw 85-2002)

Quantity of water	*Water price*
0 – 250m3/du, up to a maximum of 50,000m^3/yr	Free
Specific quantity – 100,000 m^3	20 fils/m^3
More than 100 000 m^3	60 fils/m^3

[10] One fils = 1000 JD.

Table 13 Water tariff for illegal wells as amended in 2003 (Bylaw 85-2002)

Quantity of water	*Water price*
0 – 100,000 m^3	25 fils/m^3
100,000 – 150,000 m^3	30 fils/m^3
150,000 – 200,000 m^3	35 fils/m^3
More than 200,000 m^3	70 fils/m^3

Table 14 Water tariff for illegal wells as amended in 2014 (Bylaw 85-2002)

Water quantity	*Water price*
0 – 10,000 m^3	150 fils/m^3
10,000 – 30,000 m^3	250 fils/m^3
More than 30,000 m^3	500 fils/m^3

4.2.4 Groundwater policy implementation in Azraq

Laws, strategies and policies were introduced in order to increase the government's authority in controlling and monitoring groundwater. However, each promulgated law shows implementation and conceptualization gaps, giving the possibility to users to bend or circumvent the rules in their favor. After analyzing Jordan's water polices, this section illustrates common enforcement gaps and the strategies adopted by Azraq groundwater users. Several meetings were conducted as a part of the fieldwork (farmers, multi scale users – small farmers, investors, past farmers –, policy makers, water and Land Departments' employees and water experts). User strategies have been identified and collected. Several measures that could improve the implementation of the water law and conserve groundwater resources are suggested. The government is now showing resolve to enforce different measures and to raise its level of control over groundwater.

4.2.4.1 Regulations and users' strategies

- **Well licenses and permits**

Farmers without legal land have dug wells and obtained a *permit* for illegal (but registered) wells and registered it with the WAJ database. Some farmers later legalized their land through *taswiye* or *tafweed* and then legalized the well accordingly. Others still conserve their well as illegal without a permit. Some farmers mentioned the pressure they exert on the DLS to have their land status corrected, while some indicate that obtained a license for a legal well using a fake land deed, and that the WAJ did not bother to check its validity.

As shown by Table 11, the water tariff for the registered well is much lower than for the illegal one, in addition of registered (licenses and permitted) wells being granted a certain amount of abstracted water for free (not the case for not registered illegal wells). Some farmers try to legalize their well in order to avoid higher water tariffs, while others choose to dig a new well illegally and without a meter in order to avoid paying any tariff. In this case, there is the risk that the WAJ may find out and close the well (especially after the late Bylaw amendment in 2014).

Farmers are therefore determined to legalize their wells by either making the farm were the well is dug look older than 10 years by planting older trees or by showing fake application papers to the DLS.

- **Well maintenance**

Three types of well maintenance can be done in both legal and illegal registered wells: well cleaning, well deepening and well replacement. Well cleaning is used to remove plants and roots or anything that can have an effect on water quality and pumping. Normally well deepening happens with the decreasing water table, so that users follow the water table. Well replacement is accepted if there are technical problems in the well (rather than a problem of water quantity). Each well maintenance procedure needs a specific license from the WAJ. Some water expert and also farmers mentioned that some apply for a well cleaning license but instead deepen the well to get more water (especially if groundwater was saline in the area). Some farmers who would obtain well deepening licenses would not respect the stipulated depth. Field observations showed that 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 finished they will remove the obstacles and open the well again.

- **Metering systems**

As indicated in the law each well must have a functioning metering system, but reality is far from this. Many farms visited during fieldwork had wells without a metering system. Even if a meter exists farmers have several ways to manipulate or tamper with it. Some farmers complain that their meter is broken and is not working, while others would tamper with the meter so that it records less water consumption (by using a driller to rewind the meter backward). Some farmers would also purposely bypass the meter with a parallel derivation pipe so that not all the water pumped is metered.

The law also established 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 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. Since then the WAJ stopped giving new well licenses and permits, unless specific conditions are fulfilled (old wells that can be later legalized when land ownership is regularized). Many farmers would then try to apply for domestic or industrial well licenses to dig a well, and later use it for agricultural purposes.

- **Sealing wells**

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 seal it. The original well would be reopened after the inspection. Another technique is to insert in the well a smaller pipe, which is only a few meter long and closed at the bottom end. After being filled in an obstructed with earth and rocks, the pipe is later removed to make the well operational again.

- **Hiding illegal wells**

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. Farmers can drill illegal wells to make 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. Such wells are dissimulated and hidden (such as the case reported by a WAJ 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 to officials (Addustour, 2003).

- **Bribing and intimidation**

The transaction costs for checking and controlling wells on the field (presence of a well, effective use of a well, meter readings, etc.) are quite high. The 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. WAJ staff should do quarterly monitoring but in practice cannot visit farms more than once a year (which in many cases they don't even do).

Some farmers will also pay for WAJ staff to underestimate meter readings or turn a blind eye to an illegal well, a practice that is likely quite widespread judging from the gap recently found between official and estimated abstraction figures actual groundwater use for agriculture in the basin exceeds twice the official recorded data (Al Bakri, 2015) . In yet other cases, WAJ staff work is made difficult by intimidation tactics (cases where visits are discouraged by a show of weapon) or by display of social power by some influential land owners.

- **Water transfers**

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 to drill new wells by transferring water by pipe from neighboring legal or illegal wells. If these wells are not metered, abstraction can be substantially increased, much beyond the declared or imposed limits. This transaction can be paid for but in a case observed in Mafraq, an investor had to cater for the request of his Bedouin neighbor, for fear of reprisals if he did not agree.

4.2.4.2 Control measures by the government

Faced with a situation of insufficient monitoring and control, the Ministry has tried to toughen its practices and developed several strategies and 'counter-measures' to improve enforcement and reduce law-breaking instances by farmers.

- **Departmental coordination**

The first water bills were sent by the WAJ to Azraq farmers in 2004. Farmers received the bills but few paid. Groundwater tariffs were then increased in 2003, and then decreased in 2004. As a result farmers did not take the new law amendment seriously. In July 2009 the WAJ sent the water bills again, covering the period from 2003 to 2010. Some farmers still refused to pay their bill while others did. In 2014 the Jordanian government started a new initiative that would help control and preserve groundwater resources. Government sought to interlink all governmental departments so that any governmental procedure (purchase transaction, passport or driving license request, etc.) would be refused if the farmer had not paid the water bill. This is of particular relevance for farmers

willing to hire labor for their farms (see Section 4.6.1), as the approval of the Ministry of Agriculture is conditional upon payment of the water bill.

- **New water tariff**

With the increase of agriculture expansion, illegal well drilling also increased. Accordingly, the WAJ tried to deter this phenomenon by introducing a new and very high water tariff for illegal unregistered wells. This is possible according to the WAJ as all wells in Azraq are known. It is hoped that this new tariff combined with the administrative measure described above will strongly discourage farmers from drilling new wells.

- **Controlling drilling companies**

The registration of drilling companies and the conditions and constraints established for their activity have been specified in the 2002 Bylaw. Equipment spotted while carrying out illegal drilling is liable to seizure. Official statistics mention the number of rigs seized every year and such actions are frequently reported in newspapers. It is not clear how much of a deterrent to illegal well drilling they are.

- **Satellite imagery**

The Ministry of Water and Irrigation with the WAJ is using satellite imagery to control the expansion of cultivated area and illegal well drilling. Satellite imagery and remote sensing can show the expanse of agricultural activities happening on the ground and help the WAJ identify the areas that need to be checked more thoroughly. It also provides a comparison between reported abstracted volumes and the water requirements estimated based on the cultivated area and crop type. Recent studies (Al Bakri, 2015; USAID, 2014) have indicated that abstracted volumes were seriously underreported, prompting a toughening of the policies pushed by the minister.

Satellite imagery was used as far as 20 years back to control cultivated areas. However, the situation has now significantly changed because of a dramatic drop in the price of these the images, a much easier availability, and more powerful computer processing. They can now indicate yearly changes and even spot pump houses on the field.

- **Destroying illegal wells**

The WAJ was previously using well backfilling in order to seal illegal and nonproductive wells and also in case of well replacement. Given the different user strategies to avoid control and well sealing discussed above, the WAJ has decided to use dynamite to close wells to ensure that they cannot be used again.

- **Constraining land sales**

The Ministry of Water tried to control illegal wells and unpaid water bills by introducing an article in the Bylaw indicating that no land can be sold or exchanged if it has an illegal well in it, or if the owner has not paid the water bill.

- **Stopping *taswiye***

Opening a taswiye or tafweed procedure in Azraq area encourages the local and Bedouins to claim more land 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 spread around Azraq saying that the government would release more land for farming. As a result, people started claiming state lands and planting older trees to make them look like they had been farmed for at least 10 years. Due to this, 16,000 new dunum of land were "cultivated" in Azraq within 2 weeks. The ministry was able to remove 10,000 dunum of newly cultivated land but the other 6,000 dunum remained as they were cultivated by an influential sheikh from the Bani Sakher tribe. During the attempted ministry's visit to the land, the sheikh used weapons to intimidate the visitors. As a result of such a situation settlement and delegation processes in Azraq were discontinued by the DLS.

Table 15. User strategies to access groundwater and control measures from the government to preserve groundwater

Measures	*User strategies to access groundwater*	*Control measures from the government*
Licenses or permits	• Need official land deed: expect *taswiye* • Provide fake deed • Keep well illegal	• Limit the *taswiye* • Link WAJ with the DLS and other departments • Increase water tariffs
Well maintenance	• Cleaning: may make it deeper • Deepening: may dig more than licensed • Replacement: Close the well then open it again	• Cleaning: increase WAJ staff for monitoring • Deepening: increase WAJ staff for monitoring • Replacement: use dynamite and picture
Metering systems	• Break the meter • Meter tampering • Meter bypassing • Bribing WAJ staff • Not allowing WAJ staff to take the reading • Lack of WAJ staff	• Introduce new WAJ staff to reduce bribing, • Use meters with automatic transfer of data • Schedule regular visits • Use digital meters instead • Hire additional staff
Requesting a well for domestic or industrial wells	• Since drilling agriculture well is banned so users try to get licenses for other kind of wells	• More monitoring from WAJ
Sealing wells	• Use fake well	• Use dynamite
Hiding illegal well	• Drill a well and hide it	• Continuous monitoring • Use satellite image
Bribing and intimidation	• Pay WAJ to neglect illegality	• New staff and more supervision
Transfer of water	• Use well not located inside farm	• Satellite image • Monitoring from WAJ
Agriculture land expansion	• Illegal expansion on state land and illegal drilling	• Use satellite imagery and define agriculture land boundaries

4.2.5 Effectiveness of policy options

The measures put to effect by the government in order to prevent further groundwater depletion show varying levels of effectiveness. Some of them sound are decisive and extreme (dynamite), others would face constraints, and some would seem more feasible or easier to implement. In any case, local enforcement of rules is needed for procedural measures such as well maintenance, the

control and reading of meter systems, the expansion of agriculture and sealing of wells. Presently, WAJ staff have the mandate and seemingly the regulatory tools in place to avoid well deepening and can also control that farmers respect the authorized depths. The enforcement of rules by WAJ staff should be done by visiting farms and check wells more frequently, not only while taking meter readings, which is when farmers expect ministerial staff to come. Regular visits by WAJ and ministry of agriculture staff, with the help of satellite images to crosscheck information, can also potentially help track the expansion of cultivated land and monitor the use of water (legal or not) in the new lands.

The main problems faced by the Ministry of Water and Irrigation come from illegal wells, meter tampering, and unpaid water bills. To control illegal well drilling, the Ministry has adopted two types of procedures: 1) radical, by closing the well (recently with dynamite so it is never used again; 2) more progressive, by increasing the water tariff of illegal (but registered) wells, so that farmers reduce consumption, and also by improving inter-departmental coordination forcing users to legalize or otherwise close illegal wells and pay due bills.

Despite these regulatory powers, local enforcement is difficult since it requires a direct contact with users. To that effect the WAJ has few field staff, making it difficult to control on the ground the application of rules. The lack of staff can also bring corruption as the users will be familiar with the authority representatives. The social proximity of WAJ staff and farmers in some cases (they are from the same area or live in the area) can also limit the effectiveness of rule enforcement and control.

Despite the fact that Jordan's first water law was issued in 1988 and followed by the Water Bylaw of 2002, the country is still facing the same problems related to groundwater over-abstraction it faced two decades ago. Large numbers of surface and groundwater offences are recorded due to policy enforcement limitations. The enforcement of water laws in Jordan depends on several external factors, linked to the political situation and location, and internal factors such as demographics, the tribal system and social power within communities. The country mainly holds thanks to the support of tribes and settlers, both being the main actors who reclaim land and water.

Given this situation, the government through the WAJ and the DLS cannot always enforce locally the rules. One example reported during the interviews refers to 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. In 2014 there were more than 15,000 cases of groundwater-related offenses reported by the WAJ, some for tampering meters, others for digging illegal wells, or sabotage of WAJ's water distribution pipes (Jordannews, 2015). Government data indicates that Jordan has 1,559 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 councilors) (Sawaleif, 2015). Even though the law should be blind and target all users equally, during fieldwork in Azraq some farmers raised a lot of complaints regarding this issues, as they felt the government is trying to use them as scapegoats and is enforcing the law only for them.

An additional pressure mentioned recently is the influx of Syrian refugees into Jordan, exacerbating the pressure on the country's limited resources and water demand (AlGhad, 2014).

4.2.6 Recent measures

In order to increase the effectiveness of rule implementation and enforcement, the Ministry of Water and Irrigation is using additional pressure through the law and also through the public debate. In 2013, the Ministry started a campaign to close illegal wells, starting first with unproductive wells, and also requisitioning 14 illegal drillers and developing an anti-manipulation system for meters (Ammannews, 2014; Assawsana, 2015; Sarayanews, 2013). In 2014, the Ministry introduced a new tariff for not-registered illegal wells in 2014 that has the potential, if applied, to make all new (illegal) wells economically unsustainable.

Concerning the water bills, the ministry started a new procedure for unpaid bills. Officials would claim the unpaid amount from the well owners and give them a period of 15 days to pay. After that, the Ministry would publish the names of the well owners and the unpaid amount in the newspapers and give an additional period of 60 days to settle down the charges. If the owner still refuses to pay the amount then the Prime Minister will have the power to seize the account of the well owner (Alwakeelnews, 2015; Khabreni, 2014). As of autumn 2015, the Ministry has already published a first list of 70 well owners in the official newspapers. Unsurprisingly, some of them are well known and influent people in Jordan (owing for some of them more than 200,000 JD of unpaid water bills) (Mbayden, 2013; Khaberni, 2014). In the Azraq area only, the Ministry sent 495 out of a total of 1,493 notifications for water payment (Alwakeelnews, 2015). The ministry has also opened the possibility for well owners to settle unpaid bills by installments (Sarayanews, 2013).

The ministry has also been using media to inform the public debate, publishing a series of articles highlighting the water problem in the country. Also, the King formed a Royal Commission on water resources in 2008, which issues frequent reports describing the country's water situation and needed strategies to conserve water (PM, 2008).

4.3 Cropping patterns in the Azraq basin

Farming systems in the Azraq basin vary from small scale farms with simple cropping patterns and cultivation techniques to highly sophisticated and modern farms run as enterprises with hired labor. It is surprising however to find the former type in Azraq given its climatic conditions, not very favorable for cultivation and with water scarcity and quality problems. All sources in both Azraq and Mafraq areas confirmed that the cultivated area for agriculture has been increasing on a yearly basis. The trend in Azraq might be directly related to the fact that land prices are relatively cheap and the total capital needed to invest in the basin is low compared with others part of Jordan. However, according to the present situation of decreasing groundwater quantity and quality levels, investments in these areas are expected to decrease, as farm revenues have already started to drop. The main crops present in Azraq according to official data from the agriculture and extension department are: olives, grapes, fodder crops (e.g. alfalfa) and trees (fruit tree and date palms). The total cultivated area in the Azraq area in 2005 was 61,000 dunum, having increased in 2011 to 114,000 dunum (Figure 24, Figure 25, Figure 26) (MWI, 2012). As shown in Figure 24, cropping patterns studied for this report are similar to those officially published. Olive cultivation is the dominant crop, followed by alfalfa, grapes, vegetables, and fruit trees.

Olive trees are the main cultivated crop in Azraq (Figure 27 and Figure 28), which partly reflects the fact that many farms were established to claim land ownership in the first place, rather than as a capitalistic investment. Olive trees were chosen due to their easy maintenance, low labor, and lower water requirements than other crops. An important increase in olive cultivation happened

however in 2010. Field visits and meetings with different water and land expert in the area indicated that at that time there were rumors concerning a government move to open a call for land settlement (*taswiye*) via the DLS (see above). As a result, many locals started to speculate with state land, bringing ten-year old olive trees and planting them in order to pretend that they had been doing so for the past ten years and to claim more dunum.

Figure 23. Agriculture area in Azraq (2005 – 2011)

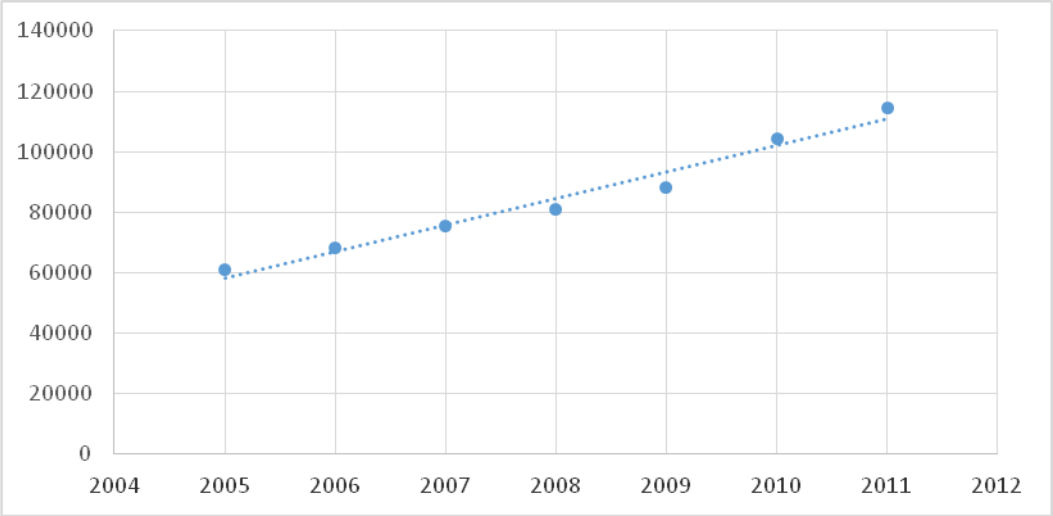


Figure 24. Cultivated area in Azraq based on fieldwork data (in percentage)

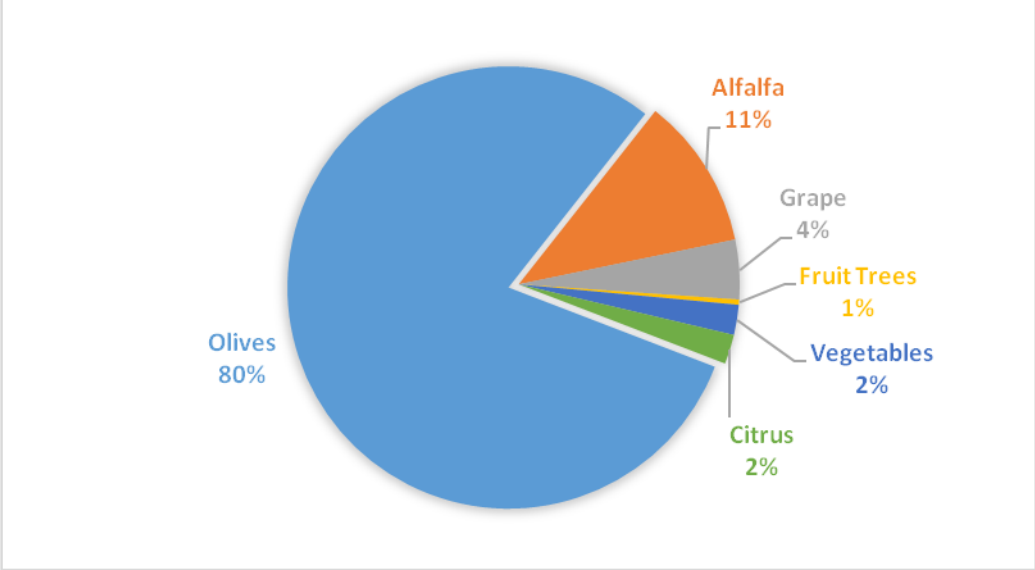


Figure 25. Cropping pattern in Azraq in dunum (2005-2011)

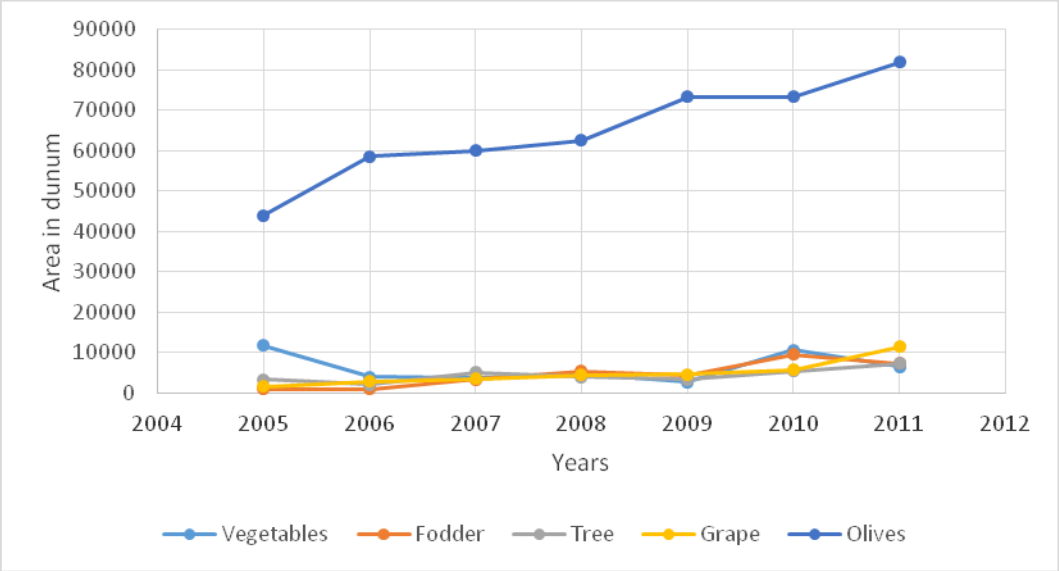
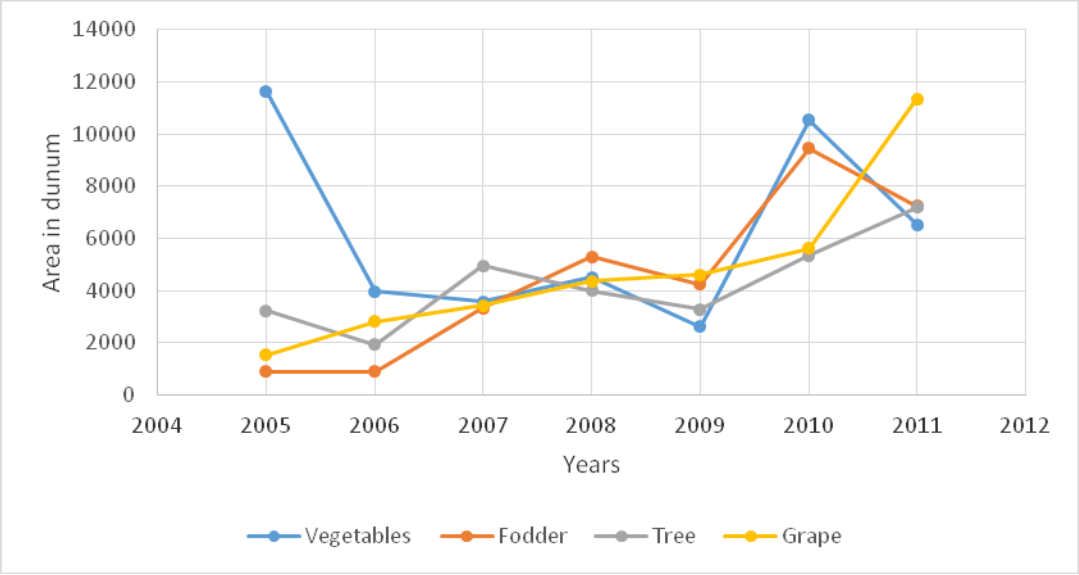


Figure 26. Cultivated Crops other than olive in Azraq (2005-2011)

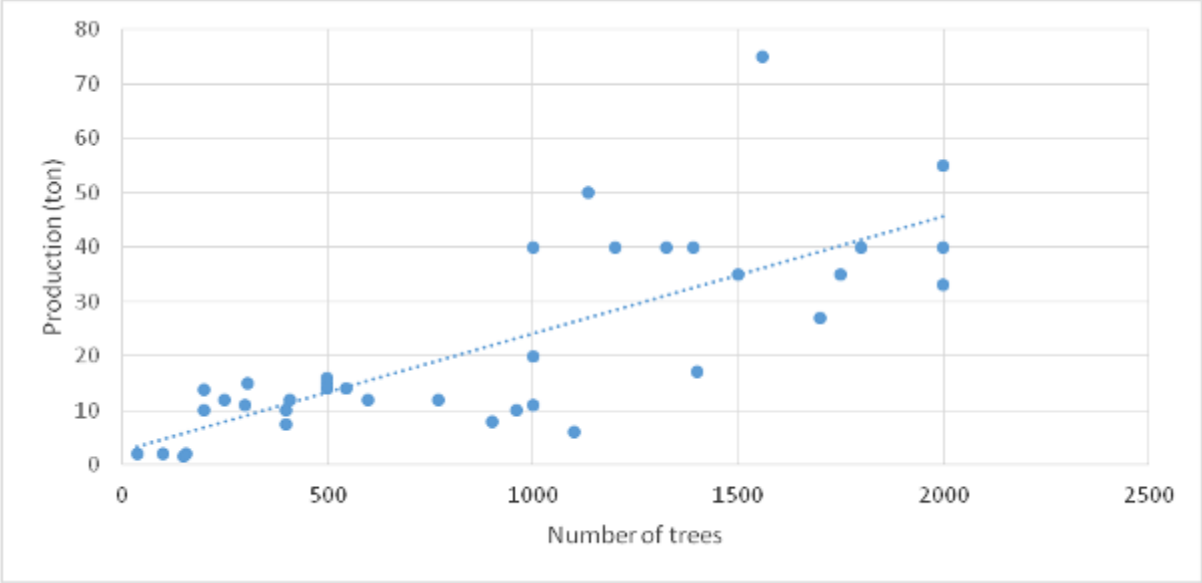


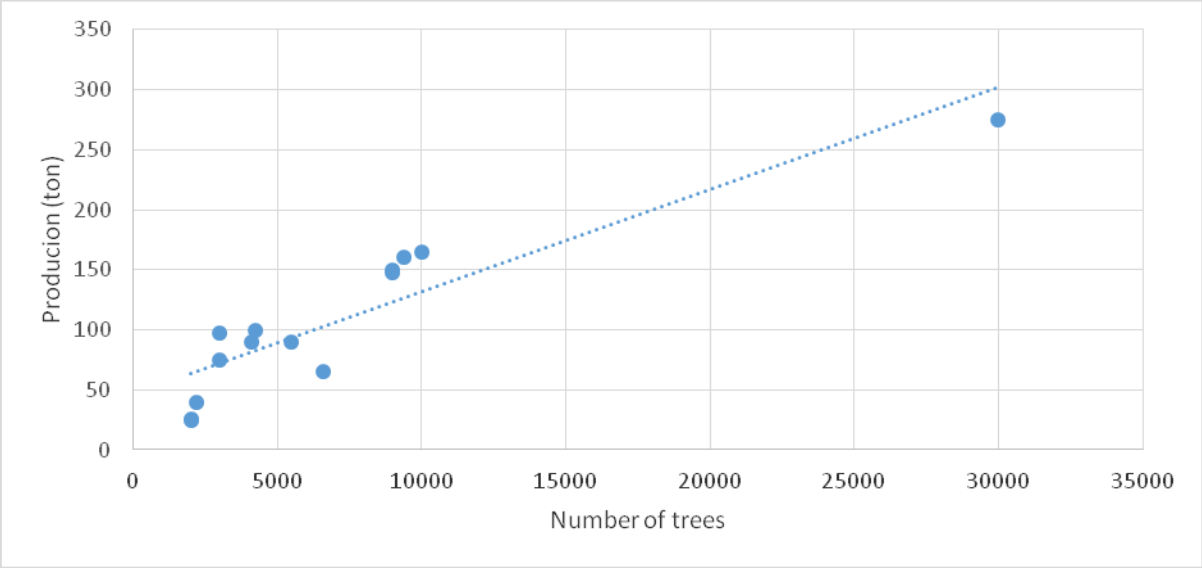
Our survey indicates that many farmers are willing to change their cropping pattern and switch to fodder production due to the crop's much higher revenue. However, this decision is influenced by the fact that fodder crops require larger amounts of water. For this reason, farmers will normally cultivate fodder crops illegally on state land and irrigate them with illegal wells in order to avoid paying water bills. The short life cycle of alfalfa helps farmers achieve high production and high profits. The cultivation of vegetables is the second option for farmers; however, due to the fact that vegetables consume substantial volumes of water in a short period of time, it has been noticed that the water table in the areas where vegetables are cultivated has dropped around 2 meters every year since 1990 during the cultivation period.

4.3.1 Olive trees

Olive production in Azraq is sold as olive oil or olive pickles. Each 1.5 ton of olives produces seven cans (one can = 20 liters) of olive oil (Figure 27). Prices for one can (or 20 liters of oil) can vary from 50 to 70 JD according to the season, and the production is normally exported due to the fact that Azraq olive oil has less acidity than other olive oils, a characteristic that is not favored by the Jordanian market.

Figure 27. Olive trees production in Azraq (a and b)



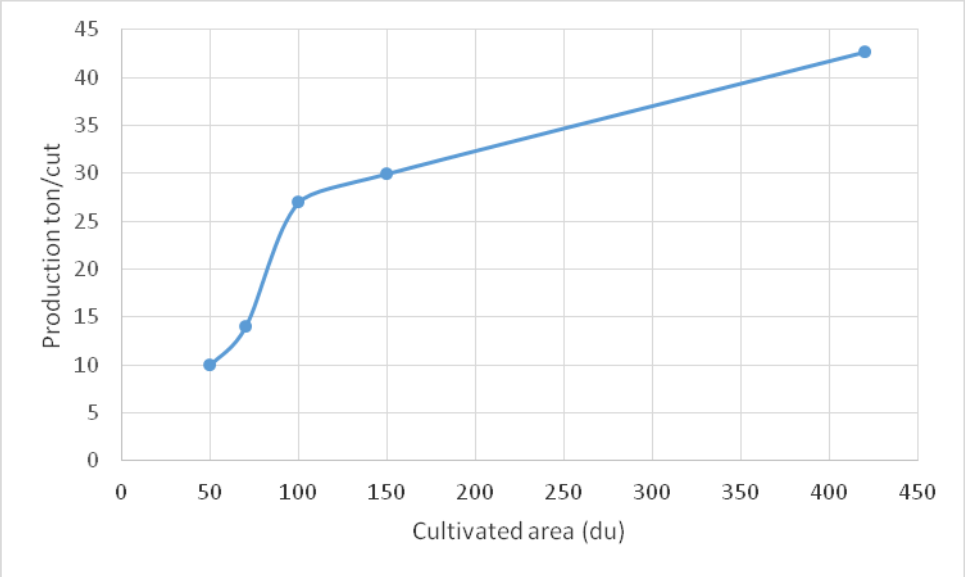


4.3.2 Alfalfa

The production of alfalfa in Azraq is mainly for local livestock or sold to as fodder to distributors. The cycle of the alfalfa plant is seven months, with one harvest every 20 days and 10 harvests for

every season. Each harvest will produce around 750 JD in revenue in Azraq area and Ratameh in specific (Figure 28). This is a thirsty crop clearly not suitable to Azraq conditions but its market has boomed and made it attractive.

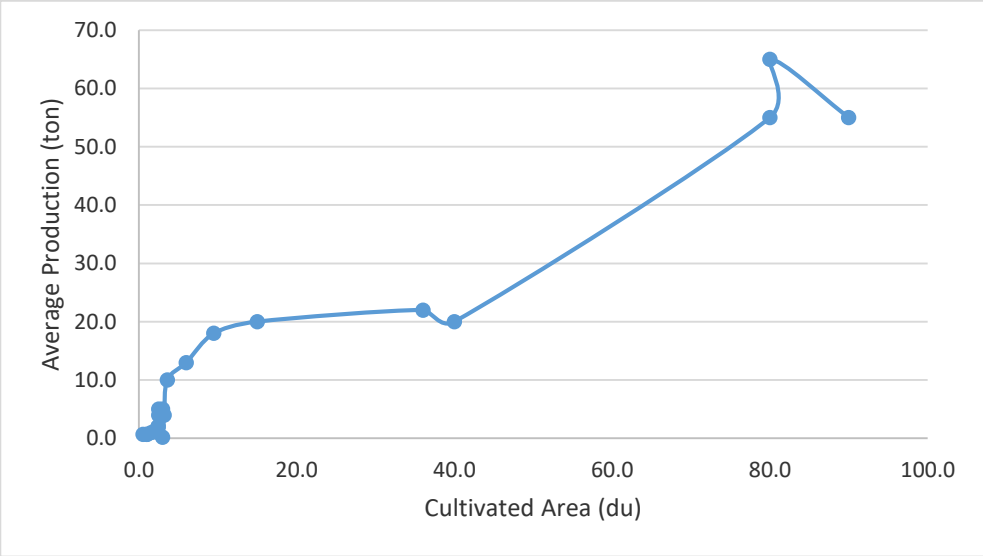
Figure 28. Alfalfa production (ton/cut) and cultivated area



4.3.3 Grapes

Grape production is distributed both inside and outside the country. The few farms found cultivating grapes are professional farms using highly technical irrigation systems (e.g. alarm system monitoring frost conditions in the air so that the farmer knows when to irrigate and therefore minimizes losses).

Figure 29. Plot production per dunum for grapes in Azraq



4.4 Farm typology in Azraq

4.4.1 Farm typology established in this study

The farm typologies used in this study were defined based on the cultivated area, cropping pattern, irrigation techniques, management practices and farm revenue but without taking into consideration the initial investment cost (difficult to assess accurately). Profits were calculated based on farm production as most farmers started their cultivation on state land or inherited land, and water bills had not been paid until 2004 (for the most part). The comparison of costs in terms of the percentage of water cost of the total farming for each farm typology is introduced below.

It can be said that agriculture was productive and profitable until the early 2000s. The loss of productivity after that date can be related in part to a decrease in water quality directly affecting crop production. Towards the mid-2000s production costs had increased, with labor wages rising from 70 JD/month to 280 JD/month. Energy costs also increased following the war in Iraq in 2003 (the price of one oil barrel rose from 6 JD to 104 JD). As a result of the increase in costs, a number of farms have been abandoned and locals have left the area. On the other hand, some farms in Azraq, particularly in the south, are still being cultivated and some in eastern area were found to be profitable. Our fieldwork suggests that these farms continue to be cultivated not because profits are being maintained but because families have no means to replace agricultural income (since they have been doing this activity for over 40 years in some cases).

Seven types of farms were defined in Azraq (Table 16 and Table 17). Olive is the dominant crop found in 6 types of farms (regardless of the area). Alfalfa is the second cultivated crop after olives.

Table 16. Azraq farm typology

Farm type	*Average size (du) (Cultivated area)*	*Number of farms found in the fieldwork*
Small olive tree farm	23	16
Large olive tree farm	750	1
Small professional alfalfa farm	45	2
Professional olive tree farm	253	10
Professional farm with olive trees and alfalfa	249	11
Professional farm with olive trees and grape	142	9
Vegetable farm	250	1
Total		***50***

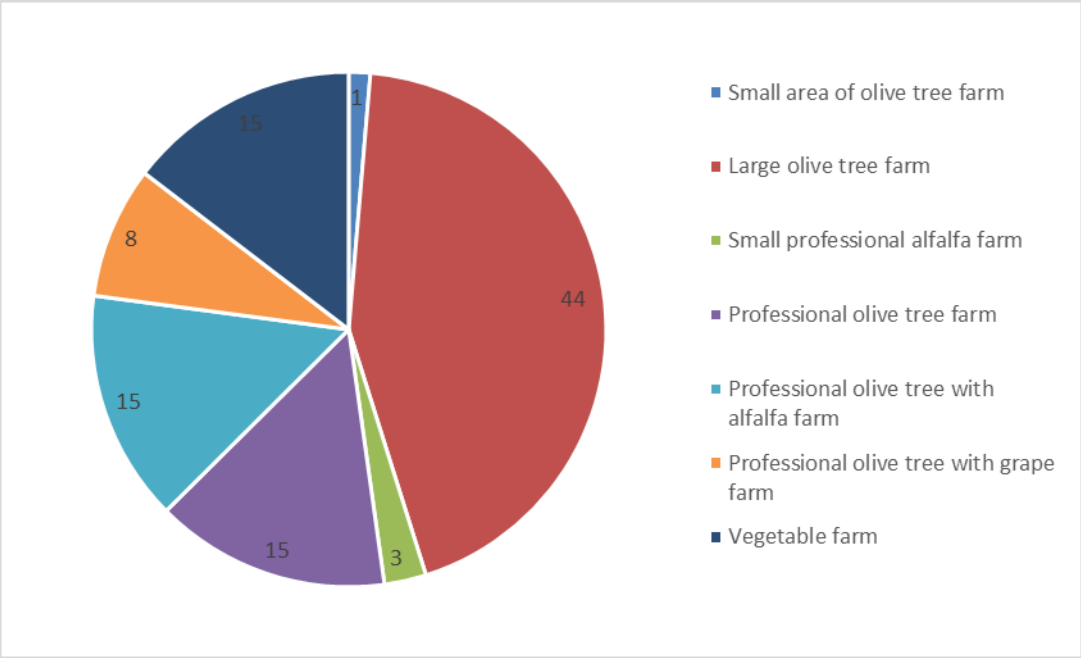
Table 17 Details on Azraq farm typology

Farm Typology	*Average size (du)*	*% of farm*	*Water consumption (m3/du/yr)*[11]	*Average profit (JD/du/yr)*[12]
Small area of olive tree farm	23	1%	1287	223
Large area of olive tree farm	750	44%	790	92
Small professional alfalfa farm	45	3%	1065	168
Professional olive tree farm	253	15%	1015	-18
Professional olive tree with alfalfa farm	249	15%	852	50
Professional olive tree with grape farm	142	8%	947	176
Vegetable farm	250	15%	600	338

[11] Water consumption is calculated according to summation of total annual water consumption (as it indicated in the bill) for each farm divided by the total cultivated area

[12] Profit calculation includes (annual return from production and market price - cost of energy, water, input and labour)

Figure 30. Typology of farms in Azraq (in percentage)



4.4.2 Detailed farm typologies in Azraq

4.4.2.1 Small olive farm

Location: 16 out of 50 farms are categorized as small olive farms. Seven of these farms are found in south Azraq, five in Awshaq and four in Ratameh.

Size: farms size range from 3 du to 42 du.

Average area: 23 du.

Land status: 15 farms are legal farms where the owners have an official land deed. Only one farm was found to be illegal, located in Awshaq (one Druze farmer cultivated it, hoping to claim the land and he is still waiting). Farmers are Chechen and Druze, settled down in Azraq and cultivating the land. Land was then owned officially through a *taswiye* with the DLS. On average it took about 15 years for these settlers to get ownership of the land (one took 65 years to own it).

Farm establishment: one of the farms is very old (established in 1930 with the first arrival of Chechens to Azraq). The rest of the farms started in the early 1970s, and the illegal farm was allegedly established in mid 2000s.

Manager: the farm owner is the direct manager of the farm and lives in Azraq.

Cultivation: Olive is the dominant crop in this type of small farms. A small area of land (total of 5 du) may be also cultivated with alfalfa as intercrop. Grapes, date palms and fruit trees are found also but mainly for family consumption.

Irrigation system: surprisingly only one farm was found still using surface irrigation techniques (flood irrigation) while the rest had installed improved irrigation techniques such as open tube and virojet since the 2000s.

Well status: 19 wells are in use in the sixteen farms. Three of the farms have two wells. This could be explained by the deterioration of water quality as two farmers dug one additional well each since groundwater in the old ones was of poor quality (salinity levels and SO_4). Since 7 of these farms are located above the more saline aquifer, owners have had to find additional sources of water and drilled additional wells hoping to reach less saline water baring formations. 4 wells out of 17 are illegal, without a permits.

Water consumption: average 1,287 m^3/du/yr.[13]

Salinity: Average salinity 1,400 ppm,[14] farmers also indicated that they faced a problem with high SO_4 concentration in water, in parallel with the salinity problem.

Water table: Average well depth was found to be 54 m, while water table can be found at 37 m. Before 20 years it was at 10 m depth and some farmers indicated that there were a time when water table was found at the surface.

Labor: two types of labor were found in the area: one is permanent labor (usually Egyptians), living in the farm and with an average monthly salary of 210 JD/month. The second type of labor is temporary labor (seasonal work during harvest) with an average salary of 250 JD/month.

Profitability: This type of farms is considered as profitable; all interviewed farmers indicate a positive revenue. Average profit reaches 223 JD/du/yr. During the field visits it was noticed that in the past this category of farmers dominated largely, but due to salinity their land deteriorated on a yearly basis and in the 2000s many farms reached a point where they were not profitable any more.

Table 18. Small olive tree farm characteristics

	Small olive farms
Location	South Azraq, Awshaq and Ratameh
Size	3 du – 42 du
Average size	23 du
Land status	Land are legal with official deed unless one
Farm establishment	1930, late 1960s and early 1970s, early 2000s (only one)
Manager	Chechen and Druze settlers
Cultivation (average du)	Olives 25 du; grapes 4; date palm 2 du; 2 du fruit
Irrigation System	Surface, virojet and open tube
Well Status	4 of 19 wells are illegal wells
Average water consumption	1287 m3/du/yr
Average salinity	1400 ppm with high SO4 concentration
Water table	Avg well depth: 54 m; avg water table: 37m; early water table level 10m
Labor	210 JD/month
Costs	Water: 8%; Energy: 17%; Input: 18%; Labor: 56%
Profit	223 JD/du/yr

[13] This is calculated based on the average of all farm water consumption (only from farms with records).

[14] Data from WAJ.

4.4.2.2 Large olive farm

Location: only one farm has been found pertaining to this type, located in Al Hora.

Size: 1200 du, cultiavted area 750 du.

Average area: 1200 du.

Land status: Illegal – Hijjeh; the owner bought the land from Bedouins through a fake *hijjeh*. However, it was known after that the land was already owned by someone else with a *hijjeh*, so he had to buy the land again from the previous owner. He applied for a settlement procedure to the DLS. Accordingly he cultivates the land with olive trees but is still waiting for a call to be opened in order to legalize the land.

Farm establishment: since 1998.

Manager: The owner himself, he lives in Azraq.

Cultivation: Olive trees.

Irrigation system: drip irrigation system.

Well status: two illegal wells (registered and not registered).

Water consumption: 790 m^3/du/yr.

Salinity: no high salinity has been noticed in Al Hora area, the salinity equals 330 ppm.

Water table: water table in 1998 was at 14 m depth, now it can be found at 32 m.

Labor: 300 JD/month, since al Hora area is far away from the city and does not have a paved road, hired labor stays and lives in the farm.

Profitability: this type of land was established in order to claim land; cultivation of olive tree was the easiest tree to be cultivated since it needs less maintenance. The land is illegally owned, wells are illegal, municipal services can't serve this kind of farm so the owner has to ensure his own energy source and open roads to the farm. Solar panels are the source of energy in this farm. This type of farm in this area has the potential to be profitable in the future since water quality is still good and energy costs could decrease with the introduction of solar panels to power the pumps.

Table 19. Large olive tree farm characteristics

	Large olive tree farm
Location	Al Hora
Size	1200 du, 750 du cultivated
Average size	1200 du
Land status	Illegal and bought by hijjeh from Bedouins
Farm establishment	Late 1990s
Manager	Palestinian farmer
Cultivation	Olives
Irrigation System	Drip irrigation system
Well Status	Two illegal wells
Average water consumption	790 m3/du/yr
Average salinity	330 ppm
Water table	Avg well depth: 43 ml, avg water table: 32m, old water table 14m
Labor	300 JD/month
Costs	Water: 13%; Energy: 58; Input: 19%; Labor: 10%

4.4.2.3 Small professional alfalfa farms

Location: two farms out of fifty are located under this group, one is located in Awshaq and the second is located in Ratameh.

Size: 20 du – 100 du.

Cultivated area : 20 du – 70 du.

Average area: 45 du.

Land status: one of the farms has an official DLS deed, while the second is being claimed by a Druze farmer who wants to increase his profit through the cultivation of alfalfa without paying either for land or water.

Farm establishment: one farm started in early 1970s while the one being claimed started in 2010.

Manager: the owner is a Palestinian investor living in Amman but the farm is managed by a permanent manager who lives in the farm, while the second farm is managed by the Druze farmer.

Cultivation: Alfalfa and olive.

Irrigation system: Sprinkler irrigation system.

Well status: three wells were found in the two farms, two are registered with permits and one is illegal not registered well (water bills are not paid).

Water consumption: average water consumption at 1065 m^3/du/yr.

Salinity: no salinity problem was indicated by farmers.

Water table: 20 years ago the water table was very shallow (at the surface), now it has decreased to around 16 m.

Labor: 450 JD/month.

Profitability: these farms are considered profitable since the owner is not paying for water bills and alfalfa gives high production and has an easy access to markets. Average profit for such a farm equals 168 JD/du/yr.

Table 20. Small professional alfalfa farm characteristics

	Small professional Alfalfa farm
Location	Ratameh and Awshaq
Size	20 du – 70 du
Average size	45 du
Land status	Legal land and Illegal claimed state land
Farm establishment	1973 and 2010 (claimed state land)
Manager	Outsider manger and Druze farmer
Cultivation	Alfalfa
Irrigation System	Sprinkler irrigation system
Well Status	Three wells; two registered with permit and one illegal not registered
Average water consumption	1065 m3/du/yr
Average salinity	No salinity
Water table	avg water table: 16m, old water table 0m
Labor	450 JD/month
Costs	Water: 0%; Energy: 21%; Input: 0%; Labor: 78%

Figure 31. Example of small professional alfalfa farm

4.4.2.4 Professional olive farms

Location: Ten out of fifty farms belong to this category. Farms are located in different places: two farms in Awshaq, three farms in Um Al Mahayel, two farms in Alewat and three farms in north Azraq (Ain El Beida).

Cultivated area: Ranges from 55 du – 1000 du.

Average area: 253 du.

Land status: three farms are illegal, the rest is legal.

Farm establishment: land was owned by hijjeh then transferred to legal deed by *taswiye* and *tafweed*, farm ages vary widely from the late 1960s to the 2000s.

Manager: these farms are managed by both farm owners and managers. Some farm owners know about agriculture by experience more than educated managers.

Cultivation: Olives.

Irrigation system: Open tube and virojet is used in all farms.

Well status: each farm has one well, with most wells registered wells with permits. Three wells were found illegal, related to the land status which is still owned by *hijjeh*.

Water consumption: 1015 m^3/du/yr.

Salinity: High salinity levels were not noticed in these farms. The highest salinity concentration recorded was in North Azraq (Ain Al Baida farm), reaching 1,100 ppm.

Water table: average well depth was found to be 88 m, with a water table found at 55 m deep.

Labor: farms have both temporary and permanent laborers. Temporary laborers are called in during the harvesting season. Average monthly salaries for the permanent labors vary between 250 and 600 JD (mainly depending on farm location and distance to the city center). This is due to the fact that labour in Alawat is more expensive due to transportation costs (as it is far from the city center and the road is not paved). Average salaries for temporary laborers range from 200 to 300 JD. Farms bring at least ten labors in the harvesting season, but it also depends on the farm area, the number and age of trees.

Profitability: in these farms the highest cost is energy (since half of the farms are still using diesel engines instead of electricity or solar energy). Accordingly, four out of the ten farms surveyed are not profitable and losing money. The average of their profits for all 10 farms surveyed is -18 JD/du. This type of farm has the potential to be more profitable if users convert to electricity or solar-powered irrigation, or if they partly shift to alfalfa (next type). Costs are also high due to higher water depths.

Table 21. Professional olive tree farm characteristics

	Professional olive farm
Location	Al Awshaq, Um AL Mathayel, Ain El Beida, Alewat
Size	55 – 1000 du
Average size	253 du
Land status	7 farms have a land deed while 3 are still illegal
Farm establishment	1969, 1978, 1988, 1990, 1993, 1996, 2000, 2003
Manager	Both farm owner and external professional manager
Cultivation	Olives
Irrigation System	Localized irrigation system (virojet and opentube)
Well Status	Both legal and illegal wells
Average water consumption	1015 m3/du/yr
Average salinity	330 – 1100 ppm
Water table	avg water table: 40 m
Labor	Permanent labors: 250 – 600 JD/month Temporary labors: 200 – 300 JD/month on average
Costs	Water:1% (farmers are not paying water bills); Energy: 37%; Input: 28%; Labor: 34%

4.4.2.5 Professional olive tree farm with alfalfa

Location: farms presenting the combination of olive tree cultivation with alfalfa are located in: Degaileh (2), South Azraq (2), Ratameh (1), Ain Al Beida - North Azraq (2), and Um al Matahyel (4). It can be said that is cultivation pattern is extended to almost all cultivated areas in Azraq region.

Size of cultivated area: 32 – 500 du. This type of farm has been established according to professionalization of farm management regardless of the area. Cultivation of alfalfa is increasing due to the high profits. Alfalfa is cultivated as an intercrop with olive trees.

Average area: 249 du.

Land status: 40% of this farm type is owned illegally, either by hijjeh or by claiming as state land. Six Palestinian bought land from Bedouins by hijjeh. It was also found that four Druze farmers are claiming state land for this type of cultivation**.**

Farm establishment: a number of farms were started when the settlers first came to the area in 1930, while other farms were established lately in the beginning of 2000s by Palestinian investors.

Manager: legal land farms are managed by a permanent manager who will come frequently to the farm. 60% of farm owners are Palestinian living in Amman, who bought the land from settlers. The illegal farms are managed directly by the farm owner (Druze) with help from Egyptian laborers.

Cultivation: Olive and alfalfa are the main cultivated crop; some farms cultivate a small area of fruit trees (total of 10 du in all farms), grape (total of 86 du in all farms) and vegetables (total of 45 du in all farms).

Irrigation system: farm managers have converted all irrigation techniques into localized irrigation system (sprinkler, virojet, opentube and GR).

Well status: Farms with legal land have registered wells, while the rest have illegal wells since they cannot legalize them without having an official land deed.

Water consumption: 852 m^3/du/yr.

Salinity: High salinity is present in south Azraq farms. One owner is thinking to establish a desalination plant to reduce water salinity (as already seen in the south of the Jordan Valley for banana).

Water table: 20 years ago the water table was found on average at 10 m below the surface, now it is found at 31 m.

Labor: Both types of laborers are present in this type of farm (permanent and temporal). Egyptian laborers live inside the farm. The average salary for permanent laborers is 250 JD/month. Olives and alfalfa harvesting and packing need temporary laborers, and the average salary is 200 JD/month. Salaries for permanent labor are higher than for seasonal or temporary workers. In total however, the farm owner spends more on seasonal workers as he brings in between 15 and 40 laborers during the harvest season, while he has only 2 permanent staff.

Profitability: profit varies greatly from farm to farm. Most of these farms are generally in deficit. However they make profit by cultivating alfalfa (each dunum generates 75 JD in profit every harvest of alfalfa). The highest benefit gained by this farm type 312 JD. The highest cost for these farms is energy since a lot of farms are still using diesel engines (40% of the farming costs are for energy, which might be the reason also for some farms' economic deficit).

Figure 32. Example of professional olive tree farm with alfalfa

Table 22. Professional olive tree farm with alfalfa characteristics

	professional olive with alfalfa farm
Location	Degaileh
Size	24 – 500 du (cultivated)
Average size	249 du
Land status	Both legal and illegal
Farm establishment	1930, 1985, 1990, 1991, 1994, 2001, 2002, 2004, 2007
Manager	Both farm owner and external professional manager
Cultivation	Olives and alfalfa
Irrigation System	Localized irrigation system (virojet, GR and opentube)
Well Status	Both legal and illegal wells
Average water consumption	852 m3/du/yr
Average salinity	No salinity
Water table	avg water table: 31 m, old water table 20m
Labor	Permanent labors: 250 JD/month Temporary labors: 200 JD/month on average
Costs	Water: 4%; Energy: 40%; Input: 21%; Labor: 34%

4.4.2.6 Professional olive tree with grape farms

Location: nine farms are located under this group mainly located in east farm are: Ain Beida - North Azraq (3), Um al Mathayel (4), Degaileh (1), and Ratameh (1).

Size: 50 – 350 du.

Average area: 142 du.

Land status: Both legal and illegal.

Farm establishment: since the 1970s, 1980s, 1990s and 2000s.

Manager: two types of manager are found, farm owners and permanent managers.

Cultivation: Olive trees and grape.

Irrigation system: all farms turned to localized irrigation techniques as virojet and opentube since the late 1990s.

Well status: both registered illegal and non-registered illegal wells, as some farms are still illegal.

Water consumption: 947 m3/du/JD.

Salinity: varies according to the area started with no salinity at all to 700 – 1500 ppm.

Water table: Average water table on 2008 was at 17 m but now it is 25 m.

Labor: 300 – 500 JD, depend on farm area.

Profitability: This type of farm ranks third in terms of profit, with an average of 176 JD/du/yr. This profit is partly due to the fact that 70% of farm owners are not paying their water bills. Grape easily finds its way to export markets. Profit can be increased, as some farms are still using diesel as a source of energy.

Table 23. Professional olive tree with grapes farms characteristics

	Professional olive tree with grapes farms
Location	Ain El Beida – North Azraq, Um Al Mathayel, Degaileh, Ratameh
Size	50 – 350 du
Average size	142 du
Land status	Both legal and illegal
Farm establishment	1970, 1971, 1979, 1980, 1983, 1990, 1999, 2003, 2006
Manager	Both farm owner and external professional manager
Cultivation	Olives and Grape
Irrigation System	Localized irrigation system (virojet, GR and opentube)
Well Status	Both legal and illegal wells
Average water consumption	947 m3/du/yr
Average salinity	700 -1500 ppm
Water table	avg water table: 25m, old water table 17m
Labor	Permanent labors: 300 JD/month Temporary labors: 500 JD/month on average
Costs	Water: 4%; Energy: 51%; Input: 21%; Labor: 24%

Table 24. Summary of farm typology in Azraq

Farm Type		*Small Olive Farm*		*Large Olive Farm*		*Small Professional Alfalfa Farm*		*Professional Olive Farms*		*Professional Olive Farm with Alfalfa*		*Professional Olive with Grape Farms*	
		%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Year to own land	**Zero years**	31	5		0		0	10	1	0	0		0
	0 - 20 years	38	6		0	50%	1	40	4	33	5	56	5
	more than 20 years	25	4		0		0	30	3	33	5	22	2
	Still Illegal	6	1	100%	1	50%	1	20	2	33	5	22	2
Well Status	**Legal**												
	Illegal Registered	95%	17	50%	1	67%	2	80%	8		16	82%	9
	Illegal not registered	5%	1	50%	1	33%	1	20%	2			18%	2
Year of Well Installation	**Before 2002**	78	14		NA	75%	2	80	8	75	12	55	6
	After 2002	22	4		NA	25%	1	20%	2	25	4	56	5
Average Well Depth		54		45		46		88		55		82	
Average Water Depth		37		32		16		55		31		25	

4.5 Farming systems in Mafraq[15]

Mafraq agriculture and farming systems are different compared to Azraq, despite both areas being located inside the same basin. Most particularly, Mafraq's aquifer is deeper and underlies the aquifer system exploited in Azraq; groundwater is found at around 350 m below the surface, making groundwater abstraction very expensive (pumping costs). Therefore, agriculture in Mafraq is limited to capitalized business entrepreneurs and 99% of farms studied for this report are profitable investments. Illegality is not an issue in Mafraq, as all lands and wells are legal. This is due to the high risk for investors to cultivate illegal lands with illegal wells, which is not compatible with the high capital outlay needed for a 500 meter deep well.

The dominant cultivation in Mafraq (North Badia) area is stone fruit trees, with climate conditions favorable for this type of trees. Farmers indicated that Mafraq area produces 300,000 ton of stone fruit (apricots, flat apricots, peach and nectarines) between the first of May and the 15th of August. Only 5% of this production is enough to cover the country's needs, the rest is exported to the Gulf countries and Syria.

Stone fruit tree production is divided into three stages: 1) early stage production, from 1 May till 15 of June; 2) mid stage: it started from 15 June till 15 of July; and 3) late stage is started from 15 of July till 15 of August. Production in the early stage is 1.5 – 2 ton/du, while it increases in the second and late stage to 3 – 4 ton/du. Prices are higher during the first and late stage (due to high market demand and low production), as it sells at 80 -100 cent/kg against 40-50 cent/kg in the mid-stage. The life cycle for the stone fruit tree varies between 10 and 12 years, with production starting after the third year and reaching its peak when the trees are between 4 and 10 year old. Some farmers store the late stage production in cold storage rooms and sell it after the season to get more profit. Each of these storage rooms has a capacity of 20 tons and costs about 2,500 – 3,000 JD.

The conflict in Syria has encouraged farmers to extend agriculture and cultivate vegetables as the demand increased due to a decrease in vegetable production from Syria. The dominant vegetable crops produced in Mafraq are: tomato, pepper, eggplant and cauliflower. Vegetables are cultivated in both open field and greenhouses. Average tomato production under greenhouse in Mafraq equals 14 t/house (0.5 du) while it produced 12 ton/du in open fields. Average production for peppers equals 10 t/house and 8 ton/du in open field conditions.

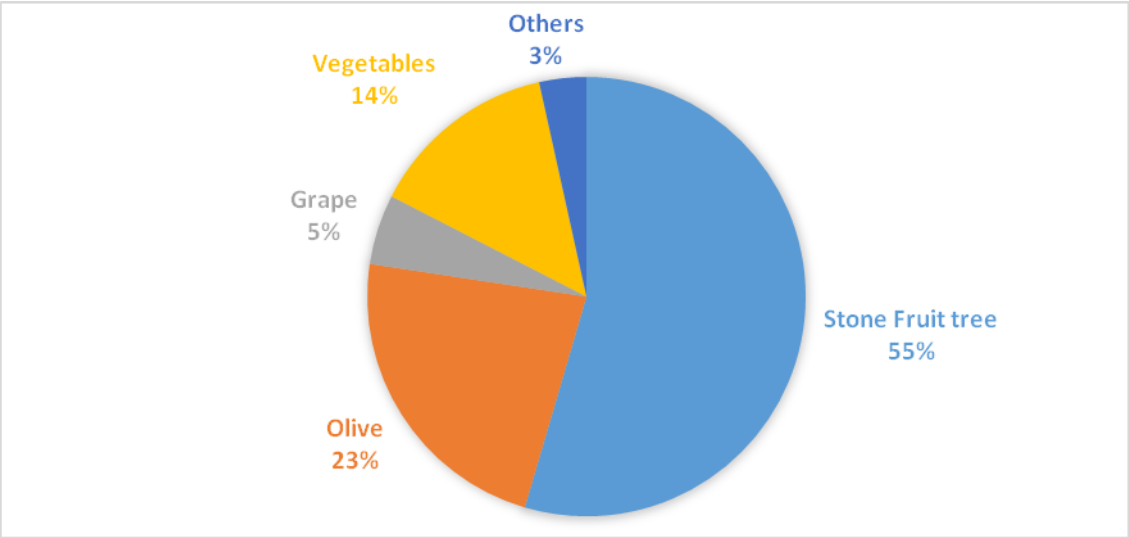
Some farmers rent their properties to a manager in order to avoid the risk of direct cultivation. The manager will take care of production and sell it. This arrangement is called 'pledge' and can be motivated by the fact that the owner has no time for taking care of farming activity and/or prefers to reduce risk and uncertainty by resorting to a professional. Two types of farm pledge were indicated by farmers: the first is to pledge the whole farm to a manager who will handle the entire production process in the farm. The second is to pledge the fruit only, so the pledger only has to harvest the production and sell it on the market. Farm pledge prices vary from one to another and depend mainly on the production amount, but in general it costs between 250,000 for an assumed 600 ton production, and 400,000 JD for an assumed 800 ton production of stone fruit, for a 300 du farm. Labor, electricity and water bills are on the account of the pledger.

During the fieldwork period almost all the farmers were complaining about frost occurrence during 2014, as between 30 and 45% of farm production was lost due to a sudden frost.

[15] Fieldwork was conducted in Mafraq during 2014 and consisted in 36 interviews covering 30 farms (of which 27 generated enough data to be analyzed).

Olive cultivation is rarely absent from any farm type in Jordan in general (as seen above for Azraq), but in Mafraq olive is only present at a level of 23%. Figure 33 shows the percentage of each crop in Mafraq area, based on the fieldwork conducted.

Figure 33. Percentage of crops in Mafraq area (based on fieldwork data)



Farm typology has been defined in Mafraq area mainly based on the cropping pattern in each farm as it appears in Table 25.

Table 25. Farm typology in Mafraq

Farm Typology	*Average area (du) (Cultivated area*
Stone fruit tree farm with olives	1220
Stone fruit tree farm with olives and grape	691
Stone fruit tree farm with grape	568
Stone fruit tree farm	338
Vegetables farm	283

From Table 31 it is possible to observe that energy costs are the highest cost in all farms in Mafraq due to groundwater depths. Water costs were found to be the lowest. This can be explained by the cheap water tariff in Mafraq area and the fact that groundwater is free for the first 150,000 m3/yr regardless of the area. All farms in Mafraq are profitable. Stone fruit tree production provides the highest revenue to farm owners compared to other crops such as olive and grape. Vegetables are found in almost all farms (cultivated in a small patch of land). Farmers with new farms tend to cultivate vegetables in parallel with stone fruit trees since the stone trees need at least three years to yield a profit (so meanwhile farmers will cultivate vegetables to earn some money). Drilling a well in Mafraq area costs around 100,000 JD for a depth of 300m. The cost of establishing drip irrigation techniques is 100 JD/du. Below are some pictures as examples of a vegetable farm, a stone fruit farm and the new cultivation of fruit trees in Mafraq.

Figure 34. Example of vegetable farm

Figure 35. Example of stone fruit farm

Figure 36. New stone fruit tree cultivation in Mafraq

Table 26. Farm typology in Mafraq

	Stone fruit tree farm with olives	*Stone fruit tree farm with olives and grape*	*Stone fruit tree farm with grape*	*Stone fruit tree farm*	*Vegetables farm*
Location	Um Al Quten, North Badia	Jaber, Um Al Quten, North Badia, Sabha, Qutraneh, ashrafieh	Zumla Al Amir Ghazi, Hamdieh, Mukefteh, Um Al Jamal, Ashrafieh	Zumla Al Amir Ghazi, Um al Quten, North Badia, Nayfeh, Mukefteh	Ashrafieh, Sabha, North Badia
Number of farms	5	6	5	7	3
Size - Cultivated	200 – 4000 du	350 – 1450 du	300 – 1050 du	140 – 535 du	210 – 400 du
Average size	1220 du	691 du	568du	338 du	283 du
Land status	legal				
Cultivation	Stone fruit tree, Olives, small area of Vegetables	Stone fruit tree, Grape, Olive, small area for vegetables	Stone fruit tree, Grape, small area of vegetables	Stone fruit tree, small area of vegetable	Vegetables
Irrigation System	Localized irrigation system (JR, Virojet0				
Well Status	Legal				
Average water table depth *(before means avg of 20 yrs)	W.T. before: 309m W.T now: 355m	W.T. before: 256m W.T. now: 347m	W.T. before: 309m W.T now: 312m	W.T. before: 360m W.T. now: 369m	W.T before: 350m W.T now: 396m
Average well depth	470m	450m	400 m	467m	450m
Average water consumption (m3/du/yr)	1007	906	1330	1068	823
Average salinity	Salinity were not found in Mafraq area Average Salinity in all farms 300 ppm				
Cost	Water: 5% Energy: 53% Input: 31% Labor: 11%	Water: 7% Energy: 54% Input: 25% Labor: 14%	Water: 10% Energy: 32% Input: 40% Labor: 18%	Water: 5% Energy: 30% Input: 28% Labor: 37%	Water: 1% Energy: 43% Input: 18% Labor: 38%
Profit	1296 JD/du/yr	1123 JD/du/yr	1963 JD/du/yr	1994 JD/du/yr	1338 JD/du/yr

4.6 Farming dynamics and constraints

4.6.1 Labor

As mentioned above, two types of labor are found in Azraq: permanent and temporary. Permanent workforce stays in the farm 24/7 and normally comes from Egypt or Yemen. Temporary labor is brought seasonally during the cultivation and harvesting seasons upon farm needs.

In order to hire external workers for farming, a labor permit needs to be issued by the Ministry of Labor with approval from the Ministry of Agriculture. Theoretically, only farms with legal land deeds can obtain labor permits. This was not applied in 1997 and 1998 as the minister of agriculture in that time neglected the relation of having labor with a land deed, however now labor permits are connected to land deeds and farmers without land deeds require to use the services of brokers to hire labor. By law farmers can hire one worker for each 10 dunum cultivated. This rule was overly generous and this right has now reduced to one worker for each 50 du. Some farmers have been complaining as they did not obtain the adequate number of permits for their cultivated area (interview 4, 9 March 2015 and interview 12, 19 June, 2013).

The Ministry of Agriculture is the entity that decides on the number of workers per farm according to the cultivated area but in fact no one from the ministry goes to the field to check the actual cultivated area. The procedure to obtain labor permits is as follows: after obtaining an official letter from the Ministry of Agriculture indicating the number of permits each farm can apply for, the farm owner has to bring a copy of the passport of the workers to be hired (either from the worker directly or through a labor broker). Interviews suggest that the labor market is controlled by these labor brokers (Interview 23., 1 May, 2014; Interview 22., 17 May, 2014; Interview 25., 1 May, 2014; Interview 20., 17 May, 2014 and Interview 26., 1 May, 2014). Farmers prefer dealing with labor brokers than going through the long procedure of applying for the official documents and permits themselves. Brokers can sell and buy labor licenses, facilitate the travel of workers from abroad, but also provide farmers with seasonal daily workers, taking a commission in return. In general, there is enough availability of labor force in Azraq but some farmers have faced problems with permanent workers ‘fleeing’. These permanent workers stay at the farm for a short period of time then migrate to cities like Amman without informing the farmer.

Demand for labor in urban areas, notably from the construction sector, have pushed some farmers to declare larger farming areas in order to get more permits (Interview 19., 24 April, 2014; Interview 23., 1 May, 2014; Interview 22., 17 May, 2014; Interview 30., 19 June, 2013 and Interview 20., 17 May, 2017). This surplus labor can be transferred to the construction sector, for which middlemen will pay between 300 and 800 JD to the farmer ceding 'his' workers (the monthly salary a worker is 300-350 JD in Azraq, but 750 in the construction sector in Amman). But this 'right' has now been reduced to one worker for each 50 du. And a new law has been passed to disallow the granting of work permits to farms with unregistered wells.

In 1997-1998 the Minister of Agriculture changed the labor law, authorizing the use of workers in illegal lands (or land with *hijjeh*). The reason for such change was due to the fact that tribe relatives of the then minister had illegal dunums in Azraq, and therefore were able to obtain permits for their workers or to sell their permits to other farmers (interview 8, 23 May, 2014). This measure did not last long however as, a year later in 1998, a new minister was assigned and changed the law, going back to the issuing of labor permits only with official land deeds.

Before the conflict in Syria, workers in Azraq were mainly from Egypt and a minority from Yemen. Following the waves of refugees from Syria, the composition of the workforce has changed. This has affected the labor market negatively from the farmer's standpoint, as Syrian workers do not accept the salaries paid to Egyptians. This raised salaries and the cost of labor in Azraq. Farmers will therefore prefer to hire Egyptian laborers permanently in the farms and hire Syrian workers for seasonal work.

4.6.2 Land

As described before, Azraq became an attractive place to invest in agriculture due to cheap and easy land and water access, the availability of labor and the presence of markets for export. However, uncertainty surrounding land ownership remains and affects agriculture investments. As explained earlier, two types of land are cultivated in Azraq: 1) land owned legally with an official land deed; and 2) land with *hijjeh* which does not grant or protect the right to ownership of the land from an official standpoint; to which can be added land directly settled, used and claimed by local Bedouins. A number of investors preferred to buy land legally, thus avoiding uncertainty and risking their investments. Other tried to buy land cheaply with *hijjeh*, aiming to legalize it later and expand agriculture. Facing this dual situation, it is difficult therefore to compare land prices as they are influenced by the existence of an official land deed or not, whether the land plot includes a well or not, whether the well is legal or not, its discharge, and water quality, and whether the land plot has access to electricity from the grid. Decreasing water table levels and the deterioration of water quality are also factors that can potentially reduce the value of the land and also increase uncertainty for agriculture in Azraq.

As indicated earlier land prices have skyrocketed and have fueled a speculative land market in the 2000s (Al Naber and Molle 2016). In Mafraq, one dunum of land which was sold at 30 JD in 1995 now reaches 1000 JD. In Azraq most recent prices range between 2000 and 4000 JD/du, while some investors recall that in the 70s land in this area could be obtained for 1JD/du…

4.6.3 Well costs

Wells in Azraq can be legal or illegal, registered or un-registered. The drilling and installation of the different well parts represents the largest portion of a farm's initial capital cost. The average cost for digging a legal well is 120 JD/m, including the drilling costs, pipes and casing (without the pump). Drilling costs only range between 35 and 45 JD/m, and twice that amount if the well is illegal. Pipe costs vary according to the diameter (from 40 to 70 JD/m).

The cost of the pump represents the largest part of the total cost. The cost of submersible pumps used in Azraq varies depending on its power and discharge, ranging between 6,000 JD for a 30 KWp pump to more than 20,000 JD for a 140 KWp pump. In Azraq, farmers can use small pumps with discharges starting from 30 m^3/hour, while in Mafraq farmers use pumps with discharges reaching 300 m^3/hour (Investments in agriculture need important amounts of capital in order to buy land, drill the well, obtain licenses, salaries, water and energy bills, as well as other farming inputs. The level of investment varies from place to place according to the region. Investments in Azraq are in general less costly than in Mafraq and the Jordan Valley in absolute value but still need an initial capital investment of no less than 1.5 million JD for a farm of 200 du (5,000 JD/du + 60,000 JD/well + farm running costs). Such large farms are therefore normally owned by large investors, while small farmers prefer to cultivate an average of 20 dunum, borrowing money from the bank and with support from the agricultural bank). This is due, as presented before, to the differences in farm size and capital invested between farmers in Azraq and in Mafraq.

Energy costs are considered one of the main constraints in agriculture in Azraq and Mafraq. These costs vary according to the area (Table 28). Normally, legal farms are connected to the electricity grid and pay a tariff of 60 fils/KWh. Illegal farms not connected to the grid rely either on diesel or (rarely) on solar energy. Farms in Mafraq are all connected to the grid (it would be too expensive to use diesel considering the depths at which groundwater is pumped).

Investments in agriculture need important amounts of capital in order to buy land, drill the well, obtain licenses, salaries, water and energy bills, as well as other farming inputs. The level of investment varies from place to place according to the region. Investments in Azraq are in general less costly than in Mafraq and the Jordan Valley in absolute value but still need an initial capital investment of no less than 1.5 million JD for a farm of 200 du (5,000 JD/du + 60,000 JD/well + farm running costs). Such large farms are therefore normally owned by large investors, while small farmers prefer to cultivate an average of 20 dunum, borrowing money from the bank and with support from the agricultural bank.

Table 27. Average discharge of pumps in Azraq and Mafraq

Discharge	*% in Azraq*	*% in Mafraq*
30 – 45m^3/hr	44%	8%
>45 – 60 m^3/hr	28%	10%
>60 – 85 m^3/hr	4%	33%
>85 – 100 m^3/hr	4%	33%
More than 100 m^3/hr	20%	16%

Table 28. Abstraction cost according to energy type in Azraq and Mafraq

Energy source	*Abstraction cost*
Diesel in Azraq	0.12 JD/^{m3}
Electricity in Azraq	0.015 JD/^{m3}
Electricity in Mafraq	0.136 JD/^{m3}

4.6.4 Crop selection

Water quality and quantity and the arid climatic conditions found in Azraq represent two major limitations for the type of crops that can be cultivated in Azraq. Aside from climatic and market availability considerations, crop selection incorporates several other factors: 1) low water requirement crops if the farmer is paying for water; 2) crops with high production and short life cycle in case of illegal cultivation; 3) crops tolerant to arid climatic conditions; 4) crop tolerant to salinity (if groundwater is locally saline); 5) low maintenance needs for crops (such as olive trees, when cultivated for the purpose of claiming land).

As described above, the main crop found in Azraq is olive, followed by alfalfa and grapes. In Mafraq, with different and more favorable climatic conditions and with security of land tenure, crops cultivated are mostly fruit trees and vegetables. The selection of crops is not directly affected by market prices as Highland production has its own market chain and production seasons, different from those of the Jordan Valley. Crop prices do not change a lot between years, increasing slightly due to the drop in Syrian produce in the market, with local products filling the gap (Table 30). Mafraq is the main producer of fruit in Jordan. Part of its production is sold internally following the country's needs, while the rest is exported to Iraq and the Gulf by truck. The cost of transport by truck and cooling are the main constraints facing the export of

products from Mafraq. In Azraq, olives are transformed into olive oil in local mills and each 20 liter sells for an average of 60 JD. Olive oil is exported to Palestine and Israel. Alfalfa is cultivated as a complementary crop to earn easy cash and is cultivated either illegally or as an inter-seasonal crop.

Based on the fieldwork results in both Azraq and Mafraq farms, Table 29shows the profitability of actual cropping pattern based on the total cultivated area of each crop and the total profitability/du.

Table 29. Profitability of main crops

Crop/ trees	*Profit (JD/du)*	*Crop/ Vegetable*	*Profit (JD/du*
Olive	352	Tomato	1311
Grape	2288	Pepper	895
Apple	2871	Cauliflower	118
Apricot	2585	Alfalfa	483
Apricot flat	2024	Cabbage	417
Nectarine	1812		
Peach	2265		

Farming input prices (fertilizers, pesticides, etc.) are controlled by private companies. Obtaining official figures on the historical evolution of input prices is difficult; farmers have been complaining about the high cost of fertilizers and suggested that farming inputs should be controlled by the Ministry of Agriculture rather than kept under private sector control.

Table 30. Agriculture production market prices (fils/kg) (MoA, 2014 and Dos, 2016)

	2005	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Vegetables										
Lettuce	187	163	160	200	154	152	125	116	146	160
Tomato	195	158	185	222	167	300	156	180	211	199
Cucumber	277	253	266	310	228	294	235	241	282	249
Pepper	346	351	365	357	284	301	320	435	430	424
Eggplant	155	168	165	189	143	228	186	203	220	252
Cauliflower	232	171	226	302	200	200	169	253	212	311
Fruits										
Citrus	309	444	450	697	500	727	683	677	631	639
Peach	525	503	493	546	562	737	814	645	846	886
Pears	545	562	578	569	638	685	715	609	682	920
Olive	805	795	850	879	752	745	764	767	804	967
Plum	446	539	429	568	568	637	504	583	543	637
Apricot	437	912	610	942	673	354	355	519	480	462
Nectarine	320	275	350	358	350	320	275	449	323	416
Apple	210	289	328	408	461	544	564	521	537	585
Pomegranate	505	510	495	550	452	605	652	558	722	778
Grapefruit	227	210	225	214	272	239	666	593	670	776
Water melon	135	136	144	205	144	160	173	193	197	206
Date Palm	532	525	550	514	555	635	839	605	530	468

4.6.5 Irrigation techniques

Drip irrigation is the irrigation technique most found in the study area, followed by sprinkler systems. The cost of establishing drip irrigation is around 120 JD/du. Maintenance of the drip irrigation system requires that the small plastic pipes are changed every three years and the main lateral ones every 10 years, on average (some farmers use higher quality material. The main problem faced by farmers using drip irrigation is the clogging of pipes and drippers with sediments in the water or salt deposits, as groundwater can be saline in some areas. Normally, farmers will change the drippers and/or install extra filters. If the case is severe then farmer ask for a permission to clean the well, increasing his system efficiency. Sprinkler irrigation system is mainly use for alfalfa cultivation. There is a lack of information about this system since normally alfalfa is cultivated illegally and farmers tend to avoid any question regarding it.

4.6.6 Water and other production costs

The distribution of production costs in Azraq and Mafraq are not the same (Table 31). Mafraq farms need more energy to pump water, and drilling costs are higher due to the depth of the water table. More labor is also needed as farms are larger than in Azraq. The types of crops in Mafraq also require more intensive labor (fruit picking, tree care, etc.) and land prices are much higher.

In both areas however, energy represents the major portion of costs, followed by labor (Table 31). Water is the cheapest cost in both locations. This is might be due to a lower water tariff compared to other production cost and also to the fact that these data have been obtained during interviews and fieldwork from direct answers from interviewees were some of them do not pay for water. A number of them do not pay for water but they have to pay for electricity. In many instances the connection to the grid is shared between the house and the farm so if the electricity company were to cut off power, it would also do so for the house. Labor and other production costs cannot be avoided and have to be paid.

Table 31. Production costs in Azraq and Mafraq according to farm type

Farm type	*Cost*			
	Water%	*Energy %*	*Input%*	*Labor %*
Azraq				
Small olive tree	8%	17%	18%	56%
Large olive tree	13%	58%	19%	10%
Small professional alfalfa	0%	21%	0%	78%
Large professional olive	0%	38%	28%	34%
Professional farm with olive and alfalfa	4%	40%	21%	34%
Professional farm with olive and grape	4%	51%	21%	24%
Vegetable farm	0%	4%	31%	65%
Mafraq				
Stone fruit tree with olive	5%	53%	31%	11%
Stone fruit tree with olive and grape	7%	54%	25%	14%
Stone fruit tree with grape	10%	32%	40%	18%
Stone fruit tree	5%	30%	28%	37%
Vegetable farm	1%	43%	18%	38%

Water productivity has been calculated as a ratio between the average annual profit and the average annual water consumption for each different farm type. Water productivity in Azraq

varied between 0.002 and 1 JD/m^3, with value of 0.002 for small olive farms, 0.26 for olive and alfalfa farms, 0.85 for olive and grape farm and 1 for professional alfalfa farms.

Water productivity in Mafraq farms varies between 0.54 to 0.97, with the lowest value found in stone fruit farms. Vegetable farms have a value of 0.59, and farms with grape and stone fruit have 0.88. The highest value of water productivity goes to farms with stone fruit and olive, with a value of 0.97. From Figure 37 and Figure 38 it is possible to notice that the economic value of water in Mafraq is higher than it in Azraq, which shows a better water management from an economic point of view.

Figure 37. Water productivity according to farm typology in Azraq

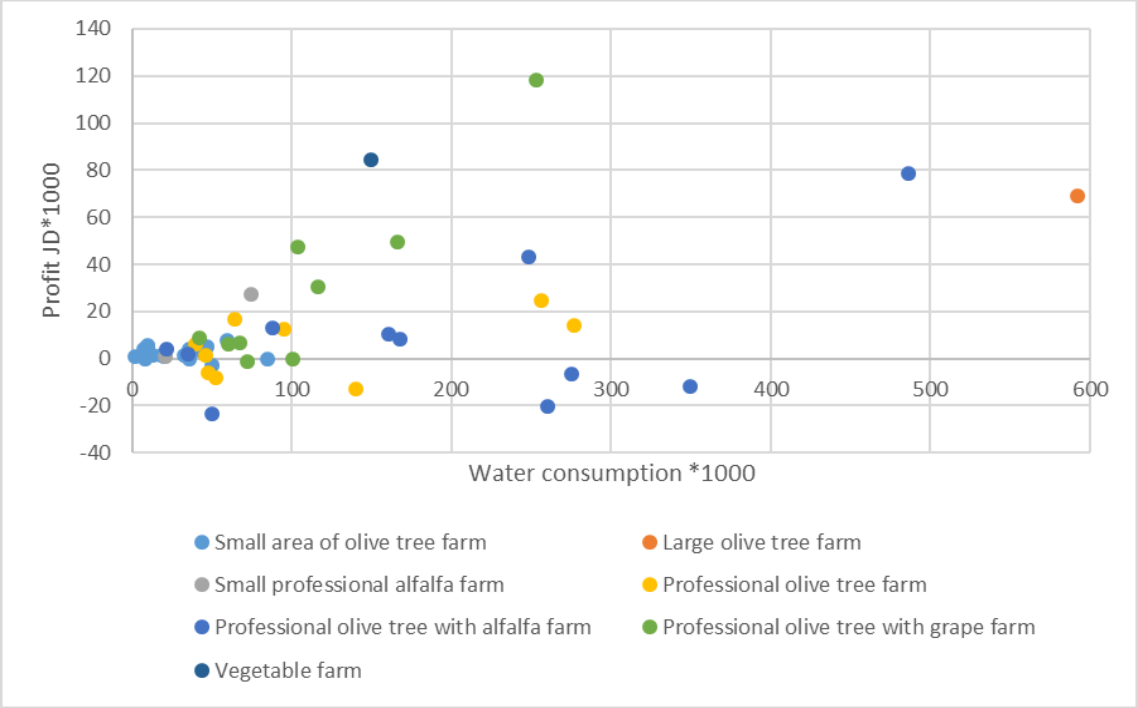
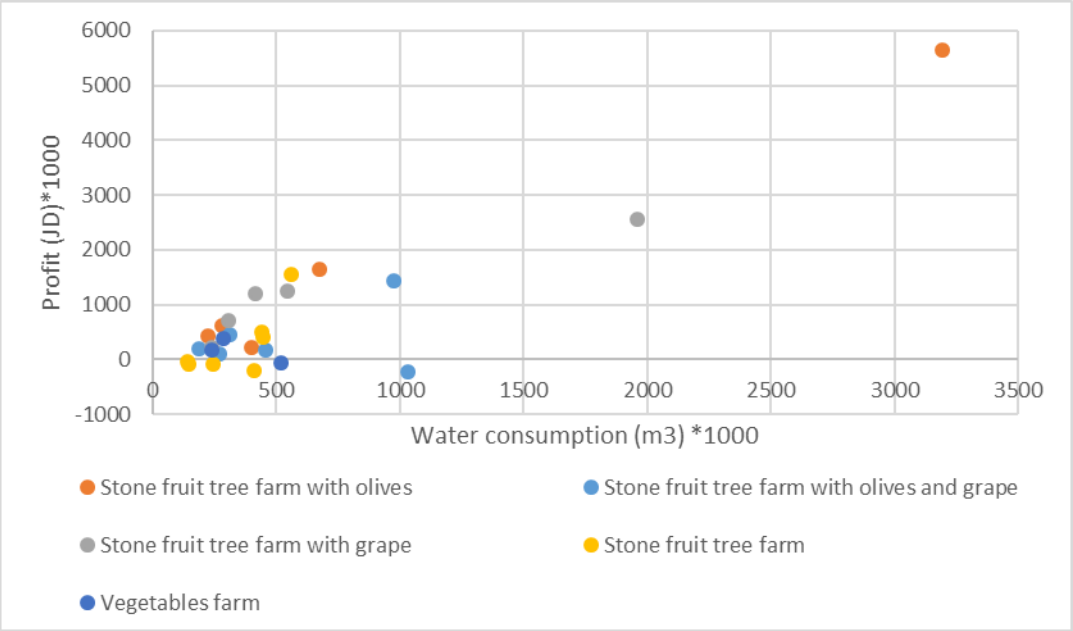


Figure 38. Water productivity according to farms typology in Mafraq



4.6.7 User participation and the Highland Water Forum

The Azraq basin has been the beneficiary of different local, regional and international initiatives to promote sustainable water management and preserve groundwater resources. One of the most prominent initiatives is the Highland Water Forum, a GIZ-funded project which ran from 2010 to 2013. This project established a 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".[16] The central task of the forum was to come up with an action plan towards the sustainable management of groundwater. The process to develop the action plan followed several meetings with different actors in the basin from the lowest to the highest level. The plan was presented to the Minister of Water and Irrigation but no real action had been initiated as of late 2015.

At the beginning of the forum farmers were positive about its aim and the idea to have an open dialogue with policy makers from different entities such as WAJ, the Ministry of Water and irrigation, the Ministry of Agriculture, and the Azraq and Mafraq municipalities (Interview 7., 2 Oct, 2013; Interview 8., 23 May, 2013 and Interview 3., 30 Jan, 2013). During discussions, farmers raised the issues of illegal ownership of the land, of decreasing the water tariff or increasing the free allowable abstracted volume, and of considering Azraq on the safe footing as Mafraq when it comes to pumping allowances and tariffs (since both areas are located within the Azraq basin).[17] Farmers also raised complaints regarding the poor role of the Ministry of Agriculture in the area in terms of agriculture extension services and guidance. Farmers also reviewed the groundwater bylaw during one of the meetings and asked for a special tariff to be adopted for saline water in Azraq. Farmers asked the ministry to implement the bylaw fairly for all well owners without any exceptions. They also were open to adopting new techniques for agriculture like: irrigation technology, the use of distilled brackish water, and a cropping pattern

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

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

that would use less water, while asking for subsidies from the Ministry of Agriculture (highandwaterforum.wordpress.com).

At the end of the process, an action plan was prepared including four major areas for intervention (GIZ, 2016):

1. *Legal and institutional framework*: groundwater law, participatory approach in groundwater management, the interlinking between all governmental entities, issues related to transboundary aquifers in order to support sustainable management of groundwater.
2. *On-farm water efficiency*: Optimizing of cropping patterns, irrigation system efficiency, alternative sources of water like unconventional water.
3. *Alternative income opportunities*: generating alternative income outside agriculture like clean energy, salt industry, and tourism.
4. *Community development*: raising awareness about groundwater depletion, working on the use of non-conventional water at the municipality level, and looking into rainwater harvesting potential.

One of the main outcomes that farmers wanted to achieve with the forum was to establish a structure inside the Ministry of Water and Irrigation that would include local farmers and provide a direct channel for a selected group of trusted farmers to policy-makers inside the ministry. This structure would serve as a consultative body for issues related to groundwater management in Azraq. Despite this idea, a lot of promises were made by the conveners of the Forum and the forum staff (GIZ and MWI) but farmers consider that nothing really happened in the end (Interview 4., 9 March, 2015; Interview 8., 23 May, 2013; Interview 3., 30 Jan, 2013; Interview 29., 26 Oct, 2014; Interview 35., 10 Sep, 2015 and Interview 34., 6 April, 2015). 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 (Interview 4., 9 March, 2015; Interview 8., 23 May, 2013; Interview 3., 30 Jan, 2013; Interview 29., 26 Oct, 2014; Interview 35., 10 Sep, 2015; Interview 28., 6 June, 2013; Interview 31., 15 Aug, 2013 and Interview 34., 6 April, 2015).

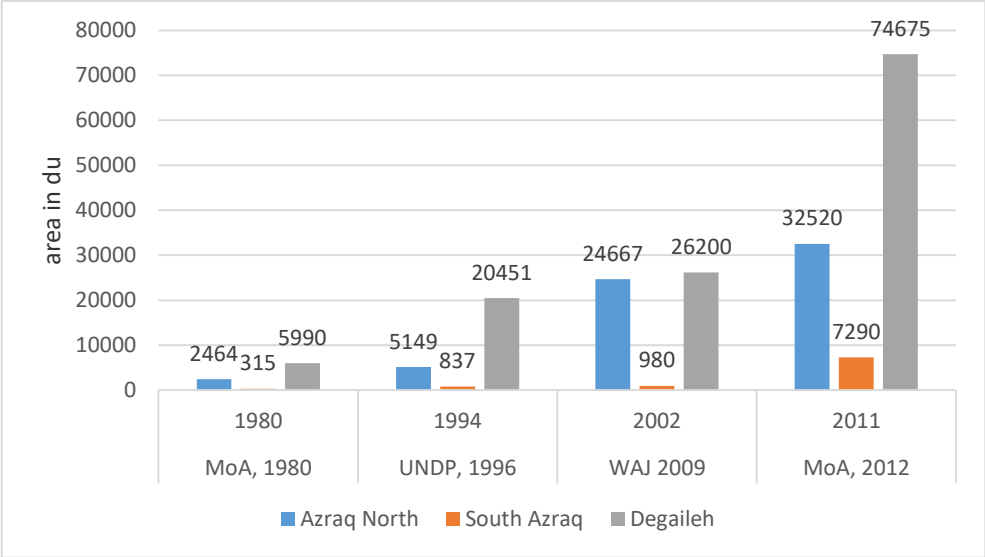
4.6.8 Prior characterization of farming practices in Azraq

As already mentioned in this report, agriculture in Azraq continues to expand. As shown by collected data on historical cultivated area, the 9,000 du cultivated in Azraq in the early 1980s increased to more than 100,000 du in 2010. Overall cultivation is concentrated in Degaileh and the Eastern farm area as discussed earlier in the report, while Azraq south has the least amount of land cultivated (Figure 39).

Following the increase in agriculture leading to environmental problems in the wetland, the Azraq basin has been a focal area attracting several international initiatives like the Azraq national dialogue in 2006 by the IUCN, the farming systems study in 2010 by the GIZ, and the USAID-funded socio-economic study of groundwater (ISSP) in 2015. Against this backdrop, this section provides some comparison of the quantitative data on farming practices in Azraq previously available through the GIZ study (2010) and 2015 (this study). In 2010, the German Development Agency project produced a report containing a general description of the physical and hydrological characteristics of the basin, highlighting the historical evolution and dynamics of agriculture development and water management. The document also discussed the dimension of public awareness about water overexploitation following the Water Bylaw No. 85

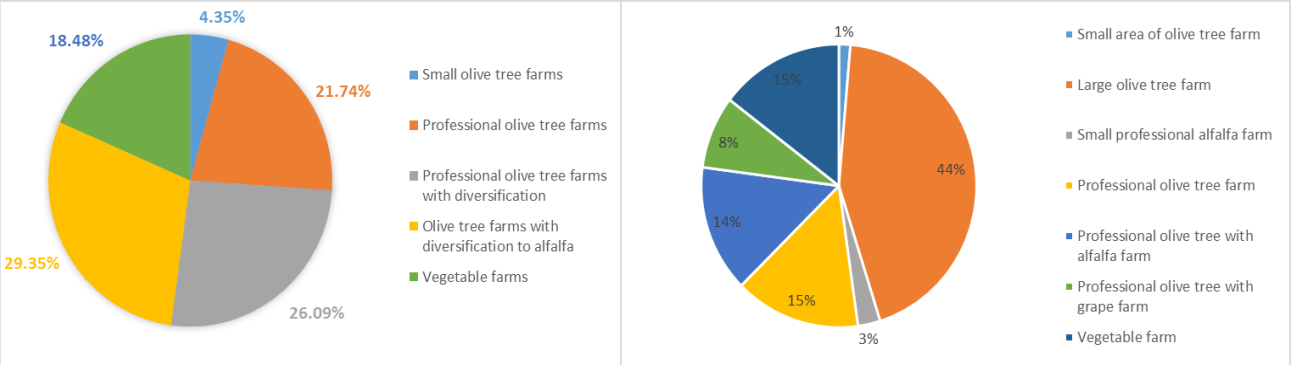
and included a farm typology based on three regions in the Azraq basin: Azraq, North Badia (Mafraq), and a minor part of Jiza.

Figure 39. Cultivated area (du) between 1980 and 2011



When comparing the prior characterization of farming practices in Azraq by GIZ and this research we find five common farm typologies in both studies: 1) small olive tree farm; 2) professional olive tree farm; 3) olive tree farm with diversification with alfalfa; 4) and olive tree farm with diversification with other crops and vegetable farm. As opposed to the GIZ study however, large olive tree farms were not mentioned in the GIZ study but were found as part of the sample for this study (only one farm was found but it was retained as a significant example of the diversity of strategies). Figure 40 presents the percentage of farm typologies found in the GIZ study and this one. Variations between this study and the GIZ one could be due to the fact that different farm samples were chosen during different seasons and years. In general however, the broad farm typology is similar, with the same cropping patterns.

Figure 40. Comparison of farms typology between GIZ study (left) and this study (right)



Regarding cropping patterns, both studies found that Mafraq is dominated by fruit tree followed by vegetables cultivation. While Azraq is dominated by olive trees, grape cultivation cannot be neglected in both Azraq and Mafraq. Figure 42 shows the existing cropping patterns in both GIZ and this study.

Figure 41. Comparison of cropping patterns between GIZ and this study (Azraq area)

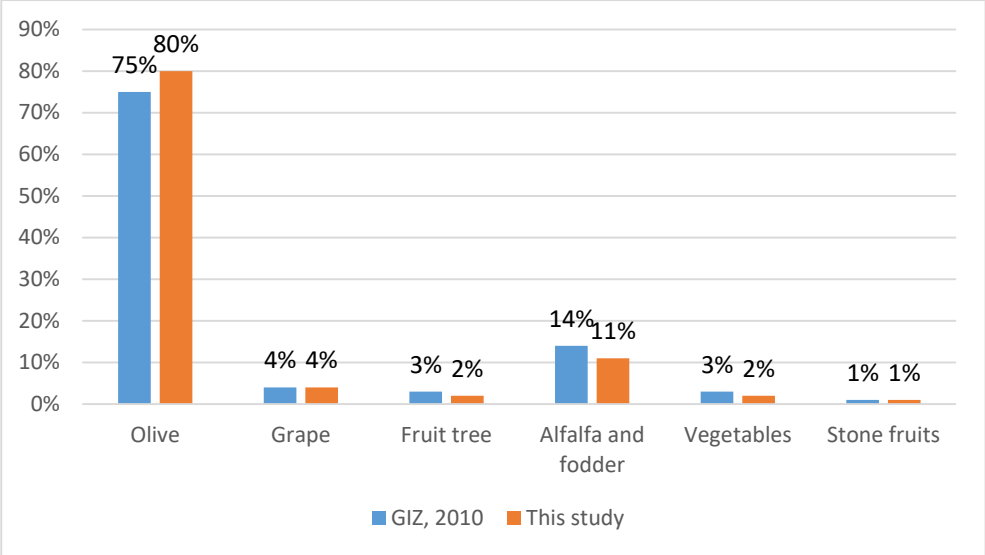
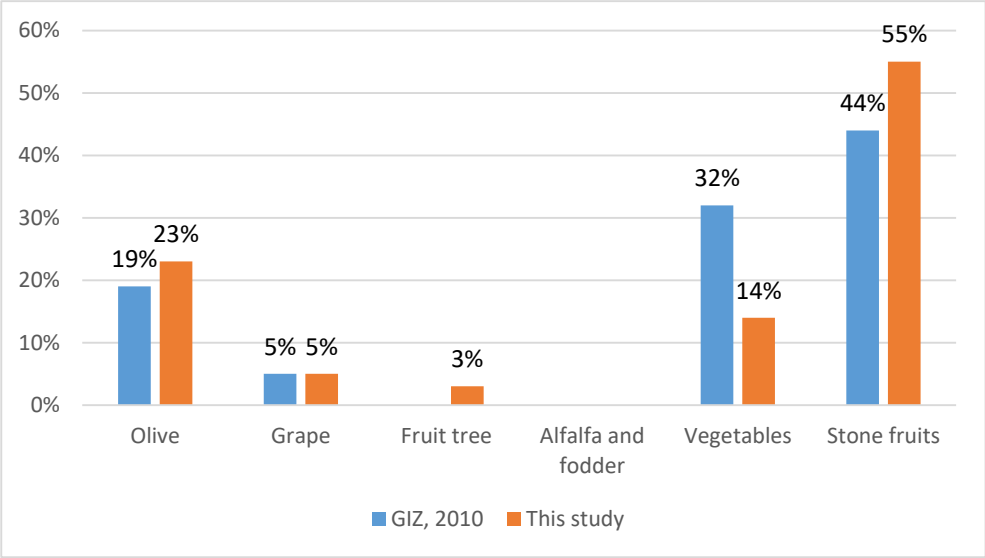


Figure 42. Comparison of cropping patterns between GIZ and this study results in North Badia area



Annual average benefits in JD/du were calculated and compared in both studies, olive tree cultivation gives a minor profit comparing fruit tree and vegetables.

The assessment of crop water consumption in both studies is shown in Figure 44. Olive cultivated in small olive tree farm consumes much more water than the tree needs, possibly due to a poor water management system and irrigation techniques in the farm.

Figure 43. Comparison of average profit for overlapped farm typologies for both studies

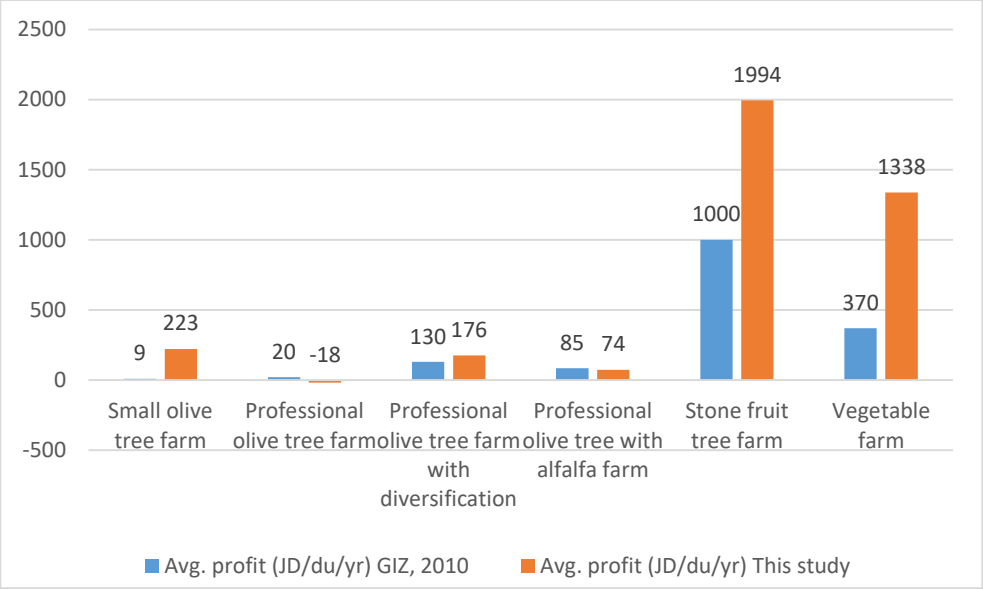


Figure 44. Comparison of water consumption in farm types common to both studies

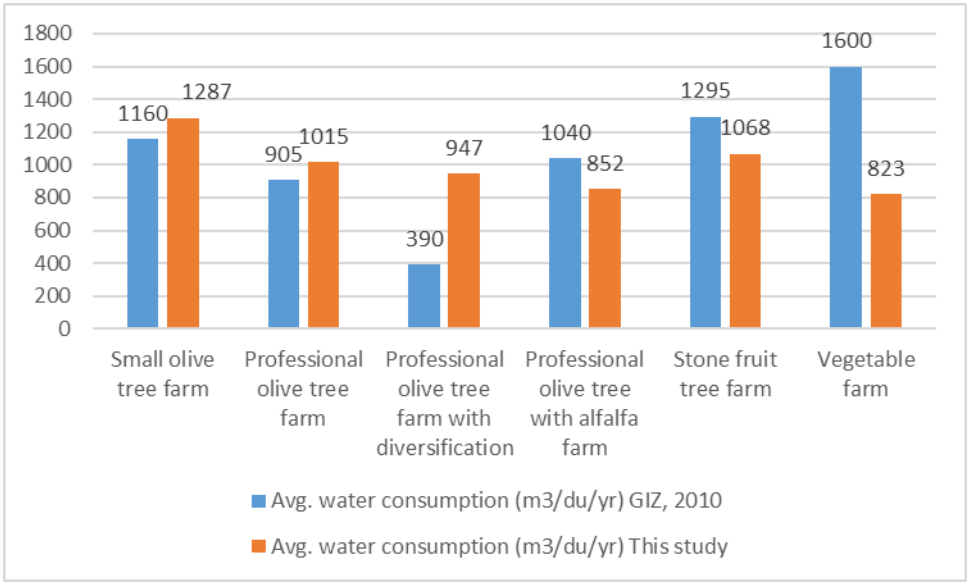
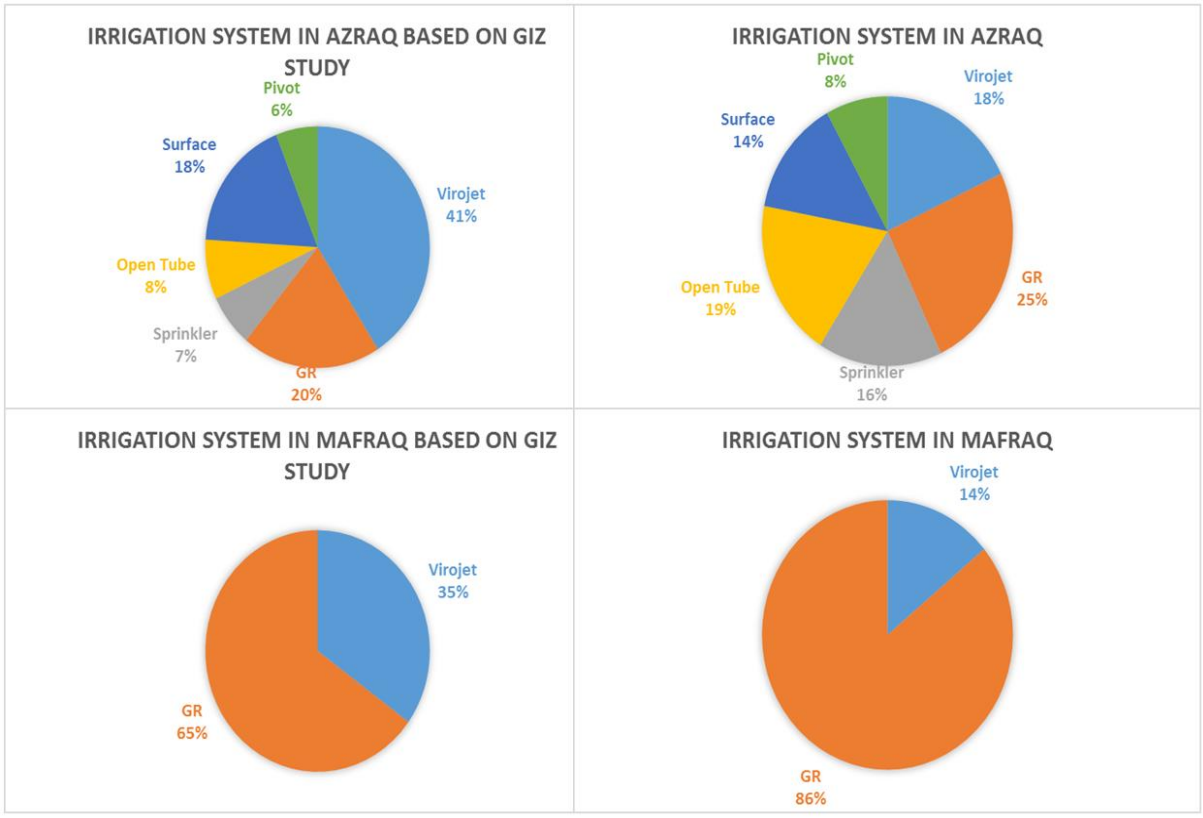


Figure 45 presents a comparison of used irrigation systems in Mafraq and Azraq area. As the figure indicates, 100% of farms in Mafraq use localized irrigation systems (virojet) on the trees and GR on vegetables and some stone fruit trees. In Azraq, additional varieties of irrigation techniques systems were found. Both studies indicate that about 90% of the cultivated area is irrigated with localized irrigation. The rest still uses traditional flood irrigation, mainly in small farms, which partly explains their high water consumption (Figure 46).

Figure 45. Irrigation systems following GIZ and this study in Azraq and Mafraq



Section 4.6.6 and Table 32 illustrate the variation in groundwater abstraction costs according to different energy sources following the GIZ study and this one. The comparison shows an increase in price per cubic meter since 2010. Diesel prices change on a monthly basis and had been increasing and decreasing in past years, causing the difference in price between the GIZ study and this one. Additional variations are due to the differences in farm sample and consumed water, and well depths. In Mafraq, the differences in energy prices reflect the differences in water table levels and the need for more energy to pump groundwater in Mafraq.

Table 32. Abstraction cost according to energy type, this study vs. GIZ (2010)

	This study	*GIZ, 2010*
Diesel Azraq	0.12 JD/m^3	0.175 JD/m^3
Electricity Azraq	0.015JD/m^3	0.034 JD/m^3
Electricity Mafraq	0.136 JD/m^3	0.143 JD/m^3

4.6.9 Changes in Azraq since 2010

The main change between 2010 and 2015 is the increase in control, rule enforcement, and monitoring of groundwater use carried out by the Ministry of Water and Irrigation. The ministry introduced a new water tariff in 2014 law amendment for illegal not registered wells while, before, these wells were neglected by the monitoring system. Furthermore, the Ministry started a campaign to close all unproductive wells as a first step towards closing all illegal wells in the country. Lately in 2015, the free abstraction block in Azraq was also changed officially from

150,000 to 75,000 m^3/yr for any new well drilled to *replace* old wells (since new well licensing has been stopped).

Satellite imagery and remote sensing tools are now used to monitor and observe agricultural activities in the basin. Moreover, an agreement was signed between MWI and NASA, so that NASA can provide satellite images every 24 hours to the Ministry which can be used to locate new cultivated areas, well locations, etc. Linking all government agencies involved is also a new step implemented aiming to improve water bill payments and clamp down on non-payers.

Farmers have noticed an increase of the cultivated area in both Mafraq and Azraq. According to this fieldwork, this went on in parallel with the situation in Syria which spurred an increase in the cultivated area in order to respond to the decrease in regional supply and fill the gap left by the decrease of Syrian imports into Jordan. When asked, a farmer with new small trees were found in Mafraq said that "the situation in Syria will never be the same and the gap in the market needs to be filled" (Interview 36., 3 May, 2014).

Before 2010 solar energy was not a feasible option available to farmers. At that time the Jordanian market was not mature for the use of renewable energies as an alternative source of energy. Small and medium size companies and farmers were not well equipped and trained about the installation of such systems. However, after the approval of the renewable energy policy in Parliament in 2012, markets opened up to importing this type of technology. As a result, a number of farms in Azraq started using it, especially the illegal farms using diesel as a source of energy. In Mafraq, farmers are thinking to convert to this type of energy as it is more sustainable and cost-effective in the long run.

5 Conclusions

Agriculture has been increasing over the last decade in the Highlands (Azraq and Mafraq) leading to augmented pressures on limited groundwater resources. Cultivation in Azraq started in the 1960s, concentrated around the city in small plots but then expanded eastwards with an increase in the farmed area. Cultivation in Azraq was started by locals but available groundwater of good quality at the time and cheap land made it a profitable investment for outsiders. Unfortunately, the extensive use of groundwater that followed the expansion of agriculture caused a severe deterioration of water quality and quantity, with negative effects on small farm productivity and profits.

Olive trees, grapes, and alfalfa are the main crops found in Azraq, while Mafraq is specialized in stone fruit trees and vegetables. Olive trees are mostly found in Azraq as they need less maintenance than stone fruit trees. The illegal cultivation of alfalfa is increasing as it represents a cash crop with quick returns. Following the study of the several farm types found in the basin (categorized following farm area, cropping pattern and type of management), a good part of agriculture in Azraq does not seem to be profitable and is associated with poor water productivity. This however varies according to the farm. The highest profit was found for 'vegetable farms', 338 JD/du/yr, followed by 'small olive tree' farms, with profits of 223 Jd/du/yr. All farms in Mafraq are profitable, despite much higher farming costs than in Azraq (e.g. land prices, well drilling costs, and energy costs). Farm investors do not gamble when investing money there and make sure their venture is profitable.

Overall, the main cost in Azraq is labor and farm inputs, and energy in Mafraq. Water and land prices are lower compared to other costs even with the existing water tariff, groundwater remains over-abstracted and un-measured from both legal and illegal wells. However, several farmers have indicated that agriculture will have no future in Azraq if groundwater uses remains the same as it is now. Some farmers are therefore trying to sell their land while others are thinking in investing in solar energy production or fish farming and diversifying their income. Professional farms are however owned by investors who seek profits and are less concerned about Azraq's future since they do not live there and farming is not their only income.

Land speculation in Azraq as in most of the Arab world has always been at the core of capital accumulation. Urban sprawl away from core historical settlements into desert land and the opportunities for high returns on investment in groundwater-based agriculture have fueled a demand for initially little-valued and non-registered arid land, which has resulted in the overexploitation of groundwater resources. So far the state land policy has fluctuated between positive incentives, 'carrots' like distributing state land various administrative processes, and negative incentives ('sticks'), like the use of force and destroying illegal houses, plantations or wells). Locals in Azraq are keen to protect their land rights and treat the land as their own even when they do not possess legal land deeds. Investors however find themselves caught up in the game of buying land from locals or Bedouins, having to cope with varying degrees of illegality (regarding both land and water) and pressure from tribal members. Land investors are moved by possible high rewards of intensive irrigation in the deserts, but this wealth-accumulating process is, eventually, threatened by the sustainability of the water resource base which is already over abstracted.

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, fueled by the profitability of irrigated agriculture as well as land speculation. This report has shown how farmers used different methods to go around regulation and escape policy constraints. Controlling groundwater use and law enforcement requires the heavy presence of government officials on the ground, something that clearly exceeds the capacity and resources given to WAJ, not to mention the constraining factors associated with the social proximity of WAJ staff and farmers, incentives to bribing, and the feeling that the degree of resolve of higher-level authorities in enforcing the law is unclear.

Currently, as this report has shown, land speculation, weak law enforcement, control and monitoring create a fertile ground for the continuation of extensive farming and irrigation in the basin by locals, Bedouins and investors. But new policies have the potential to constrain expansion: the combination of heavy water prices for illegal wells, estimating use through remote sensing or electricity consumption without resorting to meters, constraining the granting of labor permits, and the interconnection of public data (as a means of enforcing payment) may discourage farmers with little productive farms, or investors willing to drill new wells.

The future of agriculture in Azraq is therefore uncertain. One scenario contemplates a continuation of current trends, with a large proportion of farmers getting out of business because of saline water and/or dubious profitability (olive trees) in the face of rising costs, and only the most technically efficient growers of cash crops taping export markets or temporary niches such as alfalfa surviving, on the model of Mafraq. This would in particular affect some local small farmers and would encourage further migration to the city. Another scenario includes a leveling off and stabilization of the cultivated area, the gradual retirement of some farms faced with adverse increases in input prices, or the offer of both compensations and alternative economic opportunities by the state. It may well be, also, that extreme events such as severe drought, a continued Syrian crisis, political changes, or upheavals in some input or output markets determine the course of things.

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7 Annexes

Questionnaire –farm level
(Mafraq Farms)

Date:

1. Basic information:

1.1 Contact

Farmer's name:

Telephone number:

Place of living and origin:

Farm location

1.2 Land status

From where you got the land?

a. Bought it? If so how much, when and from whom?

Why did the previous owner/farmer sale it?

Why did you choose to do agriculture in Mafraq (cheap land, water access, sell it after, etc,..)

Land price in the past and now?

b. Inheritance from family? If yes, for how many years have your family owned this land and cultivated it? How did they acquired the land in the past?

c. Cultivate it for a period in order to own it? (How many year is the land cultivated? is the land yours now or you still have to cultivate it more) (I don't think there is a situation like this but will keep it in case)

d. are you renting the land from the owner? If so what is the renting period and for how much? Are you renting it with well or only a land? Price of well renting?

Details on the process of land acquisition (with regard to official procedures):

1.2 Farm Status

Who is managing the farm? himself or he hired someone else? What is his contribution in farm management?

What are the technologies that you have adopt in the farm to make it a good investment?

1.3 Farm characteristics

Farm age:
Farm area (dunum):
Cultivated area at present (dunum):
Cropping pattern:

Actual cropping pattern	**Area**	**Yield/ production**	**Market price/ selling price last year**

Any change in cropping pattern in the past ten years? reason for changing cropping pattern? when and why

Past cropping pattern	**Area**	**Yield/ production**	**Market price/ selling price**

Any change in the cropping area? If yes how and why?

Reason for selecting the actual cropping pattern?

Idea to change cropping pattern in future, types and why?

1.4 Water source

Well status; owned, rent?
Drilling cost?
Presence of metering system?
Who install it and when (was it there from the beginning)?
Is it working?

No of wells	status	Age	Water table now	Water table past	Well depth	Salinity now	Salinity before

Water quality; causes and effect:

Do you have a desalination plan? If so when did he establish it and why? Cost?

1.5 Irrigation techniques

Crop	Current irrigation technique	Past irrigation technique	Efficiency	Cost	Date of establish in farm

Why does he choose this kind of irrigation system?
And if he changed it, Why?

Advantage and disadvantage?
(Techniques are adopted because of many reasons: like increasing well depth, more pump, drill a new well, new crops, seeking water from WAJ, labor saving, take advantage of subsidies,…)

If you have drip irrigation: describe the costs of replacing lines (how often?), filters, maintenance, others

1.6 Water abstraction, tariff and payment:

How often do you irrigate? (Details for each crop and by season); estimate the time for each plot

Amount of abstracted water per season?

Water tariff?

Who is reading the meter and how often?

Are you paying for water?

Payment is it monthly or per season?

What is the official maximum abstraction amount of your well?

Do you have to pay more (higher price) for volumes exceeding this value?

Did he decrease his pumped quantity when high price of diesel? What about electricity price?
Does he already think about another source of power?

No. well	Water consumption	Electricity consumption	Cost	Diesel consumption	cost

1.7 Labour:

No. of permanent and temporary labors

In general what is the salary for hired labour in the area (per month, per day?)

For each crop, exam in when occasional hide labor needed (eg harvest for Olive): how can the farmer finds such laborers (are there middlemen for that?); Where are these laborers coming from? Is it difficult to find them, etc (here you need to collect the cost that will be added to those that you collect below in 1.9)

Labors nationalities:

1.8 Animal breeding

Animal	Number	Production

1.9 Economic aspect

Crop	Crop or seed price	Type of input Fertilizer, pesticide, herbicide	Frequency	Quantity	Total price quantity/J per season

Type of machine	Number	Status owned/ rent	Price Owned/ rent

Marketing: to whom do you sell your crops? (For each crop detail what are the possible costs of transportation, who is buying and how the prices are determined)

1.10 Investment farms situation

1. Effect of your farm and farming practices on the Azraq basin water quality and quantity, other farms?

2. Do investment farmers compete with small framers on the market? or do they sell their product to other channels like exporting outside Jordan?

3. Water levels are dropping: what is your opinion on the causes?
3.a. Is this a problem for you?

3.b. According to you what should be done to prevent worsening of the situation?

4. What are –overall- the main problems you face with your farming activity if there is any?
(after answer check one by one: crop management; water; marketing; labour; low economic profitability; relation with officials, etc)

5. Is agriculture nowadays confined for rich farmers only?

6. From your point of view what will be the agriculture status after 20 years in Azraq basin and Jordan?

7. Have you ever heard about any initiatives happened in Azraq basin like highland forum, etc ..

8. What do you think about the cooperation between farmers and ministries?

9. Are you willing to participate in any future participatory approach which would try to reduce over abstraction in the basin?

Questionnaire –farm level Azraq

Date:

1. Basic information:

1.1 Contact

Farmer's name:

Telephone number:

Farm location:

1.2 Land status

Owned land or rented

if its owned, then;
- From where you got it?

a. Bought it? If so how much, when and from whom?

Why did you choose to do agriculture in Azraq (cheap land, water access, sell it after, etc,..)

b. Inheritance from family? If yes, for how many years have your family owned this land? And cultivated it?

c. Cultivate it for a period of time in order to own it? (how many year has he cultivated?, is the land yours now or you still have to cultivate it more)

- Number of land owners; one or more than one owner, names

- Is the land registered in land department? If yes when? Did you have Hejeh before? If yes how did you legalize your land?

if not, do you have Hejeh?

Did you pay any sum in order to register the land? If so how much?

Do you have to pay any fee yearly to the land department, of even to a sheikh?

If rented, then
who is the owner
How much do you pay for rent

1.3 Farm characteristics

Farm age:
Farm area (dunum):
Cultivated area (dunum):
Cropping pattern:

Actual cropping pattern	**Area**	**Number of tree and tree space**	**Water consumption**	**Yield**	**Market price**

Any change in cropping pattern in the past ten years? reason for changing cropping pattern? when and why

Past cropping pattern	**Area**	**Number of tree and tree space**	**Water consumption**	**Yield**	**Market price**

Reason for selecting the actual cropping pattern

Idea to change cropping pattern in future, types and why?

1.4 Water source

Do you have your own well or are you taking water from a neighbor well?

If from neighbor: how much water (time, volume?) and how much is he paying?

Does he have an open access to water or just in limited days?
and how many farms are using the same well?

If he have his own well:;
Well numbers:
Well status: legal, illegal

Well licensees number for legal well

Did he buy the well from previous farmer? If so name of the previous farmer
How many farms using the same well, and how much does he sell the water?
Well condition: how many wells are functioning in the farm now? How many wells were functioning in the farms before?

well age and drilling cost?

Presence of metering system?
Who install it?
Is it working?
Well and water depth:
past (how many years ago?):
present:

Water quality:
Salinity level, if he know or differences in salinity level (is it drinkable, has an impact on crops? etc)
Effect of water deterioration on yield and soil, reaction toward that?

Pump status; diesel or electric? Was it diesel then he changed it to electric pump? Pumping costs, both diesel and electric?

Any change regarding well location, pumping system and drilling depth from the beginning of cultivation function? Reasons?

1.5 Irrigation techniques

Crop	Current irrigation technique	Past irrigation technique	Efficiency	Date of establish in farm

Why does he choose this kind of irrigation system?
And if he changed it:
Why?

At what costs? (any subsidies?)

Advantage and disadvantage?

Techniques are adopted because of many reasons: like increasing well depth, more pump, drill a new well, new crops, seeking water from WAJ, labor saving, take advantage of subsidies,…
If you have drip irrigation: describe the costs of replacing lines (how often?), filters, others

1.6 Water abstraction, tariff and payment:

How often do you irrigate? (details for each crop and by season); estimate the time for each plot

Amount of abstracted water per season?

Water tariff?

Who is reading the meter and how often?

Are you paying for water?

Payment is it monthly or per season?

How much and to whom you will pay? WAJ?

What is the official abstraction amount of your well?

Do you have to pay more (higher price) for volumes exceeding this value?

If you don't have meter then you are not receiving a bill? Then water is free?

Did he decrease his pumped quantity when high price of diesel? What about electricity price? Does he already think about another source of power?

1.7 Labour:

Is the Family working in the farm?
Number of family members;
Number of family members that are working inside farm (full time/ part time):
Do you have hired labor? Temporary or permanent? If so how many persons, nationality

In general what is the salary for such hired labour in the area (per month, per day?)
Did the ministry of agriculture give you the permit for labor? Or do you rent them from other farmers? What other economic activities/income do you have in the family?

1.8 Animal breeding

Animal	Number	Production

1.9 Economic aspect

Crop	Crop or seed price	Type of input Fertilizer, pesticide, herbicide	Frequency	Quantity	Total price quantity/J per season

Type of machine	Number	Status owned/ rent	Price Owned/ rent

Did you take any loan? For what investment?

1.10 Small farms vs investment farms

1. When the investment farms came to the area and what is there effect on small farms, competition on water, effect of that on water quality and quantity?

2. Do investers compete with small framers on the market? or do they sell their product to other channels like exporting outside Jordan?

3. how did small farmers keep themselves in competition? (Increase his farm activities, crop rotation, cultivate more cycle in season and use more water, etc)?

4. Did this increase the price of land?

5. What options did he adopt to survive? (changing irrigation system, deep drilling, open a new well, buy water, changing the cropping pattern, etc…)

6. What other activities and possible sources of revenue are available in the area for him? Does

7. Is it worth to cultivate in Azraq? If not why he is continuing? (doesn't know what else to do; this is family land and tradition, revenue is not that bad, etc)

8. If he sold the land and the wells, what price he could get for it? What activity he could start with this capital?

9. Water levels are dropping: what is your opinion on the causes?

10. Is this a problem for you?

11. According to you what should be done to prevent worsening of the situation?

12. What are your plans for the future?
13. Does one of your children want to continue with farming?

14. What are –overall- the main problems you face with your farming activity?

Questionnaire – Past farmers

Date:
Personal information:

Name:

Telephone number:

Native place:
Living place:

Current status:

What is he doing now? Working in other sector? Still in agriculture but different place? Retired?

From where does the family monthly income come from? Other work, government, his children, etc,?

Still living in Azraq?

Land information:

Registered land in land department?

What is the official paper that proved his ownership? Hijeh or Qushan

Did he have Qushan first then he registered in land department if so when he did so and how much did he pay for dunum?

Did he face any difficulties while registering the land?

Land status:

Still have the land? Did you let it fallow?

or sell it? How much, when and for whom? Is it cultivated now by new owner with different techniques? If so name of new owner

Cultivation:

For how many years did he cultivate the land?

Any extension in agriculture area through the years and why?

Total area:
Cultivated area:
Cropping pattern:

Any changes in cropping pattern? ,why?

Changing in yield?

Type of used irrigation system?

Any change in irrigation system?

Water source:

Before wells did he use other source of water like springs swept (before drying)? If so how was the water quality at that time

Number of well?

Well status: legal, illegal

Legal: licenses number:

If he sold the land, did he sold the well too?

Amount of abstracted water?

Water table when he began the cultivation

Water table when he quitted?

Did he try to deepen the well to reach water?

Difficulties and quitting:

Why did he quit? (No money? Cultivation without revenue? Marketing problems? Bad water quality, no water at his current well depth and he can't offered to drill deeper? Soil deterioration? Competition with big farmers in market, Etc..?)

If it is because of deterioration in water quality and quantity then;
When did it begin (water quantity and quality deterioration) or when did he notice that and how?

What did you do against the deterioration (water quantity and quality) problem?

Did you try to adopt a new technique before quitting and failing? If so then why you failed?

Overall changes that he adopted to the farm from the beginning of cultivation till he quitted

INTERNATIONAL WATER MANAGEMENT INSTITUTE (IWMI)

The International Water Management Institute (IWMI) is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. It is headquartered in Colombo, Sri Lanka, with regional offices across Asia and Africa. IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a real impact on poverty reduction, food security and ecosystem health. IWMI is a member of the CGIAR System Organization, a global research partnership for a food-secure future, and leads the CGIAR Research Program on Water, Land and Ecosystems (WLE).
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