German-Jordanian Programme "Management of Water Resources"

The Azraq Dilemma

Past, Present and Future Groundwater Management

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The Azraq Dilemma:
Past, Present and Future Groundwater Management

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سلطة المياه
WATER AUTHORITY

Contents

1 | The Water Situation in Jordan 6
1.1 | Overview 6
1.2 | The Azraq Groundwater Basin Profile 10

2 | The Azraq Groundwater Basin Features 12
2.1 | Hydrogeology in Azraq 12
2.2 | The History of Azraq Groundwater Basin Abstraction 18
Governmental abstraction 18
Private agricultural abstraction 18
2.3 | Groundwater Abstraction from the Azraq Basin 19
2.4 | The Diversity of Farming Systems in the Highlands 21

3 | The Azraq Water Dilemma 25
3.1 | Ecological Consequences 25
3.2 | Consequences of Over-abstraction 26
Watertable drawdown 26
Groundwater salinisation 26

4 | Challenges 29
4.1 | Population Growth 29
4.2 | Growing Competition Among the Sectors 30
4.3 | Land Tenure and the Illegal Wells 32
Land tenure 32
The illegal wells 33
Why land and water laws are not being respected? 36
4.4 | The Imminent Arrival of Electricity to the Farming Areas 38
4.5 | Yearly Decrease of Precipitation Due to Climate Change 38

5 | Key players in Azraq Basin 40
5.1 | The Azraq Melting Pot 40
The Druze 41
The Chechens 42
The Bedouins 42

6 | The Highland Water Forum Initiative 44
6.1 | Background 44
6.2 | Rationale for Stakeholder Involvement 44
Tasks 45
6.3 | Organisational Structure 46
6.4 | The Highland Water Forum Process 47
Stakeholder selection 47
Awareness activities 48
Dialogue consultations 50
6.5 | The Highland Water Forum: The Way Forward 50

Annex 1 | The Groundwater Control Regulations 52
Annex 2 | The Existing Farming Systems in Azraq Basin 56
Annex 3 | Crop Water Requirements in Azraq Region 60

References 61

Figures

Figure 1: Water resources of Jordan in 2010. 6
Figure 2: Map of Azraq groundwater basin. 6
Figure 3: Domestic use of groundwater in Jordan. 7
Figure 4: Water deficit in Jordan from 1995 to 2020. 10
Figure 5: Water consumption in Jordan by sector in 2010. 10
Figure 6: Precipitation in Azraq Basin (long-term isohyetal lines averaged over 50 years. 11
Figure 7: Azraq Basin topography. 11
Figure 8: Azraq region features. 12
Figure 9: Zones of Azraq Groundwater Basin depending on the outcrop formation. 13
Figure 10: Distribution of groundwater recharge in Azraq Basin. 14
Figure 11: Azraq groundwater basin water balance in 2010. 15
Figure 12: Spatial distribution for the wells in Azraq Basin. 19
Figure 13: Water consumption from Azraq groundwater basin per use in 2010. 19
Figure 14: Abstraction from the different aquifers in Azraq Groundwater Basin in the different governorates in 2008. 20
Figure 15: Crop distribution in Azraq region. 22
Figure 16: Crop distribution in North Badia region. 22
Figure 17: Crop distribution in Jiza region. 22
Figure 18: The Azraq Oasis in the 1960s. 25
Figure 19: The Azraq Oasis in recent years. 25
Figure 20: Isosalinity maps of the Azraq Basin. 26
Figure 21: Groundwater level in Azraq over the years in the well F1014. 26
Figure 22: Relationship between abstraction and salinity increase in a well in Azraq. 27
Figure 23: Salinity in a well close to the depression in Azraq basin. 27
Figure 24: Effect of over-drafting on the salinity of wells near the salt-fresh water interfaces in Azraq. 27
Figure 25: Evolution of water abstraction per use in Azraq groundwater basin. 28
Figure 26: Scenarios of evolution of Jordanian population. 29
Figure 27: Evolution of Jordanian population since 1921. 29
Figure 28: Sectoral contribution to the GDP of Jordan at constant basic prices. 31
Figure 29: The number of legal and illegal wells and their abstraction. 36

Figures

Figure 30: Cumulative rainfall in different areas within Azraq groundwater basin and Amman. 38
Figure 31: Druze, Chechen and Bedouin women and men in traditional attire. 40
Figure 32: The Highland Water Forum members with HRH Prince Faisal Bin Al Hussein. 44
Figure 33: The Highland Water Forum organisational diagram. 47
Figure 34: Stakeholder Network Analysis announcement of results workshop in October 2009. 48
Figure 35: Interview on the field with the Social Network Analysis team. 48
Figure 36: School logo competition awards ceremony. 49
Figure 37: Awareness campaign in the schools by the HWF Secretariat. 49
Figure 38: HWF members during a working session. 50
Figure 39: The former Secretary General of MWI and Assistant Secretary General of WAJ engaged in discussion in a working group. 51
Figure 40: The HWF members visiting a farm in Azraq region. 51
Figure 41: Evolution of groundwater-related laws and regulations in Jordan. 52
Figure 42: Size of farms in Azraq Basin. 56
Figure 43: Repartition of irrigated crops in Azraq, North Badia and Jiza. 58
Figure 44: Repartition of water abstraction per farming system and by respective irrigated area in Azraq agricultural region. 58
Figure 45: Repartition of water abstraction per farming system and by respective irrigated area in North Badia and Jiza. 59

Tables

Table 1: The water budget of the Jordanian groundwater basins in 2010. 7
Table 2: Water abstraction within Azraq groundwater basin, geographically and per use in 2008. 20
Table 3: Economic return per cubic metre of water for the different economical sectors. 30
Table 4: Fees for issuance of licenses mentioned in the Under-ground Water Control by-law no.85 of 2002 and its amendments. 53
Table 5: Water fees for agricultural wells as mentioned in the Under-ground Water Control by-law no.85 of 2002 and its amendments. 54

Tables

Table 6: Fees for illegal wells authorised to abstract by WAJ. 55
Table 7: Farm types and their main features in Azraq region. 57
Table 8: Farm types and their main features in North Badia and Jiza. 57
Table 9: Water requirements per crop in Azraq region according to the Ministry of Agriculture. 60

Boxes

Box 1. Mega-projects in the Jordanian water sector 8
Box 2. Hydrology in Azraq 16
Box 3. The Super Green Revolution 18
Box 4. Olive oil quality 23
Box 5. Why Azraq became such a popular area for setting up a retreat house or a farm? 24
Box 6. Land ownership in Azraq 34
Box 7. Recent evolution of the legal statuses of lands in Azraq 37
Box 8. Geopolitics of water 39

List of acronyms

AWSA	Amman Water and Sewerage Authority
du	Dunum (equal to 0.1 Hectare)
DLS	Department of Land and Survey of the Ministry of Finance
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoJ	Government of Jordan
HWF	Highland Water Forum
JVA	Jordan Valley Authority
m^3/cap/y	cubic metres per capita per year
MCM	Million cubic metres
MOPIC	Ministry of Planning and International Cooperation
MWI	Ministry of Water and Irrigation
PIA	Participatory Impact Assessment
ppm	Parts per million
RSCN	Royal Society for the Conservation of Nature
SNA	Social Network Analysis
UNFCCC	United Nations Framework Convention on Climate Change
USAid	United States Agency for International Development
WAJ	Water Authority of Jordan
WHO	World Health Organisation

1 | The Water Situation in Jordan

1.1 | Overview

Jordan is one of the driest countries in the world and faces a critical water issue. It is heavily dependent on groundwater resources, which constitute 57% of the supply[1]. Groundwater is the main source of drinking water for the Kingdom and the main source of water for irrigation in the Highlands, while surface water is the main source for irrigation in the Jordan Valley. Renewable groundwater resources represent the major source of water supply, as shown in Figure 1.

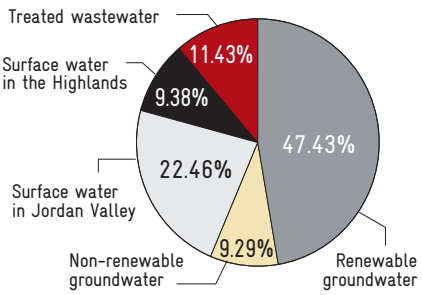

Figure 1. Water resources of Jordan in 2010 (MWI Water Budget of 2010).

Water scarcity has led to significant competition between different sectors, mainly agriculture and drinking water. In 2010, 10 of the 12 groundwater basins in Jordan faced severe over-abstraction, sometimes at about twice their annual recharge rates (or safe yield[2]), as shown in Table 1.

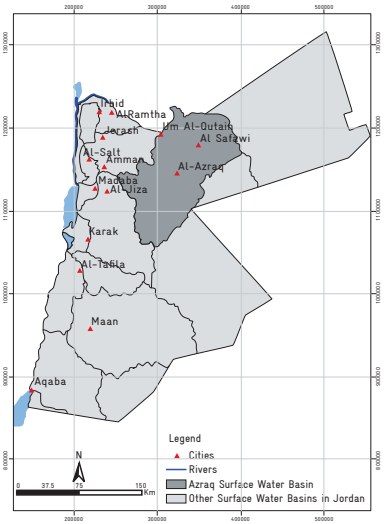

Figure 2: Map of Azraq groundwater basin (Hamdan, 2010).

[1] MWI Water Budget of 2010.
[2] Safe yield is defined as the quantity of groundwater permitted to be extracted annually from the aquifer without causing depletion, change in static water level, lowering water or pollution thereof.

1 | The Water Situation in Jordan

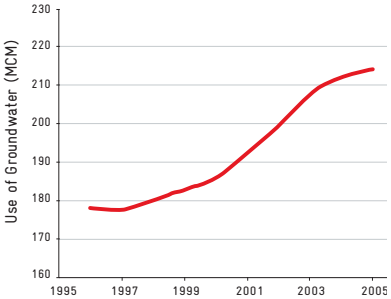

Figure 3: Domestic use of groundwater in Jordan (Al-Raggad, 2007).

The demand for water exceeds the available water resources. For instance, in 2008 water demand reached around 1500 MCM while water resource availability stood at around 900 MCM[3].

Table 1: The water budget of the Jordanian groundwater basins in 2010 (MWI Water Budget of 2010).

GROUNDWATER BASINS	SAFE YIELD (MCM/YEAR)	ABSTRACTION (MCM/YEAR)	% OF ABSTRACTION
1. JAFR	9	33	360%
2. AZRAQ	24	53	222%
3. SIDE WADIS	15	28	185%
4. AMMAN-ZARQA	87.5	159	181%
5. NORTHERN WADI ARABA	3.5	7	205%
6. SOUTHERN WADI ARABA	5.5	7	125%
7. JORDAN RIVER	21	27	128%
8. DEAD SEA	57	82	144%
9. YARMOUK	40	50	125%
10. SARHAN	5	1	29%
11. HAMMAD	8	1	15%
12. DISI AND MUDAWARRA	125	63.2	non renewable
TOTAL	275.5	511	185%

[3] MWI Jordan's Water Strategy, 2008.

Box 1. Mega-projects in the Jordanian water sector

In order to increase water supply, the Jordanian Government seeks new water resources and considers several mega-projects such as tapping the Disi aquifer and constructing the Red Sea-Dead Sea Conduit. The Ministry of Water and Irrigation sees these mega projects as the ultimate solution to Jordan's water dilemmas.

The Disi project

This is a project to convey water from the Disi aquifer, located in the southern desert area on the Jordanian-Saudi Arabian border (see Figure 3), to the capital Amman. The project will be designed to ensure the conveyance of about 100 MCM/y of water by building a 320 km-long pipeline. Gama, a Turkish company, is responsible for building and pumping from stations to bring water to Amman and will sell water to Jordan for 40 years before the Government of Jordan takes full ownership of the project.

There are several disadvantages to this project:

- The project cost is high, with a current estimation of $600 million.
- The location, on the Jordanian-Saudi Arabian border, makes further exploitation politically sensitive since both countries are competing for the same resource in an arid region while facing a water-scarce future.
- The risk of water leakage in the pipeline.
- The Disi aquifer is non-replenishable, therefore there is a high risk of rise in salinity levels of the water as the resources is depleted.
- The aquifer will not be able to supply water to Amman before 2015, and by 2020 it will be sufficient to supply only 20% of the projected municipal demand.
- High levels of radioactivity in the water.

The Red Sea-Dead Sea Conduit

This project will connect the Red Sea and the Dead Sea as well as an associated hydroelectric power plant and desalination facilities. The length of the canal will be about 180 km, and it will provide 850 MCM/y of fresh water to Jordan, Israel and Palestinian Territories. This conduit is also envisaged to stabilise the Dead Sea's water level, which is in continuous decline.

1 | The Water Situation in Jordan

The main advantage of this project is the virtually unlimited supply of water. However, some disadvantages also exist, like:

- The estimated cost of the project is about $5 billion, which may take up to 20 years to complete,
- Political hurdles, such as the volatile peace process between Israel and the Arab States, may create unforeseen obstacles for the project.

The desalination plant at Aqaba

The principle of a desalination plant is to convert sea water to fresh water that is suitable for consumption and irrigation. Contrary to the mega-projects that are mentioned above, desalination does not require regional cooperation, however the project cost and, consequently, the water price, will be considerable (estimated at $0.50 to $1.00 per cubic metre).

The Ministry of Planning and International Cooperation estimates that a desalination plant would cost $50 million. However, according to various studies, the total investment cost of a hydropower seawater desalination plant is around $389 million, including treatment and operational costs. The price per cubic metre will still remain very high.

Source: USAid Economic Development Program, 2008.

1 | The Water Situation in Jordan

In this context, and due to a steep population growth as well as sudden influx of refugees caused by political instability in the region, the annual per capita share of water has declined from 3600 m^3/cap/y in 1946 to less than 150 m^3/cap/y today[4]. This is more than 45 times less than the amount available in the United States (which is 9000 m3/cap/year[5]). See Figure 4.

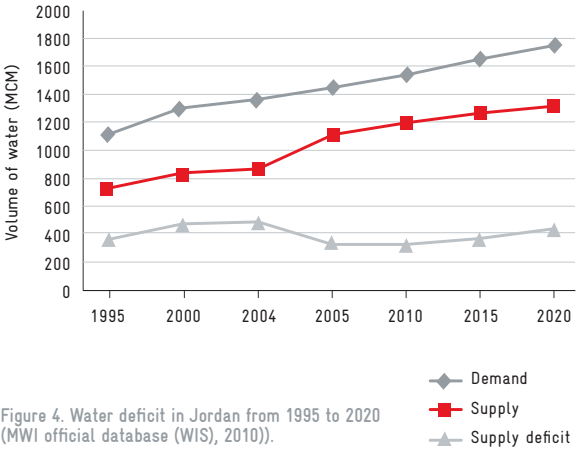

Figure 4. Water deficit in Jordan from 1995 to 2020 (MWI official database (WIS), 2010)).

Only 5% of the Jordanian territory receives enough rainfall to support cultivation; therefore most lands require complimentary irrigation. Agriculture is currently the largest consumer of water (see Figure 5). While farmers irrigate less than 10% of the total agricultural land, agricultural demand of water represented 56% of the total water demand in 2010[6].

1.2 | The Azraq Groundwater Basin Profile

The Azraq groundwater basin is one of the most important sources of renewable groundwater. It is also one of the most over-pumped in Jordan (see Table 1).

Azraq is one of the largest groundwater basins in Jordan; it represents 15% of the country. It is

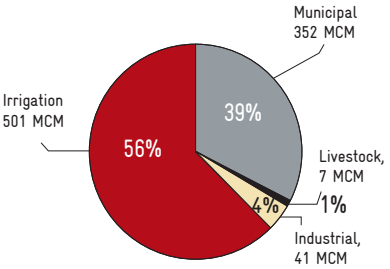

Figure 5. Water consumption in Jordan by sector in 2010 (MWI Water Budget of 2010).

situated in the northeastern part of Jordan, in the Highlands Plateau, and covers an area of about 12700 km^2 [7] (see Figure 3).

The climate of Azraq Basin is characterised by hot and dry summers, leading to very high evapotranspiration rates (80–90%). The winters are fairly wet and mostly cold.

The mean annual rainfall within Azraq Basin ranges from 100–150 mm in the west and north, 50–100 mm in the middle of the Basin to less than 50 mm in the south and east (see Figure 6).

4 MWI Jordan's Water Strategy, 2008.
5 Denny et al., 2008.
6 MWI Water Budget of 2010.
7 Wolter et al., 2009.

1 | The Water Situation in Jordan

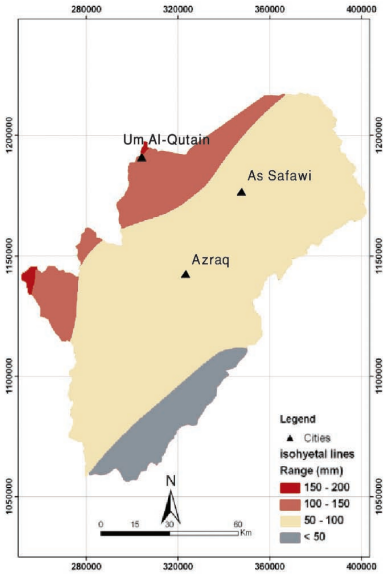

Figure 6: Precipitation in Azraq Basin (long-term isohyetal lines averaged over 50 years (Hamdan, 2010)).

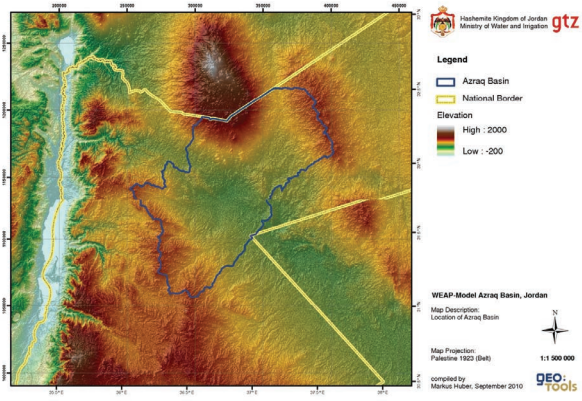

Figure 7: Azraq Basin topography (Huber, 2010).

Real rivers with a constant flow are absent, and only few wadis[8] are flooded during heavy rainfall events in winter.

The predominant landscape is bare soil or rock. Plant-covered land (natural vegetation and irrigated areas) are limited to the oasis and to the foothills of Jabal Al-Arab in the south of syria.

In the centre of the Basin is the Azraq Oasis. It stands at a distance of about 120 km northeast of Amman. Azraq Oasis was an example of a wetland in an arid region, but it dried out in the early 1990s. The Oasis area is a depression with a central mudflat (Qa'a or Sabkha) that is occasionally inundated.

The highest point in the Basin is in Tillin Town in Syria (alt. 1550 m[9]); whereas the highest point of the Basin in Jordan lies at 1234 m in North Badia. The lowest point of the Basin is at the Azraq Depression (Qa'a) at an altitude of 500 m.

92% of the aquifer stretches over Jordanian territory, while 5% is located in Syria and 3% in Saudi Arabia[10].

8 *A wadi is a valley, gully, or streambed in northern Africa and southwest Asia that remains dry except during the rainy season.*
9 *El-Naqa, 2010.*
10 *Sunna', 2008.*

1 | The Water Situation in Jordan

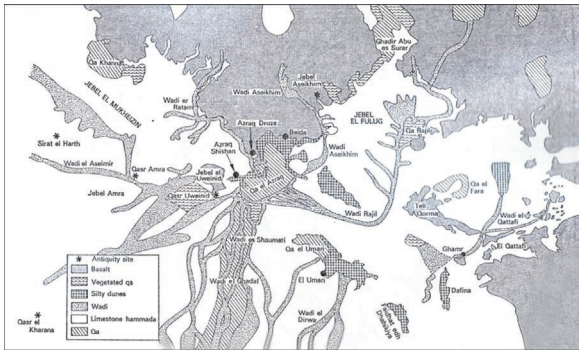

Figure 8: Azraq region features (Nelson, 1973).

Several wadis from all directions drain into the Oasis, which is the natural water collector of surface water in the Basin. The principal wadis include Wadi Rajil, Wadi Hassan, Wadi Asekhim, Wadi Shaumari, Wadi Jesha and Wadi Ghadaf. Water in these wadis remains for several months before being lost to evaporation. The voluminous wadi runoffs, in the form of flash flooding, are caused by intense thunderstorms.

There are four dams located inside the Azraq Basin whose main purpose is groundwater recharge in addition to supplying the local population with drinking water: Jilat Dam, Muwaqqar Dam, Wadi Rajil Dam and Deir Al-Kahf Dam.

The Basin is characterised by a shallow water table. In fact, wells used to be dug using a shovel and water would flow as shallow as 3 metres.

2 | The Azraq Groundwater Basin Features

The Basin is a major source of drinking water for the main cities in Jordan (Amman, Zarqa and Irbid) as well as for the Azraq area itself. The total abstraction rate from the Basin in 2010 was at about 53 MCM while the safe abstraction limit of the Basin lies at 24 MCM[11].

2.1 | Hydrogeology in Azraq

Most information available concerns the upper aquifer, and little information is available on the deeper aquifers.

The upper aquifer is unconfined and is the major aquifer in Azraq Basin. It consists of different layers, which makes big differences in the chemical and physical characteristics of the groundwater. The water in this aquifer differs in depth, quantity and quality from one place to the other.

Two geological formations are predominant within the boundaries of the Azraq Basin. The Basin is therefore divided into two zones related to the outcrop formation (see Figure 9). The first one is located in the northern part of the Basin, or the quaternary basalt outcrop overlaying the aquifer A7/B2 (limestones of the Balqa and upper cretaceous Ajloun group) and the second zone in the south, or B4 formation (limestones of the lower tertiary Balqa group).

[11] MWI Water Budget of 2010.

2 | The Azraq Groundwater Basin Features

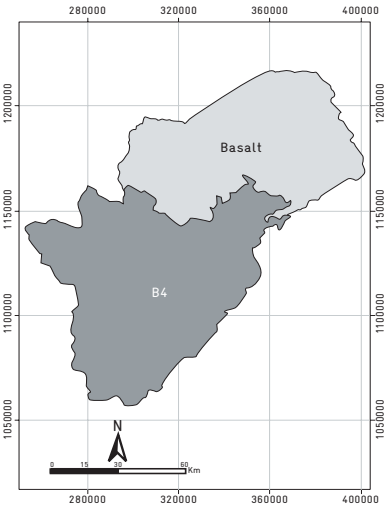

Figure 9: Zones of Azraq Groundwater Basin based on the outcrop formation (Hamdan, 2011).

Groundwater moves down gradient from high potential to low. Water in the Upper Aquifer, therefore, flows towards the Azraq Qa'a.

The A7/B2 and the Basalt are hydraulically interconnected and form the most important aquifer of northern Jordan. The B4 aquifer is separated from the A7/B2-Basalt complex by the marls of the B3 aquitard[12] (which is characterised by very low transmissivity[13])[14].

Significant precipitation, including snowfall in winter, occurs only in the north at the slopes of Jabal Al-Arab (in the south of Syria) and groundwater recharge is limited to the A7/B2-Basalt complex. Only a small amount of water reaches the B4 formation either through percolation from the basalt or directly during rare thunderstorm events. Al-Raggad (2007) assumes that there are additional vertical, hydrodynamic flows from A7/B2 to B4 through fractures and faults.

An estimation of absolute aquifer volumes and groundwater volumes is not possible because of lacking information on groundwater levels, especially in the eastern part of the Basin.

According to MWI estimations, the northern part of the Basin has an annual recharge rate of around 11% and the southern part an annual recharge rate of approximately 3%.

WEAP[15] simulations (a water resource planning tool that is used by MWI in order to update continually the National Water Master Plan) demonstrate that 50% of the down-streaming water is lost to evaporation and 50% infiltrates into the groundwater[16].

The difference between the north and the south of the basin is important to take into consideration in light of climatic and hydro-geological patterns, not to mention groundwater recharge and land uses, mainly for agriculture. Since the soil is generally thin in Azraq Basin, regional differences in groundwater infiltration are mainly related to the lithology and the topography (see Figure 10).

12 WERSC, 1996.
13 Transmissivity is the volume of water flowing through a cross-sectional area of an aquifer.
14 Huber, 2010.
15 Water Evaluation and Planning System.
16 Huber, 2010.

2 | The Azraq Groundwater Basin Features

It is important to consider the differences between the north and the south when tackling land use and groundwater recharge policies, especially in light of climate and hydro-geological patterns.

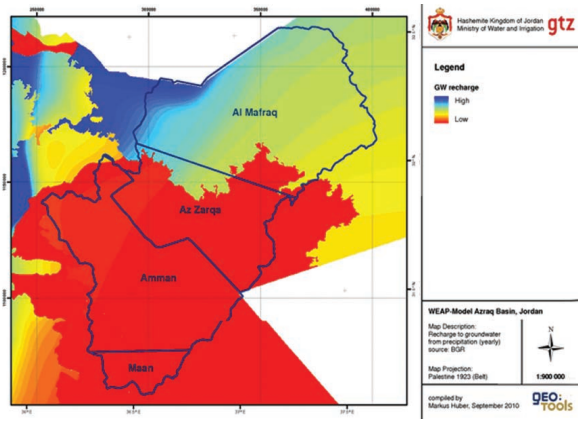

Figure 10: Distribution of groundwater recharge in Azraq Basin (Huber, 2010).

Most of the recharge to the upper aquifer takes place in the northeastern and northwestern parts of the basin. It is assumed that water does not reach the B4 aquifer, which can therefore be considered a non-renewable aquifer.

Surface runoff plays only a minor role within the Azraq Basin. The water streaming down these wadis either ends in the former Azraq Oasis or evaporates on its way there. However, there are small retention ponds constructed in river beds at the slopes of Jabal Al-Arab for the purposes of artificial recharge and feeding livestock. Due to the absence of continuous flow measurements, MWI estimates that available precipitation has a surface runoff rate of 2% of the available (effective) precipitation.

In addition to the recharge from precipitation, MWI estimations show that 75 MCM/y come from Syria to Jordan (to other groundwater basins including Azraq) as subsurface flow, of which 18 MCM flow into Azraq Basin, mainly from the Jabal Al-Arab[17]. The high rainfall and snow on Jabal Al-Arab Mountain in Syria is a major source of groundwater recharge for the Basin. Water infiltrates into the basalts and follows the tuff layers to reach the Jordanian part of Azraq Basin.

The velocity of groundwater flow from the recharge area in Jabal Al-Arab to the springs in the Azraq Oasis is believed to be very slow. Recent studies show that groundwater in the well-field about 3 km north of the oasis is between 4000 to 20000 years old. Titanium (half life of 12 years) has never been detected in the wells, indicating that no recent recharge to the groundwater has taken place[18].

According to MWI and WAJ, the total annual recharge of Azraq basin is estimated at 42 MCM, and is calculated as such:

– Around 20 MCM for the A7/B2-Basalt aquifer complex in the north

[17] *MWI Water Budget of 2010.*
[18] *GEF, 1993.*

2 | The Azraq Groundwater Basin Features

due to precipitation,

– Around 4 MCM for the B4 aquifer in the south due to precipitation,

– Around 18 MCM groundwater sub-flow from Syria.

According to MWI (2010), the Basin is being exploited beyond its safe limit (which is 24 MCM/y[19] in 2010). The safe limit is composed of the recharge minus the natural discharge (springs, rivers, lakes…).

The 18 MCM/y (inflow from Syria) can be challenged since all of the springs have long dried out.

It is worth mentioning that according to Al-Raggad (2007), the water budget of the Azraq Basin shows that the average yearly infiltration is 35 MCM. About 1 MCM/y flows through to adjacent areas and about 14 MCM/y is lost to evapotranspiration and discharges of the springs. The net recharge of the Upper Aquifer Complex is only 20 MCM annually.

Table 1 shows that abstraction from the Azraq Basin amounts to 222% of the sustainable yield in 2010, while Figure 11 shows the water balance of Azraq groundwater basin for the year 2010 (according to MWI calculations).

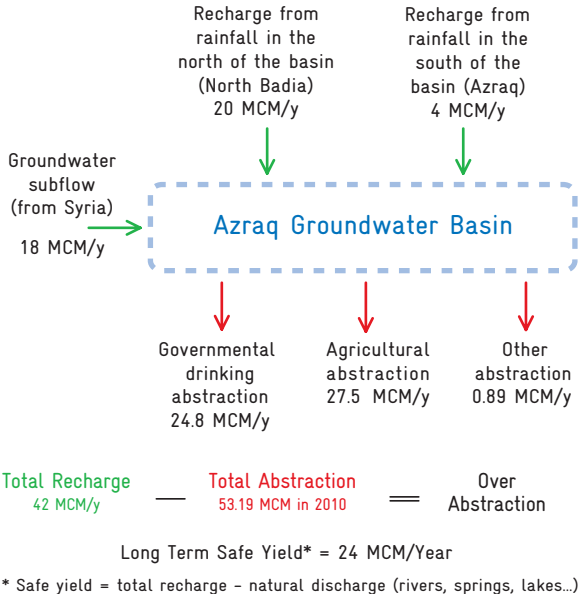

Figure 11: Azraq groundwater basin water balance in 2010.

[19] *MWI Water Budget of 2010.*

2 | The Azraq Groundwater Basin Features

Box 2. Hydrogeology in Azraq

The groundwater in the Azraq Basin is found in different aquifer systems ranging from recent deposits to deep sandstone aquifer complexes:

1. The upper aquifer complex (Shallow Aquifer Complex), which is composed of the quaternary sediments, basalts, Shallala and Rijam formations. The B4 layer and the basalt are part of this aquifer complex. The thickness of the basalt increases towards Jabal Al-Arab in Syria, where it may reach approximately 1500 m. The quaternary sediments are of great importance in the farming areas northeast of Azraq Druze and east of the Azraq Qa'a. Most of the hand-dug wells are in the top ten metres of this formation and are used for irrigation. Comparing the transmissivity of the basalt with that of the B4, a significant difference can be detected. The recharge rate in the basalt part is higher than in the B4 part. This upper aquifer is a very important aquifer because:

- The groundwater quality is relatively good (however, the salinity of the water from the basalt aquifer is usually low),
- Drilling costs are relatively low compared to the rest of the areas in the Kingdom, and
- The aquifer is renewable.

2. The middle aquifer complex (Upper Cretaceous Aquifer Complex) is divided into several layers from A1/2 to B3. It is relatively old, dating back to hundreds to thousands of years. The layer A7/B2 is part of this aquifer complex. The A7/B2 unit is by far the most important aquifer in Jordan because of its vast extent and its favourable auriferous properties. In the central part of the Azraq Basin (the Amman-Wadi Sir system A7/B2), water is mineralised and sulphurous and is of generally poor quality, with total dissolved solids concentrations ranging between 800 and 2500 milligrams per litre (mg/L). In the western and northwestern rims of the basin, the quality is good with total dissolved solid concentrations ranging between 200 and 500 mg/L. The depth of the aquifer is more than 600 m.

3. The lower aquifer complex (Deep Sandstone Aquifer Complex) is where the Disi group aquifer is. The water is also old (the aquifer was recharged during the last humid period, probably about 5000 years ago). The depth of the aquifer lies at more than 800 to 900 m from the ground surface. The water extraction costs are very high because of the depth and also the bad quality of the water. There are only few wells drilled in this complex, all of which are used for exploitation purposes.

2 | The Azraq Groundwater Basin Features

The groundwater in the different aquifers, from the shallow one to the deep complex, is hydraulically interconnected. This well field produces water from the shallow aquifer. The dominant soil is characterised as arid soil, with a high soluble salt content in the subsurface horizons. Sampling has proven that salinity increases with depth.

Source: Hobbler et al., 2001.

2 | The Azraq Groundwater Basin Features

2.2 | The History Of Azraq Groundwater Abstraction

Governmental abstraction

In order to meet the growing domestic water demand, the Government of Jordan pumps water from Azraq Basin. The first wells in Azraq were drilled in the 1930s and water was pumped to Mafraq[20], in the north of Jordan, for drinking. In 1963 and throughout the 1970s, only small quantities of Azraq's groundwater were pumped to the town of Irbid[21].

In 1981, the Amman Water Sewerage Authority (AWSA) began pumping water to Amman at a rate of 1.5 MCM/y[22]. In 1982, AWSA drilled 15 wells in Azraq in the northern parts of the Azraq Oasis in order to meet the domestic water needs of Amman and Zarqa[23]. The AWSA well field (the main well field in Azraq basin) is considered a main source of water for municipal use in Amman. In 1993, the Azraq Basin provided 25% of Amman's potable water[24].

Water management in Jordan was under the responsibility of the "Water Supply Corporation", established in 1973, covering all of Jordan except for Amman. Back then, water supply in Amman used to be the responsibility of AWSA up until 1983, when the Water Authority of Jordan (WAJ) was established and assumed all water services throughout the country until this time.

Nowadays, according to the abstraction database of MWI, the abstraction of an average AWSA well equals about 17 MCM/y.

Private agricultural abstraction

The introduction of diesel motor pumps to Jordan in the 1950s and 1960s led to a further spread of wells, but the real boost in the number of wells was started by the "Super Green Revolution" that swept Jordan in the 1980s (see Box 3. The Super Green Revolution.).

Box 3. The Super Green Revolution

"Super Green Revolution" is the term that describes the improvements that the Jordanian agricultural sector witnessed in the late 1970s and the 1980s. During that period, agricultural revenues increased ten-fold for vegetables and doubled for fruits. Labour from Egypt became widely available and was cheap. Moreover, energy costs decreased, well-drilling techniques improved, and land was cheap, fertile and immune to disease. In the Jordan Valley, irrigation and cropping techniques (greenhouses, drip irrigation, plastic mulch, fertiliser, new varieties, etc.) were developed and disseminated to the farming community by the government.

20 Van Aken et al., 2007.
21 GEF, 1993.
22 GEF, 1993.
23 Van Aken et al., 2007.
24 Darmame, 2004.

2 | The Azraq Groundwater Basin Features

Although Jordan reaped the benefits of this movement during the 1980s as it contributed to the economic development at that time, it also led to an over exploitation of the country's water resources.

Source: Van Aken et al., 2007.

2.3 | Groundwater Abstraction From the Azraq Basin

In the Azraq basin, irrigation developed exponentially since the beginning of the 1990s.

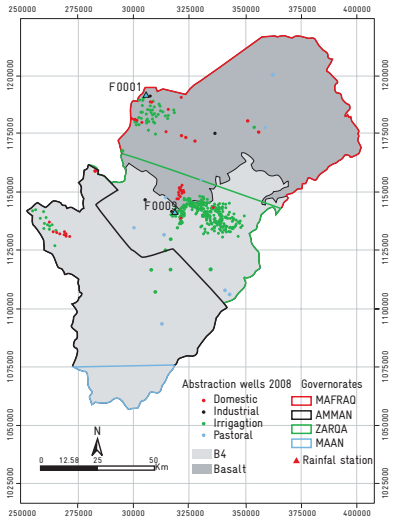

Figure 12: Spatial distribution for the wells in Azraq Basin (Hamdan, 2010).

As shown in Figure 12, three agricultural hotspots, where private agricultural abstraction is concentrated, have been identified within the basin:

– The area around Azraq Oasis (henceforth referred to as Azraq area). Here, most of the wells are located (70% of the Basin abstraction) and area of arable land amounts to 290000 du[25]),

– North Badia, which constitutes around 25% of the Basin's abstraction, and

– Jiza.

The previously stated 222%[26] overdraft that the groundwater basin suffers can be attributed mainly to agricultural and drinking water abstraction, as shown in Figure 13.

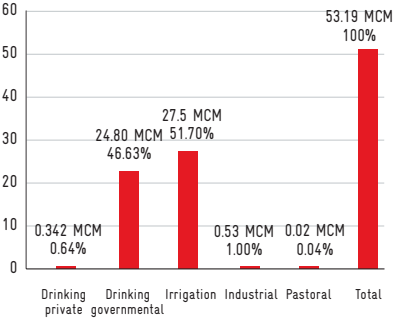

Figure 13: Water consumption from Azraq groundwater basin per use in 2010 (Source: data from WAJ and MWI).

25 Huber, 2010.
26 MWI Water Budget of 2010.

2 | The Azraq Groundwater Basin Features

Table 2: Water abstraction within Azraq groundwater basin, geographically and per use in 2008 (Hamdan, 2010).

Use / Governorate	Drinking (Governmental)		Irrigation		Industrial		Pastoral		Total	
	Abstraction (m^3)	%	Abstraction (m^3)	%	Abstraction (m^3)	%	Abstraction (m^3)	%	Abstraction (m^3)	%
Amman	1777699	7.4%	1379664	4.7%		0.0%	27643	19.1%	3185006	5.9%
Mafraq	5111725	21.3%	8017452	27.4%	24096	7.5%	61842	42.7%	13215115	24.6%
Zarqa	17072569	71.2%	19913136	67.9%	299088	92.5%	55359	38.2%	37340152	69.5%
Total	23961993	100%	29310252	100%	323184	100%	144844	100%	53740273	100%
Percentage (%)	44.6%	-	54.5%	-	0.6%	-	0.3%	-		100%

As shown above, the distribution of groundwater abstraction differs from one governorate to another. In the north of the basin (North Badia region), water is abstracted from the renewable aquifer, the A7/B2-Basalt Aquifer Complex. Whereas, in the centre of the Basin (Azraq region), water is being pumped from the non-renewable aquifer, the B4 formation. Many of the deeper wells pump from multiple aquifers.

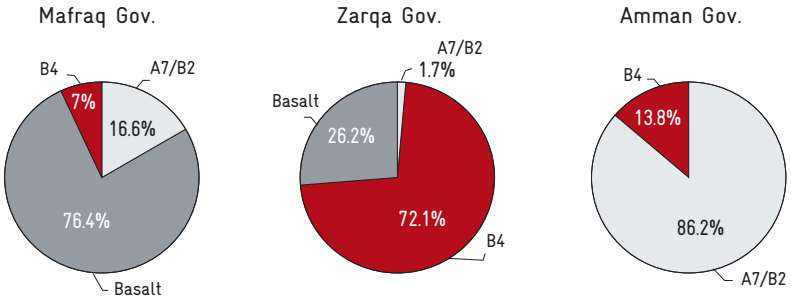

Figure 14: Abstraction from the different aquifers in Azraq Groundwater Basin in the different governorates in 2008 (Hamdan, 2010).

2 | The Azraq Groundwater Basin Features

2.4 | The Diversity of Farming Systems in the Highlands

Agricultural activities in the Highlands date back to only 20 years and are far from being homogeneous. The three areas already mentioned (Azraq, North Badia and Jiza) have completely different characteristics[27]:

In Azraq, the farms the closest to the town or the former oasis are generally quite small in size (smaller than 50 du) whereas the newer farms in the northeast are usually bigger in size. Olive tree cultivation covers around 71%[28] of the total cultivated areas in Azraq region (even 83% according to other sources[29]). See Figure 15.

In North Badia, the farms are large (generally larger than 250 du), and the wells registered (licensed). These farms are highly competitive, specialised and profitable. There, the farmers are investors from the cities and most of them are well aware of the agricultural technology and marketing (39% of the farmers constitute 50% of the irrigated land, pump 39% of the overall consumed water resources and do not depend on farming as their main source of income[30]). Agricultural practices in North Badia are far more diversified than Azraq area, covering vegetable farms, fruit tree farms (stone fruits, grapes and olives) and, in few cases, animal husbandry. See Figure 16.

In Jiza, the farms are bigger than those found in Azraq, ranging between 100 to 250 du, and are intensively cropped with vegetables with high productivity per dunum (compared to Azraq). Here, intensive horticulture predominates (tomatoes, cauliflower and water melon are the most common). Farms are scattered over the area, with horticultural farms closer to the Desert Highway and tree farms further to the east. See Figure 17.

Most of the farms in the Basin are specialised farms (specialised in one crop). There are only few farms that combine field crops and animal husbandry.

According to the Ministry of Agriculture, the cropped area in the Azraq region amounts to 3984 km^2 (all of which are totally dependent on groundwater[31]). There are approximately 550 farms, the majority of which are cultivated with olive trees. The area of forests and rangelands is estimated to be 150000 du. There are 250000 sheep and goats, as well as 573 cows on 10 dairy farms.

27 Department of Lands and Irrigation of the Ministry of Agriculture, 2008.
28 Van Aken et al., 2007.
29 Other sources include the Ministry of Agriculture (Regional Directorate annual statistics for 2010) which state that olive tree represents 73230 du out of 87928 du for the all cultivated area in Azraq region.
30 Hagan, 2008.
31 Tarabieh, 2007.

2 | The Azraq Groundwater Basin Features

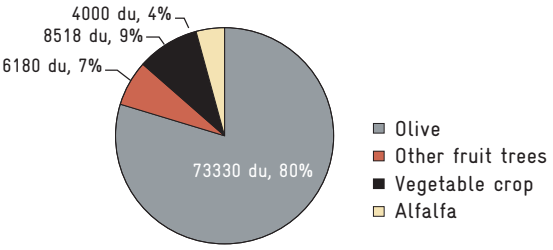

Figure 15: Crop distribution in Azraq region (Directorate of Agriculture in Azraq and WAJ office in Azraq, 2010).

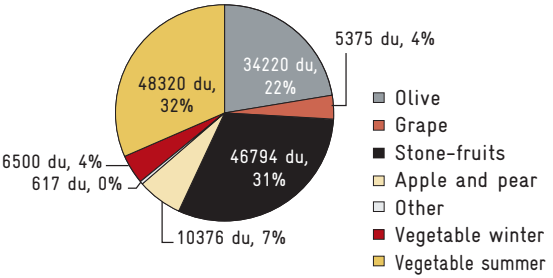

Figure 16: Crop distribution in North Badia region (Directorate of Agriculture in North Badia and WAJ office in North Badia, 2010).

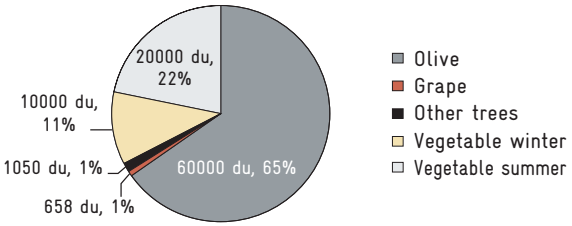

Figure 17: Crop distribution in Jiza region (Directorate of Agriculture in Jiza and WAJ office in Jiza, 2010).

The cultivation of olive trees has multiplied in the desert, mainly in Mafraq and Azraq[32]. Farmers have an emotional and cultural attachment to olive trees. Studies[33] indicate that the area of irrigated farms has increased a thousand fold since the early 1970s. Since 2000, arable land has increased by more than 25% in Azraq area and by 37% in North Badia[34].

The continuous deterioration of water quality in the desert part of the Highlands means that the future of olive oil production is at risk. Although oil produced in the irrigated area "fits with quality standards for the export market, this oil shows no particular organoleptic characteristics compared to different olive oils on the international market"[35]. See Box 4.

32 Demilecamps and Mondon, 2007.
33 Vieth et al. (2010) and IUCN (2007).
34 Vieth et al., 2010.
35 Demilecamps and Mondon, 2007.

2 | The Azraq Groundwater Basin Features

Box 4. Olive oil quality

The International Olive Oil Council (IOOC) is an intergovernmental organisation based in Madrid, Spain, with 23 member states. It promotes olive oil around the world by tracking production, defining quality standards, and monitoring authenticity.

The evaluation of olive oil quality is carried out through a chemical analysis, taking into account:

- Free acidity: It measures the percentage of free fatty acids. Olive oil is labelled "Extra Virgin" with less than 0.8% acidity, "Virgin" up to 2% and "Lampante" with higher values. The latter is not suitable for human consumption.
- Peroxide value, variations of which are due to the excess of maturity or freezing of the olives.
- The capacity to absorb the ultraviolet rays, which reflects the oxidation state of the olive oil.

In 2002, Jordan became a member of the International Olive Oil Council (IOOC). Since then, the IOOC standards analyses have been applied. A panel test has been set up by Jordan Institution for Standards and Metrology (JISM) and accredited by the IOOC in 2004. On top of this, a laboratory for chemical analysis is being accredited. The establishment of this "control security door" for the quality of olive oils reinforces the credibility of the Jordanian products on the export market.

Source: The Free Encyclopedia (2004) and Demilecamps and Mondon (2007).

Drip irrigation is the main irrigation method for vegetables and trees in the Highlands. Other irrigation techniques, such as flood and furrow irrigation, are still used in a few farms in Azraq region. Flood irrigation is limited to olive tree farms[36].

With such high level of specialisation, policies for changing water use practises need to be adapted. Indeed, seasonal crop farms can and will react more directly to economic incentives, while tree farms, a long-term investment of about 15 years, are expected to last the duration of their investment life even if benefits are temporarily negative, and therefore will not directly react to economic incentives. Therefore, the increase of water fees should have a greater and earlier impact on the production of seasonal crops than on tree farms.

[36] *Demilecamps, 2010.*

2 | The Azraq Groundwater Basin Features

Box 5. Why Azraq became such a popular area for setting up a retreat house or a farm?

Natural reasons (source: Voorwold, 2007)

The shallowness of the water table. People used to dig traditional wells (also known as "Arabic wells") by shovels and did not require pumps to access water. Water was accessible as shallow as 3 metres.

At the societal level (source: Mirza, 2009)

Land in Azraq was almost exclusively distributed to Sheikhs and high-ranking individuals or sold at a really low price. Eventually, it became very fashionable to own a piece of land in Azraq, demand grew and many people ventured into the real estate business through their connections to tribes and the locals.

The previous reason has rendered land in Azraq cheaper than elsewhere in the country because it could be gained so effortlessly. The remoteness of the area and the bad conditions of the roads (which are detrimental to agricultural products) as well as the high demand also contributed to the low price of the land.

At the policy-making level (source: Badwan, 2010)

National policy dictates that proven activity in an acquired land is sufficient to grant the alleged owner right to this land. As agriculture proved to be the cheapest form of investment to prove ownership of land, the number of farms multiplied.

Although a by-law for regulating groundwater abstraction does exist (WAJ by-law no. (85) of 2002), with higher tariffs for the Azraq region, its implementation is too feeble to inflict any changes on the water abstraction habits of the highlanders.

At the field level (source: Voorwold, 2007)

Due to the shallow water table in Azraq, the costs of drilling wells and of extracting water are much cheaper than in other areas in Jordan. In 2007, the average energy cost per extracted cubic metre in Azraq was 0.060 JD and it was 0.150 JD in Mafraq.

Under-ground water control WAJ by-law no. (85) of 2002 is considered to be very lenient. Even though the tariff (according to this by-law) is higher in Azraq than elsewhere, the high quality of its water resources and its easy access should be better reflected in the tariff system. Most farms do not have a functional filtration device.

3 | The Azraq Water Dilemma

For over 20 years, Azraq Basin has been an important source of fresh water for Jordan. Currently, the basin suffers from over-abstraction. Municipal abstraction (for Amman and Zarqa) has been constant since 1983, and ranges between 23-24 MCM/y. However, agricultural abstraction by private agricultural wells increases by the year and currently consumes more than 55% of the total abstracted water[37].

Figure 18: The Azraq Oasis in the 1960s (Al-Raggad, 2007).

Figure 19: The Azraq Oasis in recent years (Al-Raggad, 2007).

3.1 | Ecological Consequences

Azraq was once a true oasis in the middle of the desert. An important stop in the way of migrating birds, Azraq oasis was a witness of about twenty species of birds (including water birds). It is also the natural habitat of the Azraq Killifish (*Aphanius sirhani*) and plant species, which can still be seen at the RSCN Wetlands Reserve.

A Ramsar Bureau visit to Azraq in 1990 resulted in a number of recommendations. Following these recommendations, the GoJ launched a rehabilitation programme in 1994, which started with the pumping of 1.5 MCM/y into the Wetlands Reserve. Another part of this rehabilitation programme included fencing and guarding the wetland, implementing monitoring activities and launching public awareness campaigns.

With the exhaustion of groundwater recharge, the natural springs supplying the Oasis dried up in 1991 and the Oasis slowly dried up[38].

In 1997, the Azraq Oasis was listed by Ramsar for its ecological importance and significant role in bird migration patterns. RSCN is currently mandated with the protection of the oasis, however, no local laws to regulate interventions in the area exist.

37 MWI official database (WIS), 2010.
38 Abul Hawa, 2007a.

3 | The Azraq Water Dilemma

3.2 | Consequences of Over-abstraction

Severe exploitation of Azraq Basin has resulted in the drawdown of the water table. The increasing salinity of the aquifer is yet another problem. Quantity and quality of groundwater has deteriorated over the past two decades at various well field locations due to over-pumping and return flow of agricultural water.

Watertable drawdown

The groundwater level has been in continuous decline since the 1980s, which has caused the dry out of major springs feeding the Azraq Oasis in the 1990s. Severe over-exploitation has led to dropping water levels in a significant number of wells (the water table has dropped by 0.3 to 0.8 m per year).

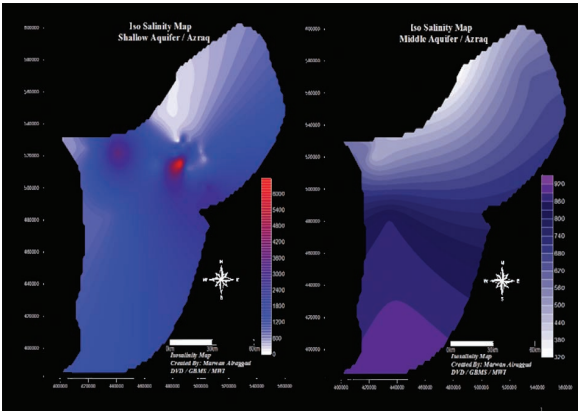

Figure 20: Isosalinity maps of the Azraq Basin (Al-Raggad, 2007).

Therefore, the water table in the AWSA well field has declined by 11 to 16 m since 1992[39]. The future availability and quality of groundwater of this heavily exploited aquifer are at risk[40].

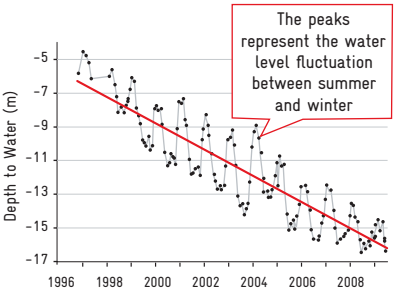

Figure 21: Groundwater level in Azraq over the years in the well F1014 (MWI official database (WIS)).

For the most part, abstraction is concentrated between the months of April to October. After that, groundwater recovery starts to take place and the groundwater level rises again (which explains the fluctuation in the groundwater levels in Figure 21).

Groundwater salinisation

Geo-electrical surveys[41] show local salt water bodies at 50 to 80 m depth within the basin (see Figure 20). The saline water is mainly present in the centre of Azraq Basin, according to the figure on the left. Therefore in the Azraq area around the oasis, the quality of the groundwater often does not meet quality standards for human consumption.

39 El-Naqa, 2010.
40 Bajjali and Al-Hadidi, 2005.
41 Worzyk and Huster (1987) cited in Al-Raggad (2007).

3 | The Azraq Water Dilemma

Figures 22 and 23 show the increase in the salinity level in a well in Azraq and its relationship with abstraction.

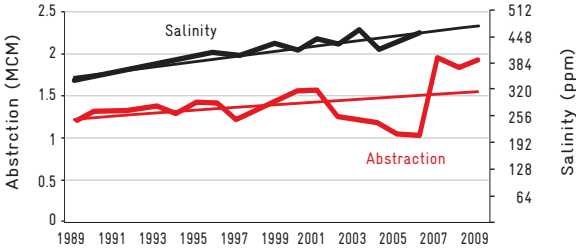

Figure 22: Relationship between abstraction and salinity in a well in Azraq (MWI official database (WIS)).

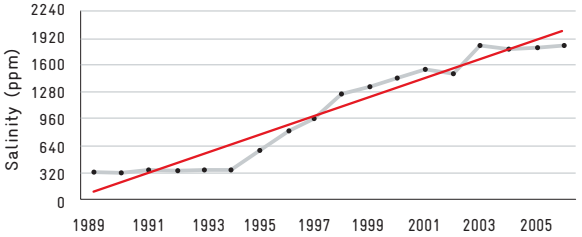

Figure 23: Salinity in a well close to the depression in Azraq basin (MWI official database (WIS)).

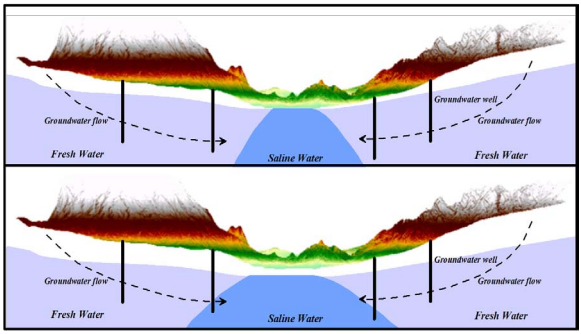

Figure 24: Effect of over-drafting on the salinity of wells near the salt-fresh water interfaces in Azraq, not to scale (Al-Raggad, 2007).

Saltwater intrusion can have several causes, some of which are natural whereas others are induced by human activity. The salinisation of the shallow aquifer (Basalt/B4) of the Azraq Basin is believed to be the return flow from "Sabkha" or "Qa'a" to the AWSA well field. This return flow results from the low hydraulic gradient of the water table and the increasing drawdown in the AWSA well field. This, in turn, causes a natural saltwater flow from Qa'a towards the freshwater system in the AWSA well field[42] as shown in Figure 24[43]. This is often exacerbated by insufficient recharge to the freshwater aquifer, which can occur in times of drought.

Water quality deterioration is also related to the intrusion of brine groundwater from the middle aquifer into the shallow aquifer, prompted by over-pumping disturbances[44]. Once saltwater intrusion has occurred, it is almost impossible to reverse, making this a significant threat to freshwater resources.

There have been attempts by GoJ to alleviate the problem. In 1992, an official law was issued whereby no further licenses were issued for the drilling of wells. In 2002, WAJ issued by-law No. (82) to control private agricultural abstraction. Although this by-law is very generous in terms of the allowed water abstraction

42 El-Naqa, 2010.
43 Al-Raggad, 2007.
44 El-Naqa, 2010.

3 | The Azraq Water Dilemma

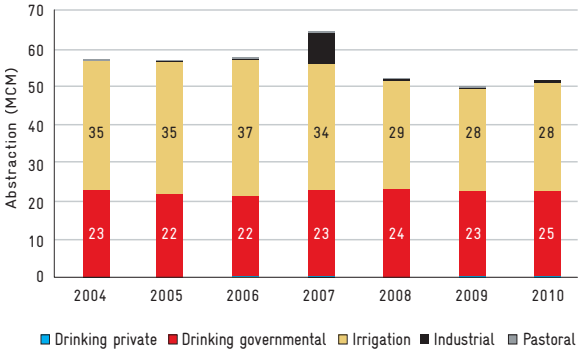

Figure 25: Evolution of water abstraction per use in Azraq groundwater basin (MWI Water Budget of 2010).

and tariff, it is considered the first real attempt to tackle the groundwater situation (see Annex 1. The Groundwater Control Regulations).

In recent years, the steep decline of water level and the productivity of the wells due to the increase in operational costs (most notably energy costs), the salinisation of the water and the lack of profitability has reduced the levels of groundwater abstraction. Some farms in Azraq were forced to shut down (see Figure 25).

4 | Challenges

Water resources will be further under pressure in the light of population increase (from about 6 million in 2008 to around 8 million by 2022 in addition to immigration influxes[45]) and the development of industry and tourism. In addition to this, climate change scenarios predict decreasing precipitation, therefore decreasing replenishment of groundwater basins. The most recent report of the Second National Communication of UNFCCC predicts that rainfall will decrease by about 20–30% and the runoff by about 30%. The future problem of energy demand and supply also has to be taken into consideration. The recent rising cost of oil has already affected every sector of the economy.

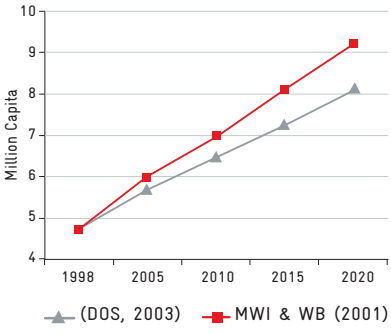

Figure 26. Scenarios of evolution of Jordanian population (Al-Raggad, 2007).

4.1 | Population Growth

Jordan's natural population growth rate stands at 2.5%[46]. Jordan's population count witnesses booms depending on the events in the political neighbourhood as Figure 27 shows. More than 2 million Iraqis fled to Jordan since the conflict began in Iraq in 2003 resulting in increased municipal water demand[47]. This means that the competition for water resources, particularly for drinking water, will only increase in the future.

Jordan's per capita domestic consumption is already low; the average Jordanian is supplied with 90 litres per day compared to the "normal" consumption rate of 170 litres cited by WHO[48].

Future megaprojects in the water sector, such as the Disi Project and the Red-Dead Sea Project are not envisaged to start before 2015 or to be completed for another 20 years and are only temporary solutions (see Box 1. Mega-projects in the Jordanian water sector).

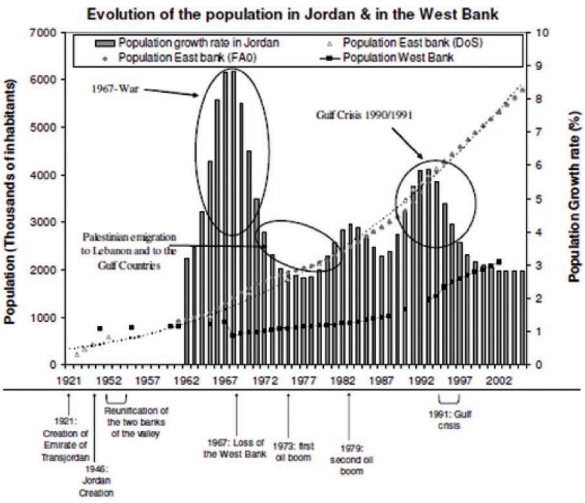

Figure 27: Evolution of Jordanian population since 1921 (Van Aken et al., 2007).

45 MWI Jordan's Water Strategy, 2008.
46 Late King Hussein's website, 2008.
47 Janua, 2008.
48 Information Bureau: Environment and Water, 2009.

4 | Challenges

4.2 | Growing Competition Among the Sectors

As in the rest of Jordan, the main consumer of water resources of the Azraq Basin is the agricultural sector. Agriculture contributed 8% of Jordan's GDP in 1976[49]. Since then, the situation has changed and in 2008 agriculture contributes a mere 3.6% of the GDP[50] (see Figure 28). Meanwhile, the other sectors, notably tourism and industry, have gained a lot of support from GoJ and have therefore experienced considerable developments. The amount of water used for irrigation in the whole country increased by 20% between 1985 and 2003, yet agricultural returns increased by only 4.5% in constant prices over this period.

The USAid Economic Development Program (2008) compares water consumption and contribution to GDP between agriculture and industry. It states that agriculture consumed 603 MCM (65%) of the total water supply in 2005 while contributing just 2.5% of the GDP. In that same year, industry consumed approximately 45 MCM (3%) and contributed 20% of the GDP. In other words, agriculture needs about 240 MCM to produce 1% of the GDP whereas industry consumes 2.25 MCM to contribute 1% of the GDP. Furthermore, for one cubic metre of water invested, agriculture generates the lowest return on investment, with a return of 0.30 JD/m^3, compared to a return of 20 to 40 JD for tourism and industry, respectively. In the Qualifying Industrial Zones (QIZ) and for the Potash Industry, water tariffs range from JD 0.250 up to JD 1.800 per cubic metre pumped from private wells. In other words, the economic return per unit of water from industrial use is one hundred times the economic return from agriculture.

The study also addresses the labour issue. Industry provided 3777 jobs per MCM consumed in 2004. Tourism contributed 1693 jobs per MCM and agriculture 148 jobs per MCM. In 2006, about 56% of all workers in the agricultural sector were non-Jordanian and therefore did not contribute income tax revenues to the treasury. Jordanian agricultural labour is primarily relegated to seasonal and occasional jobs, the non-permanent jobs with the lowest pay[51].

Table 3: Economic return per cubic metre of water for the different economical sectors (USAid Economic Development Program, 2007).

Sector	Return to Water JD/m^3	Employment per million m^3
Agriculture	0.36	148
Tourism	25.00	1693
Industry	40.00	3777

[49] Van Aken et al., 2007.
[50] HKJ Department of Statistics, 2010.
[51] Hagan, 2008.

4 | Challenges

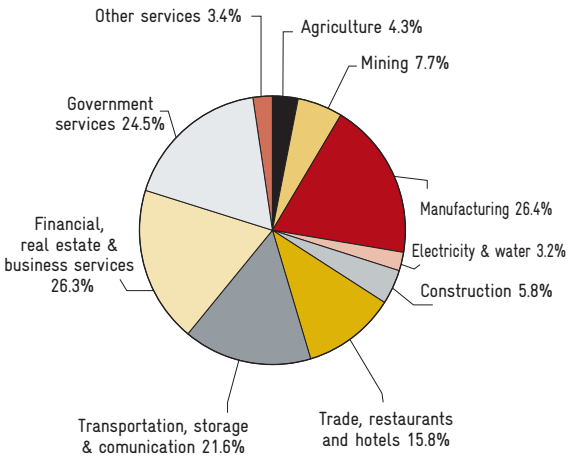

Figure 28: Sectoral contribution to the GDP of Jordan at constant basic prices (Central Bank of Jordan, 2009).

Agricultural output decreased to only 3.6% of the total GDP in 2008, a decline from the 2007 (3.9%) and the 2006 (4%) figures. The growth rate, at a constant price, of agriculture, hunting, forestry and fishing was around 0.1% in 2008 whereas it reached 1.7% in 2007[52]. These results can be traced back to the increase of energy prices and poor weather conditions, which affected the production.

The indicators related to the agricultural sector show an increase of the value of agricultural exports of up 25.4% in 2008, which can essentially be traced back to the increase of exports. However, parallel to this, investments in the agricultural sector declined in 2008 compared to 2007 (JD 4.2 million in 2008 against JD 13 million in 2007). Moreover, the capital of registered agricultural companies at the Ministry of Industry and Trade declined to JD 151.9 million. This sum was distributed amongst 651 companies at the end of 2008, compared to JD 313.8 million distributed amongst 399 companies at the end of 2007.

To present the issue from all angles, other reports discuss the importance of considering the inter-linkages between the agricultural sector and other sectors. These views encourage seeing things from a wider perspective. Agriculture, seen purely from a production point of view, contributed 4% of the GDP in 2007. Agro-business services (brokers and agents in the central markets, export and import companies, agricultural credit corporations or banks, public and private institutions for agricultural support, research and information) and merchants (mainly agricultural inputs, agrochemicals, and irrigation systems) are, however, also important factors to take into consideration. When taking the contribution of all of these businesses to the GDP into account (the indirect contribution to GDP), agriculture is said to have contributed 29% to Jordan's GDP in 1999[53].

[52] Central Bank of Jordan, 2008.
[53] Van Aken et al., 2007.

4.3 | Land Tenure and the Illegal Wells

The problem in Azraq is in essence a matter of land tenure and unregulated ownership of wells.

Land tenure[54]

Jordan's Department of Land and Survey recognises GoJ as the owner of rangelands and gives the authority of managing them to the Ministry of Agriculture (according to MOA by-law no. (20) of 1973). The vast area of the Badia region belonged to the state and was treated as rangelands. But the Bedouin tribes consider land as a private property, based on tribal claims and proprietorship under a legal title of land that has been given to them by the State since 1940.

Land ownership can be categorised as follows:

– Private land, called "Miri" and "Mulk" in Arabic, which is owned by individuals.

– Tribal land or "Wajehat Asha'eria" in Arabic, which is claimed by the tribes and historically distributed by the tribal Sheikhs.

– State-owned land (free access to all resources), which is owned by the State and at the same time claimed by tribes, although it is not divided among the tribe members.

There is a misunderstanding by both parties (government and people) as to which land is state land and which land is tribal land. Bedouins distinguish between two kinds of lands: the tenure which is a tribal land belonging to one tribe and respected by other tribes (nobody other than the tribe has the right to use, cultivate or own it) and private land which is registered and documented for individuals.

Since 1970, many rangelands in Jordan have been moved from State ownership to Bedouin ownership based on the argument of Bedouin settlements. Government policy has been motivated by the false assumption that giving away land might encourage Bedouins to settle. Other forces have contributed to this phenomenon like the fact that most Jordanian government cabinets were driven by political and social forces and tried to avoid conflicts with the different tribes. Most of the time, giving away land was considered a reward for some tribal leaders. Settlement became a tool to gain the right to own land by law and then it was sold to non-Bedouins or non-settlers. Originally urban settlers found an opportunity to own private farms at affordable prices, irrigated with quality water that can't be found to this extent anywhere else. In Azraq, the cost of digging wells and of extracting water is in fact much cheaper than in other areas of Jordan where in 2007, the average energy cost per extracted cubic metre was 0.060 JD compared to 0.150 JD in Mafraq[55]. The investors' financial abilities were

[54] Al-Aoun, 2005.
[55] Voorwold, 2007.

4 | Challenges

well above those of the resident Bedouin families, whose economic hardship forced the majority of them to sell land for cheap prices. Agriculture, particularly the hardy olive trees, was the cheapest proof of investment in the land, therefore the number of farms, hence the number of wells, multiplied.

People in Badia view all land as tribal land simply because all tribes have a traditional right to claim it.

The illegal wells

Currently, different types of boreholes exist in Azraq Basin: there are production, exploratory and observation wells. More than 549 wells are drilled in the Basin and most of them are located in the north and east of Azraq Oasis (see Figure 14); 499 of them are private agricultural wells.

Over abstraction of the Azraq Basin can also be attributed to the considerable number of illegal wells. Figure 29 shows the big difference in abstraction between legal (licenced[56]) and illegal wells. The problem with illegal wells is that owners of unauthorised wells do not meet the official quotas that are stated in groundwater bylaw and generally abstract twice to 5 times as much as the water that is permitted for the legal wells.

The WAJ office in Azraq estimates that the illegal abstraction rate reaches 13 MCM/y.

[56] *A license is needed for abstracting water. It indicates, therein the usage, the limit of the quantity by cubic metre of underground water is permitted to be extracted annually, within the conditions of the safe yield, and the capabilities of the aquifer of the well location.*

Box 6. Land ownership in Azraq

Every Bedouin tribe in Jordan has a territory that is well defined, where most of the inhabitants are still mainly from that tribe. But not all of Jordan is tribal territory, and Azraq is one of the areas where originally no indigenous tribe comes from earlier than 100 years ago. Lands in Azraq legally belong to the Government of Jordan Treasury. However, Bedwin families from elsewhere in the kingdom arrived in Azraq. Each tribe has at its head a Sheikh, highly regarded by his family with good connections to the Government officials and responsible for distributing the land per tribe claims.

In most Arab countries, there is a law called "Wa'd el Jad" that states that Bedouins have the right to own (and therefore sell) tribe-owned land. It so happens that individuals and tribes claim certain lands as theirs simply by delineating them (it has even been reported that one of these ex-officials marked land using his four-wheeler's odometer!) Tribes claimed hundreds (if not thousands) of dunums in Azraq, and the Sheikhs of these tribes in their turn, sell this "tribe-acquired" land according to wa'd el jad by means an informal piece of paper (Hijjah).

How does the GoJ legalise Higgah and register the land in someone's name?

1. On the state-owned land:

If the farmer has established his farm on state-owned land, he goes to the Department of Land and Survey (DLS) and follows the following procedure to acquire it:

- Farmer informs DLS about the fact that the land is now under agricultural use.
- DLS surveys the quality and intensity of his farming activities with the help of the MoA regional directorate present in that area. The role of DLS is to check if there is any legal claim on this land (violations).
- In the case where the farm is profitable and older than 15 years, a committee from the MoA regional directorate gives its permission and sends the report to DLS.
- The land may be legalised by DLS, provided that the owner does not sell it within the next 10 year. This condition is meant to avoid the trade of the treasury land.

If the farmer still has not established the farm on state-owned land, then he goes to DLS and follows the following procedure to acquire it:

- Farmer informs DLS about the fact that he wants to make an investment on the state-owned land.
- DLS forms a committee to check if there are any claims on that land.

4 | Challenges

- In case the committee grants the applicant the approval to invest on the land, a contract of one year can be signed, renewable and negotiable each year. Generally the legalisation of that land is granted after 5 years.

2. In the case of illegal land, as the case is for"Wa'd el-Jad", DLS does not interfere in the negotiations.

3. The renting processes related to the type of land:

- Private Lands

Renting contracts is organised in the 34 Land Registration Directorates (LRDs), which are distributed in all over the Kingdom in 5 registration offices. Renting is done under the approval of the concerned people with the duration of a lease and the rental value declared and written in the contracts.

- Treasury Lands

Conditions and required documents:

- Persons:
  - Approval from the concerned governmental entity.
  - Citizenship certificate or a copy.

- Companies:
  - Approval from the concerned governmental entity.
  - Memorandum of association of a company (registration papers).

- Processes:
  - A formal letter to concerned LRD to execute the field work and to prepare the field work report and send it back to treasury land directorate.
  - The agreement of DLS director sent by formal letter to Minister of finance to make another agreement.
  - The rental contract is signed by the director of DLS and sent with all documents of the renting transaction to the concerned LRD.

4 | Challenges

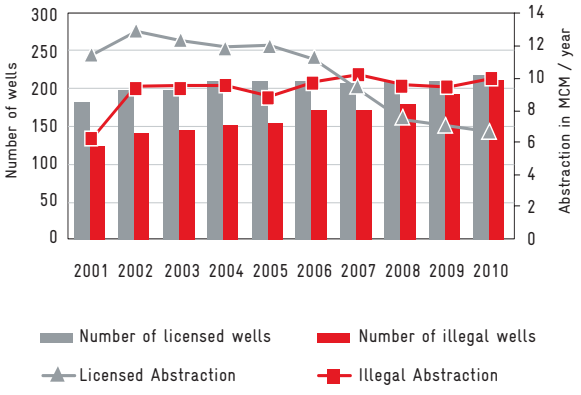

Figure 29: The number of legal and illegal wells and their abstraction (WAJ regional office, 2010).

The situation in North Badia is different from that in Azraq: In North Badia, 90% of the farms are large and have registered wells[57].

The interest for a farmer to legalise his land resides in the fact that the water abstraction prices are lower for legal wells than for illegal ones and in the context of water scarcity, this trend should be emphasised further. By law, to receive a permit to abstract water, the farmer's land has to be registered.

Why land and water laws are not being respected?

There are numerous factors affecting the implementation of laws and regulations. For example, the influence of kin and relations among tribes and high-ranking land-owners exerts considerable pressure on the enforcement of these laws. Moreover, the existence of certain farming systems in the Azraq area can also be considered a limiting factor. According to a study in 2007, more than 42% of the farmers are absentee owners residing in other regions in Jordan. They have therefore no real interest in the Basin and do not identify with its problems[58]. Apart from the farms adjacent to residential areas, all of the farms are fuelled by oil (diesel pumps). However, electricity is currently being supplied to the farming area and soon enough most of the farms will be powered by electricity. Farms will, therefore, be inclined to increase their cropped areas, resulting in increased water abstraction.

57 *Department of Lands and Irrigation of the Ministry of Agriculture, 2008.*
58 *Voorwold (2007).*

4 | Challenges

Box 7. Recent evolution of the legal statuses of lands in Azraq

- Since 1992 it is the Prime Ministry forbade the drilling of wells for agricultural purposes. This law was revised in 2003.

- In 2002, the Underground Water Control By-Law no. (85) was issued (see Annex 1), which introduced a system of quotas combined with a taxation system for any pumping exceeding the defined quotas. This by-law also introduced an effective metering and fee collection mechanism.

- In 2007, an amendment of the Underground Water Control By-Law no. (85) of 2002 indicates that the non-licensed agricultural wells drilled after the 1st of July 2005 should be backfilled.

- In July 2009, WAJ distributed water bills (4.5 Millions JD for 2003-2010) in the Al-Azraq region which did not come into effect.

- In February 2010, the Ministry of Interior Affairs gave the order to destroy all illegal farms which were younger than 2 years (between 1000 and 2000 du). The decision on which farm was to be destroyed was made by a committee comprised of the police, representatives of the Ministry of Interior and of the Department of Land and Survey. After the army had destroyed the farm land, the concerned farmers had to sign a document, in which they promised never again to farm on governmental land.

- In March 2010, WAJ again distributed water bills in the Al-Azraq region. Most of the bills were based on estimations because the wells do not have metres. The estimates, in turn, are based on the farm size and the kind of crops/trees planted.

- Farmers complained that the bills were too high (the water too expensive) and delegated 10 representatives to MWI to express their concerns. MWI agreed to put a hold on the payment of the bills until WAJ carried out a survey to judge whether the bills were indeed too high. The survey, which was conducted on 60 farms, resulted in exempting the farmers from the water metre maintenance fees (80 JOD/y). The total value of the due bills amounted to approx. 4 Mio JOD for all farmers in Azraq for the period 20032010-. The final bills were distributed mid-May, 2010, and farmers who refuse to pay their bills were to have their assets frozen.

4 | Challenges

4.4 | The Imminent Arrival of Electricity to the Farming Areas

The future of irrigation in the Highlands depends on the energy that will be used for pumping groundwater, particularly since energy is the most expensive cost for many farms. In Azraq region, electricity was only available in the vicinity of the residential area. Therefore, only the farms closest to Azraq town were equipped with electric pumps and the rest of the farms use fuel for generating electricity. But this is changing.

Once the farms are connected to the electric grid, the cost of pumping water will become cheaper: 0.060 JD at a depth of 20 m using a diesel pump compared to only 0.011 JD when using an electric pump at the same depth[59].

In January 2009, work started to connect most of the farming areas to the electric network. This will have an impact on groundwater abstraction. Indeed, as water pumping costs decrease, farmers will be inclined to pump more water. Experience in the Jordan Valley has proven that farmers re-invest all possible available water on the farm to expand their cultivated area[60]. Land is a limiting factor in the Jordan Valley. In the Highlands, however, land is an abundant resource, which means that the increased connection to the electric grid might actually expand the farming area and, subsequently, increase water abstraction rates.

The introduction of renewable energy could also decrease the costs of energy for the farmers, but it could provide alternative income from selling surplus electricity. Alternative energy could be an interesting alternative source of income for farmers, but the conditions for that must be carefully defined.

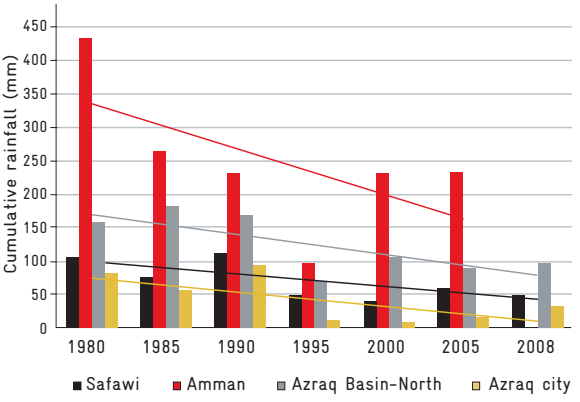

Figure 30: Cumulative rainfall in different areas within Azraq groundwater basin and Amman.

4.5 | Yearly Decrease of Precipitation Due to Climate Change

Rainfall, which is the Basin's main source of replenishment (whether it falls directly within the Basin or on Jabal Al-Arab) is observed to have decreased in the whole area.

Figure 30 shows a reduction in the amount of rainfall for different areas in Jordan, and particularly within Azraq Basin: North Badia, Safawi and the city of Azraq and Amman. The graph demonstrates that the basin recharge is not constant and that it is in continuous decrease over time.

59 *Voorwold, 2007.*
60 *Courcier and Guerin, 2004.*

5 | Key Players in Azraq Basin

The following pages describe the key players in the Jordanian water sector and the different aspects of decision-making.

Box 8. Geopolitics of water

For the water policy, the three most crucial ministries are MWI, the Ministry of Planning and International Cooperation (MoPIC), which oversees the funding and implementation of many projects and the Ministry of Agriculture.

In Arab contries, the phenomenon of *wasta* still plays an important role in the everyday functioning of societal relations. The phenomenon refers to a century-old custom of giving weight to tribal and family connections when awarding professional positions. Wasta does not suffer from an overly negative public perception and is simply seen as a means of doing business. Through wasta, powerful tribes are able to build and maintain links to the Government and thereby actively lobby for the interests of their group.

When looking at power centres in Jordan, it is also essential to consider the power of major donors and lending organisations, such as the World Bank, who sets terms and priorities on the implementation of national projects that it wishes to finance, which can therefore influence certain water policies.

Jordan's water policy and the related decision-making power are dictated by regional geopolitics. Most of Jordan's major water resources are transboundary. Although Jordan is considered an island of stability in an unstable region, it is not sufficiently large or powerful to affect destabilising factors that originate abroad. Therefore, the Government of Jordan is prone to be reactive to external stimuli rather than responding proactively to long-term crises, such as water scarcity.

5 | Key Players in Azraq Basin

5.1 | The Azraq Melting Pot

The Azraq Basin stretches across the four governorates of Greater Amman, Zarqa, Ma'an and Al-Mafraq. Azraq district lies within Zarqa governorate and has 8 residential areas.

The total number of inhabitants living in the Azraq Basin area reached about 29000 in the year 2008[61]. The Azraq Basin is sparsely populated with only a few thousand people living in and around the city of Azraq and in villages in Mafraq governorate in the north. The total population of Azraq's urban area is estimated at 12000, the majority of which (6500) are from the Bani Ma'arouf tribe (Druze). The rest are comprised of the Shishan (Chechens) and the settled Bedouins[62]. Jordan continues to possess a strong tribal system which is reflected in the farming community of Azraq, where influential farmers often have other businesses in Amman.

Azraq was considered a wintering area for the Druze and Bedouins, who also stayed in the area during spring and summer to trade products and basic needs for their tribes. During this time, the region witnessed an economic boom[63]. Azraq was (and still is) an important stop for pilgrims coming from Turkey and Asian countries on their way to Mecca to perform the Haj duty.

Figure 31: Druze, Chechen and Bedouin women and men in traditional attire (Photos courtesy of The Free Encyclopedia (2004), Jaimoukha (2009), Al-Shamal Gate Forums (2000)).

61 *According to the HKJ Department of Statistics cited in Hamdan (2010), p. 4.*
62 *Wolter et al., 2008.*
63 *Tarabieh, 2007.*

5 | Key Players in Azraq Basin

North Azraq holds the majority of inhabitants (6500 inhabitants), consisting mainly of Druze in addition to the Bedouin tribes of Qaisi and Da'aja. A considerable number of Iraqis, including the Iraqi Ziyadi tribe inhabit Azraq as well, who came following the 1990s Gulf War. South Azraq comes in second place with regard to its population, which consists of 4000 people, namely Chechen families and Bedouin tribes (see section about Bedouins below). As for the area of Ain-Al-Baida and the farms that are inhabited by 500 people, most of them are from the Ahel Al-Jabal tribe. The military airbase is inhabited by 350 people and in the Al-Omairi area by around 400 people in addition to some families in the Um Al-Masayel and Dughela areas (two farming areas closest to the heart of the Azraq residential area).

Each of these population groups is known for its solidarity, if not bias toward their own group.

The Druze

The Druze originally come from Al-Sweida'a governorate in Syria. Originally, the Druze, also known as Unitarian Druze, represented a religious sect that diverged from Islam in the time of Caliph Al-Hakim in 1017 A.D. They are currently citizens of Syria, Jordan, Lebanon, Israel and the Palestinian Territories. The Druze are considered Muslims in Jordan but that is different in other countries.

In Jordan, Druze are known as "Bani Ma'arouf", to mimic the usual tribal nomenclature (e.g. Bani Sakhr, Bani Hassan). The number of Druze in Jordan is approximately 20000 to 25000 according to Sheikh Ajaj Ata[64]; the Mukhtar or tribal leader of Druze in Azraq; half of which live in Azraq and the other half in Amman[65]. After a first visit in 1888 to find water and food for their sheep herds, the Druze were given land in Azraq by the Ottoman Sultan in 1905[66]. Until their final settlement in Azraq in the 1920s, the Druze only came for the transhumance during the dry season from the north. Twenty-two Druze families arrived in North Azraq (which was called Azraq Ad-Druze after them) from their native area in Syria following the 1920 uprising against the French occupation in Jabal Ad-Druze (or Jabal Al-Arab)[67] in Syria. These families took shelter from wild animals and the raids of other tribes in the Azraq Castle. The Druze played a role in the formation of the Jordanian state. For instance, Rasheed Tlei'a, a Durzi, was the first prime minister (twice) of Jordan in 1921.

The Druze of Azraq worked mainly in salt production in the areas known as Mallahat, in the Azraq Qa'a. After the salt industry stopped in Azraq in the year 2000, many Druze reverted to agriculture and to working in the public service (governmental positions). The Druze head 6 out of the 10 registered Community Based Organisations in Azraq.

64 Ata, 2010.
65 Akhawia Forums, 2011.
66 Ata, 2010.
67 Mannheim, 2000.

5 | Key Players in Azraq Basin

The Chechens

The Chechens (pronounced "Shishan" in Arabic) fled their homes in the Caucasus from Russian oppression to preserve their freedom and faith at the end of the 19th century. They moved south towards the "land of Islam"; some settling in Turkey and Syria whereas others continued their way to Jordan. The first wave of Chechens (about 70 families) arrived in Jordan in 1902 and settled in Zarqa along the banks of the Zarqa River, which is the main residence for Chechens in Jordan. Eventually they expanded to the towns of Sweileh (1904), Sukhneh (1911) and finally to South Azraq (or Azraq Ash-Shishan) which came into being in 1912, following an agreement between a group of Zarqa Chechens and local Bedouin tribes.

The number of Chechens in Jordan is estimated at 20000, mainly inhabiting their traditional settlements and Amman. The Chechens are recognised as a single tribe. This means that socially, tribally and politically they are treated as a Jordanian tribe. This also implies that Chechens are recognised politically in Jordan and are represented by quota in the Jordanian parliament. Chechens have been keen on working in the armed forces and government; however the number of engineers, technicians and entrepreneurs has increased as of late. Several Jordanians of Chechen origin played a leading role in Jordanian politics, particularly in the armed forced. The Jordanian Chechen keeps in touch with his/her community through a multi-branched Chechen Benevolent Association that is mainly concerned with the welfare of the needy members of the Chechen community[68].

Chechens in Azraq, currently 50 families (around 300 inhabitants[69]), have dwindled in number, largely due to younger generations leaving to Amman and Zarqa for better employment opportunities. They still inhabit South Azraq.

The Bedouins

Bedouins, or Badu, consider themselves to be "true Jordanians". Bedouins take pride in their way of life and view themselves as the noblest class in Arab society. Their social organisation is based on collectivism and fierce loyalty to family, clan and tribe[70]. The main tribes inhabiting Azraq are Bani Sakhr, Al-Hweitat and Al-Zayadi.

Al-Shoshan and Al-Nimer family are the main existing families (Asheera) belonging to the Bani Sakhr tribe in Azraq. They live from trade and agriculture, and assume governmental positions. The Hweitat families started coming to Azraq from the south of Jordan in the 1960s following their enlistment

68 *Jaimoukha, 2005.*
69 *Al-Shishani, 2010.*
70 *Al-Homoud et al., 2008.*

5 | Key Players in Azraq Basin

in the Desert Force (Al-Badia Force)[71] and continued to come until the 1990s. The Zayadi tribe is of Iraqi origin and came to Jordan following the Gulf War in 1993. Its members therefore arrived in Azraq in the early nineties. They mainly live from trade, animal husbandry, agriculture and assume governmental positions.

[71] *The Desert Force (Al-Badia Force), also known as Desert Patrol, was founded by Glubb Pasha to secure Transjordan›s desert region of the country; everything east of the cultivated area that formed Trans-Jordan's western border with Palestine. Among its tasks were also to guard Jordanian borders with Iraq, Saudi Arabia and Syria as well as to provide protection for oil pipe lines of Iraqi Petroleum Company (IPC).*

6 | The Highland Water Forum Initiative

6.1 | Background

As mentioned before, Azraq groundwater basin is heavily overused, exceeding the safe yield by 22 MCM in 2010. Irrigated agriculture uses up more than half of the abstracted groundwater, leading to a yearly decline in groundwater levels and quality.

In the light of increasing water scarcity in Jordan and, thus, growing competition for water resources, Jordan is challenged with increasing pressures to reduce water consumption for agricultural use. The Ministry of Water and Irrigation, supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), has therefore established the Highland Water Forum under the patronage of His Royal Highness Prince Faisal Bin Al Hussein in 2010. The Forum is officially mandated by the Jordanian Prime Ministry to develop and implement the Highland Water Action Plan, which aims at sustainable management of groundwater resources, including a clear agenda for implementation. This action plan contributes to the implementation of the National Water Strategy.

6.2 | Rationale for Stakeholder Involvement

The groundwater situation in the Jordanian northeastern Highlands has been assessed repeatedly and options to address the problem of groundwater over-abstraction have been tested. All evaluations

Figure 32: The Highland Water Forum members with HRH Prince Faisal Bin Al Hussein.

have shown that stakeholder participation and clear definition of roles and responsibilities among governmental bodies are the levers with the greatest direct impact on farmers' behaviour. An external evaluation of the GTZ-Water Programme component "Water Management in Irrigated Agriculture" (WMIA) in April 2008 analysed the options to achieve the objective of sustainable groundwater resource management and recommended a multi-stakeholder approach to tackle the problem. In November 2008, the Jordanian Ministry of Agriculture proposed a concept of a Stakeholder Dialogue for the Highlands, focusing on mobilising key stakeholders and involving them in a dialogue with governmental decision makers in order to draft a mutually-agreed roadmap towards a sustainable management of the groundwater resources.

The value of the Forum manifests itself in its potential for being a tool for learning, developing and introducing innovative concepts and solutions for groundwater management. In addition, in its core lies the potential for building

6 | The Highland Water Forum Initiative

trust between negotiation partners and enforcing the consciousness of being part of the same solution. Stakeholder involvement will promote a common understanding and vision of the problem and allow for the introduction of innovative concepts and solutions for groundwater management, including concepts for alternative business opportunities and effective incentive schemes. The Forum therefore creates greater acceptance among water users of political decisions issued by the water regulating authorities. In the process, it serves to promote the alignment and complementarities of the roles and mandates of the different governmental organisations. Furthermore, the bottom-up approach provides incentives and transparency and thereby facilitates donor involvement.

Tasks

The forum consultations contribute to the elaboration of the groundwater management action plan through recommendations collected from the stakeholders during the dialogue consultations. Deriving from these recommendations, concrete measures are defined and, in turn, feed into the aforementioned action plan. The action plan is comprised of the following four fields of intervention:

- Legal and institutional framework conditions,
- On-farm water-use efficiency,
- Water-responsible, income-generating activities, and
- Community development.

The action plan describes activities that stem from the knowledge and interaction of the stakeholder representatives (the Forum members). However, the applications of these activities will always require monitoring tools and methodologies and activities to improve the framework conditions under which these activities would yield the best outcomes. With this in mind, the action plan pursues a double incentive approach; one that favours voluntary shifts in water consumption behaviours, and one that sets the appropriate policy environment that enables these shifts to occur in a sustainable manner.

Therefore the HWF action plan follows a strategic programme approach which goes beyond disconnected projects and aims to mainstream best-practice techniques into one programme, with the overall goal of overcoming groundwater depletion and developing ways of sustainable resource management.

The elaboration of an action plan as a dynamic process and the progress of the stakeholder dialogue will grow in unison. Parallel to this, a financing system for the implementation of the action plan is being developed, that takes into consideration the different financing procedures of interested donors.

The Highland Water Forum is a long-term strategic initiative that will thrive only with the interest and commitment of its members. Stakeholder involvement is especially important to water

6 | The Highland Water Forum Initiative

governance in the sense that it ensures that the different segments of the society are heard and represented and, most importantly, consulted in issues that touch their very existence.

6.3 | Organisational Structure

As part of its organisational structure (Figure 33), the Forum consists of and is supported by a Secretariat, an Advisory Board and a Steering Committee. Donors are involved through the development of a financing structure that will complement the Forum by supporting the implementation of activities and measures mentioned in the action plan. The Highland Water Forum consists of 60 stakeholders (otherwise referred to as the Azraq Working Group) from the agricultural water users, government institutions and NGOs and research institutions.

The Highland Water Secretariat is a unit based at MWI. The Secretariat, in its own right, is a model for multi-organisational cooperation; over time it has been seconded by technical experts from MWI, WAJ, GIZ, the French Cooperation

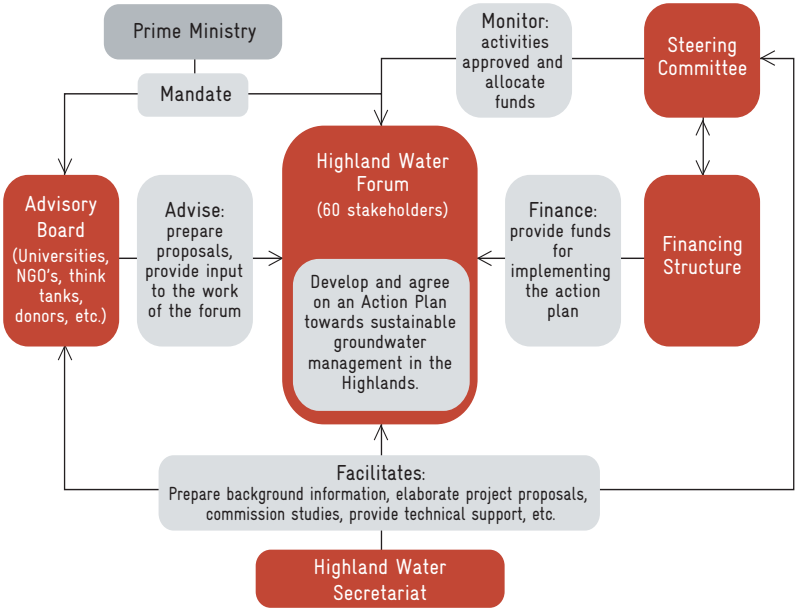

Figure 33: The Highland Water Forum organisational diagram.

6 | The Highland Water Forum Initiative

(the French Embassy in Amman), and the Jordan Hashemite Fund for Human Development (JOHUD). Furthermore, an Outpost for the Secretariat was established in the Azraq WAJ office in order to ensure close proximity to the main stakeholder groups (civil society and farmers).

The Steering Committee closely monitors the developments of the action plan and makes sure that HWF is working to achieve its goal. This wide spectrum of governmental institutions serves to achieve role alignment and coordinate their efforts regarding the water sector. In order to ensure that this cross-sectoral alignment also reaches the operational levels, measures are formulated to this end in the Action Plan. The involvement of NGOs and research institutions guarantees that the interests of the local communities are present and local development are taken into consideration in the implementation and design of interventions of the Action Plan. The Steering Committee meets on a yearly basis to discuss the progress of the Highland Water Forum.

The members of the Advisory Board provide technical and scientific input to the work of the Forum. They also maintain connections to other actors in the field. The Advisory Board comprises strategic partners and active members from the water sector and experts from different fields, such as universities, NGOs, donors, media etc.

6.4 | The Highland Water Forum Process

Stakeholder selection

The selection of the Forum members was of particular importance due to the difficulties, the power struggles and social considerations and affiliations that exist among the stakeholders themselves on one hand, and between them and the Jordanian government on the other hand. Taking these relationships into consideration while selecting the stakeholders was necessary to understand the reasons for the ineffectiveness of laws and regulations in Azraq region. The identification of the influencing stakeholders and understanding their social structure to develop a strategic plan dictated performing an extensive stakeholder analysis that covers the whole basin. The analysis also aimed at mapping the stakeholder landscape, identify key stakeholders, links and networks, and optimise strategic stakeholder participation. After interviewing more than 200 farmers in Azraq groundwater basin area, the agricultural water users (the farmers) were determined by the number of votes that they received. The Stakeholder Network Analysis (SNA) guaranteed that the stakeholders the most important for this process, i.e. the farmers, not only will be present but will contribute to forming a public opinion amongst the other farmers. This will also allow for an efficient exchange of information between HWF and the entire stakeholder

6 | The Highland Water Forum Initiative

community. The rest of the stakeholder groups representatives were determined in a participatory process with actors who were active at that time in the area (local community, CBOs, NGOs, etc) by means of a Participatory Impact Assessment (PIA).

The SNA marked the onset of the dialogue, largely because it was the point where much awareness about groundwater over-abstraction was communicated to the agricultural water users, and because news about the HWF concept was disseminated. SNA extended over a period of two months of field surveys which was followed by another month of data analysis by the specialists. The Forum members were officially announced during a launching ceremony presided by His Royal Highness Prince Faisal Bin Al Hussein, who champions many water-related initiatives in the kingdom. The official nature of the ceremony helped to cement the commitment of the members to the dialogue process and evoke confidence in the process.

Figure 34: Stakeholder Network Analysis announcement of results workshop in October 2009.

Awareness activities

Awareness-raising is an important accompanying measure that cannot be separated from the activities of HWF, which have been regarded with interest by several other donor organisations.

As a tool that could be used when discussing with stakeholders, the Physical Groundwater Model proved to be invaluable. The Secretariat reproduced this model, of which previous copies had existed in MWI and WAJ since years. These copies, however, were old and algae-infested. The model is a transparent box made out of acrylic filled with sand layers of different densities which reflect the geological situation of Al-Azraq basin. Once water flows

Figure 35: Interview on the field with the Social Network Analysis team.

6 | The Highland Water Forum Initiative

through the sand layers, the model demonstrates the movement of groundwater and the impact of over-abstraction and pollution. The model is a tool for awareness-raising regarding the groundwater situation in the Al-Azraq region for all groups of stakeholders.

In order to provide the Forum with a corporate identity, the Secretariat organised a logo competition with the support of MWI, WAJ, GIZ and the Ministry of Education. The main goal was to raise the awareness of the students in the project area about the groundwater problem of Azraq basin. 25 schools were visited (in Azraq, Mafraq and North Badia areas) and a presentation was given to 700 students about the groundwater problem in the Highlands (using the Physical Groundwater Model) and activities of the Highland Water Forum. More than 900 sketches were received, and the HWF members voted for the winner among the best 20 logos which were pre-selected by MWI and designers from the Al-Quds College. The top 20 logos were exhibited throughout August 2011 at the Children Museum in Amman.

In 2012, the United Nations Development Programme (UNDP) in Jordan implemented the "Groundwater Governance in the Highlands Project" under the umbrella of HWF in cooperation with MWI. The project aimed to implement a Groundwater Competition for water-friendly business ideas and finance 3 projects. The support also covered a capacity development programme for Community-Based Organisations representatives, better known as the Groundwater Ambassadors. The Ambassadors have the potential for being catalysts for awareness raising and development in their respective areas and CBOs.

Figure 36: School logo competition awards ceremony.

Figure 37: Awareness campaign in the schools by the HWF Secretariat.

6 | The Highland Water Forum Initiative

Dialogue consultations

The Forum is intended as a permanent platform of discussion and information and not as a decision-making or fund-allocating body. In other words, it represents an open "market place" of ideas and projects where all the important players can meet each other and nobody is excluded on the basis of strategic choices. The Azraq Working Group has repeatedly since 2010 tackled the fields of intervention that constitute the Highland Water action plan.

Figure 38: HWF members during a working session.

A lot of effort was put into designing the moderating the sessions. The outcomes of the sessions are compiled and documented as minutes of meeting and distributed to all forum attendees. Depending on the topic, the outcomes took the format of a Recommendation Paper, such as the case in the agenda item "Laws and regulations", which pertains to the field of intervention "Legal and institutional framework conditions". The Recommendation Paper represents the voice of the stakeholder community on what it believes should be considered for the elaboration of a just and effective groundwater by-law. This Recommendation Paper was discussed by the Steering Committee and disseminated to all project partners.

6.5 | The Highland Water Forum: The Way Forward

The government of Jordan has taken broad steps towards institutionalising stakeholder participation in the management of groundwater resources in Azraq basin. Since MWI initiated HWF in the year 2010, its outcomes have resonated among the public as well as Jordan's donor community.

In 2012, MWI and WAJ and the European Union Delegation in Jordan will cooperate with the German-Jordanian Water Programme to start engaging the stakeholders in Yarmouk River Basin. Yarmouk is a basin situated north of Jordan of great importance to Jordan's political stability and water security. The project will utilise the same methodology that was followed in Azraq basin.

6 | The Highland Water Forum Initiative

Figure 39: The former Secretary General of MWI and Assistant Secretary General of WAJ engaged in discussion in a HWF working group.

Similarly, the World Bank Institute in cooperation with MWI have put forth a concept for establishing the Jordan Valley Water Forum. This concept calls for establishing a collaborative decision-making platform designed so that critical water issues facing the Jordan Valley can be addressed through better coordination and engagement between the public and private sector stakeholders.

Figure 40: The HWF members visiting a farm in Azraq region.

It is evident that stakeholder participation is integral for sound water governance, particularly in the extreme case of water scarcity in Jordan. Though approaches of stakeholder engagement may change and take various forms, what remains constant is the necessity to commit towards involving the conflicting water users in decision-making and harnessing their differences towards innovative solutions.

Annex 1 | The Groundwater Control Regulations

There have been several attempts by the Government of Jordan to tackle the problem of groundwater over-abstraction (see Figure 41).

In 1992, the drilling of agricultural wells was frozen by a decision of the Prime Ministry whereby no further licenses were given for the drilling of new wells except under certain conditions defined by MWI (industrial wells, university, tourism, etc.)

In 2002, the Government of Jordan issued a system of quotas combined with a taxation system for any pumping that exceeds the quota, as well as introduced effective metering and fee collection mechanisms (see Table 4). WAJ therefore issued Underground Water Control By-Law No. (85) of 2002 to control groundwater abstraction. Although this by-law is generous in terms of water quantities allowed for abstraction and set tariffs, it is considered as the first real attempt to tackle the groundwater issue.

But instead of endorsing the previous quotas (50000 and 70000 m^3/y/well, and sometimes 100000 m^3/y/well after 1990), the by-law allowed the free use of 150000 m^3/y/licensed well, a volume much higher than the limits mentioned in licenses[72]. It is reported that farmer interest groups have obtained the cancellation of the former limits and in return accepted the principle of taxing volumes abstracted above a certain limit[73]: Technical, institutional and political difficulties act as impediments to the effective implementation of the reforms[74].

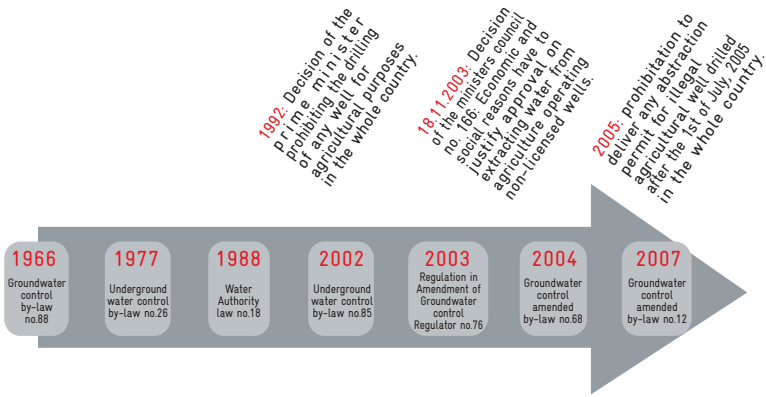

Figure 42: Evolution of groundwater-related laws and regulations in Jordan.

[72] Venot et al. (2007) and Van Aken et al. (2007).
[73] Pitman (2004) cited in Venot et al. (2007), p. 11.
[74] Van Aken, 2007.

Annex 1 | The Groundwater Control Regulations

The Underground Water Control by-law no. 85 of 2002 indicates that:

- Underground water is owned and controlled by the state. A license is needed to be able to extract water indicating the usage of the well (purpose), the extraction quantity, etc.
- Land ownership does not imply ownership of underground water. The license to extract water issued to the landowner is considered as a permit to utilise it.
- The fees in Table 4 shall be levied by the Authority for issuance of licenses:

The bylaw was amended in 2003, 2004 and 2007 and is quite generous for agriculture. Only wells for agricultural purposes are free of charge for an amount of water pumped. Wells for all other purposes have to pay from the first extracted cubic metre, and the price per cubic metre extracted is more expensive than for agriculture (see Table 5).

According to the by-law, for agricultural wells the water prices are categorised into 4 categories:

- The licensed wells for the whole country and permitted wells for the whole country except Azraq region,
- The permitted wells in Azraq region,
- The illegal wells,
- The brackish water wells.

There is NO FREE abstraction for illegal wells (without a valid extraction license or permit).

The abstraction permit in Azraq indicates an allowed abstracted quantity which is FREE of charge.

For the saline water wells exploited for agricultural purposes, it concerns abstraction from brackish aquifers: the higher the water salinity, the lower the fee. Since the salinity level of the Azraq basin is lower than 1350 ppm, the second amendment does not affect abstraction in Azraq, and the rules described above apply.

Table 4: Fees for issuance of licenses mentioned in the Under-ground Water Control by-law no.85 of 2002 and its amendments.

Drilling license	1000 JD – one thousand Jordan Dinars
Renewal of drilling license	500 JD – five hundred Jordan Dinars
Water extraction license	100 JD – one hundred Jordan Dinars
Renewal of extraction license	50 JD – fifty Jordan Dinars
Substitute drilling license	750 JD – seven hundred and fifty Jordan Dinars
Well Deepening license	500 JD – five hundred Jordan Dinars
Well maintenance or cleaning license	300 JD – three hundred Jordan Dinars
Possession or use of a drilling rig license	500 JD – five hundred Jordan Dinars
Renewing the license for drilling a well to replace another well	200 JD – two hundred Jordan Dinars
Renewing the license for training, repairing or deepening a well	100 JD – one hundred Jordan Dinars

Annex 1 | The Groundwater Control Regulations

Table 5: Water fees for agricultural wells as mentioned in the Under-ground Water Control by-law no.85 of 2002 and its amendments.

Water prices (per cubic metre)	Water Quantity	Licensed wells all over the kingdom
For free	From (zero) up to 150.000 m^3	
fils 5	More than 150.000 up to 200.000 m^3	
fils 60	More than 200.000 m^3	

Water prices (per cubic metre)	Water Quantity	Agricultural wells awarded permission to extract water in Azraq area
For free	From (zero) to the limited quantities	
fils 20	More than limited quantities up to 100.000 m^3	
fils 60	More than 100.000 m^3	

Water prices (per cubic metre)	Water Quantity	Agricultural wells without extraction licence or permission to extract water (violating wells all over the kingdom)
fils 25	From (zero) up to 100.000 m^3	
fils 30	More than 100.000 up to 150.000 m^3	
fils 35	More than 150.000 up to 200.000 m^3	
fils 70	More than 200.000 m^3	

Water prices (per cubic metre)	Propotion of salinity (parts per million)	Water Quantity	Saline wells used for agricultural purposes only
For free		From (zero) up to 150.000 m^3	
fils 15	From 1350 up to 1500	More than 150.000 m^3	
fils 10	More than 1500 up to 2000		
fils 5	More than 2000		

"Owners operating wells which were not licensed prior to the effectiveness of this Regulation must discontinue the extraction of water from the said wells, and must fill them up (with earth) under the supervision of the Authority within a period not to exceed one year from the date of its effectiveness. However, in case there are economic or social reasons justifying the continuity of extracting water from the said wells, the council may, on the basis of principles ratified by the council of Ministers, approve and allow the extractions of water from the said wells for a specified period and according to the conditions determined by it. This shall be made against the payment of an amount of money according to the schedule indicated below

Annex 1 | The Groundwater Control Regulations

for each linear metre of the depth of the well, provided that no harm will be entailed to the interests of the neighbouring owners of licensed wells, and provided that the well owner will, in such case, bear any claim for compensation against any damage inflicted upon third parties." (Excerpt of the article 41 of the Under-ground Water Control by-law no.85 of 2002 amendment in 2003).

In this case, the amounts of charges for illegal wells with further usage will be paid once as indicated in Table 6.

After a minimum period of 3 years, by a resolution from the Council, an extraction permit may be amended to en extraction license, in case there is no objection thereto according to the previsions of this Regulation.

In order to compare the free amount of water allowed for agricultural purposes with the everyday life consumption of water, the first free 150000 m^3 represented about 67 MCM of free water pumped (in 2005). It is the equivalent to supplying 100 l/cap/d to 1.8 million municipal residents for one year, nearly one-third of Jordan's population[75].

Table 6: Fees for illegal wells authorised to abstract by WAJ.

Depth of the well	Fee per metre of depth
Less than 50 m	30 JD
Over 50 till 100 m	40 JD
Over 100 till 150 m	50 JD
Over 150 till 200 m	100 JD
Over 200 m	150 JD

[75] *USAid Economic Development Program, 2008.*

Annex 2 | The Existing Farming Systems in Azraq Basin

According to the Highlands Farm Survey 2008 prepared for the Ministry of Agriculture and the Department for Lands and Irrigation, the agricultural sector in the Highlands is characterized by specialised farms.

Farms with more than 250 du of cultivated land dominate in the Highlands. However, the distribution of small, medium and large-scale farms is different in the three basin directorates.

While 50% of the farms in North Badia are larger than 250 dunum, small farms with less than 50 dunum are dominant (83.3%) in Azraq. These small farms can be found close to the village of Al Azraq and the old oasis, whereas the farms northeast of Azraq are mainly big farms. In Jiza, farms between 100 and 250 dunum are common. Most of these farms are intensive vegetable farms with a high output per dunum (Figure 43).

Despite the widespread use of localised irrigation (small farms in Azraq are still using surface irrigation), the efficiency of irrigation systems is very low. Most farmers are not using the full potential of their modern irrigation method (with the exception of the stone fruits farms with high technology in North Badia). Average efficiency of irrigation is estimated to be 67% in North Badia, 66% in Jiza area, 63% in Azraq area.

According to a recent study[76], farms types and their main characteristics in Azraq are summarised in tables 7 and 8.

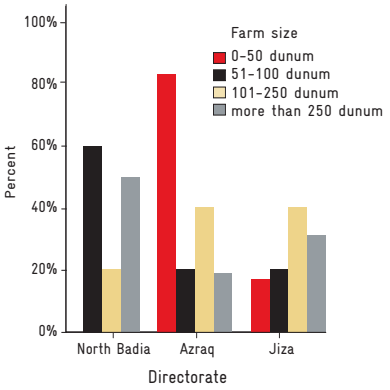

Figure 42: Size of farms in Azraq basin.

[76] *Demilecamps, 2010.*

Annex 2 | The Existing Farming Systems in Azraq Basin

According to tables 7 and 8, most of the farms in the Azraq region are not making good profit whereas it is in this area than around 70% of the Azraq Basin groundwater abstraction happens. Most of the abstraction comes from professional olive trees farms and olive tree farms with alfa alfa which have a high consumption of water per dunum. Most of the farms in Azraq region are small farms which just pump a small amount of water. In North Badia and Jiza, most of the farms are making a good profit.

Table 7: Farm types and their main features in Azraq region.

Farming systems	Average farm size	% of Azraq farms	% Total irrigated area	Average water consumption	Average yearly profit
Small olive tree farms (with fruit tree intercroppimg)	40 du	42%	11%	1160 m^3/du/y -Surf: 1300 m^3 -OT: 900 m^3	9 JD/du/y
Professional olive tree farms	200 du	19%	25%	905 m^3/du/y	20 JD/du/y 100 if prad
Professional olive tree farms with diversification (grapes pomegranate...)	240 du	14%	22%	390 m^3/du/y	130 JD/du/y
Olive tree farms with diversification to alfalfa	270 du	22%	39%	1040 m^3/du/y	Variable 85 JD/du/y
Vegetable	170 du	3%	3%	1400 m^3/du/y	N/A

Table 8: Farm types and their main features in North Badia and Jiza.

Farming systems	Average farm size	% of farms	% Total surveyed area	Average water consumption	Average yearly profit
Stone fruit trees Entrepreneurs	320 du	13%	12%	1295 m^3/du/y	1000 m^3/du/y
Family mixed farms vegetables and trees	240 du owned +180 du rented	48%	58%	1315 m^3/du/y	460 m^3/du/y
Open field vegetable farms	160 du	8%	4%	1600 m^3/du/y	370 m^3/du/y
Large olive trees farms	400 du	22%	25%	570 JD/du/y 800 if no pb	60 JD/du/y 175 if no pb
Small olive trees farms with livestock	10 du	9%	1%	180 JD/du/y	No profit

Annex 2 | The Existing Farming Systems in Azraq Basin

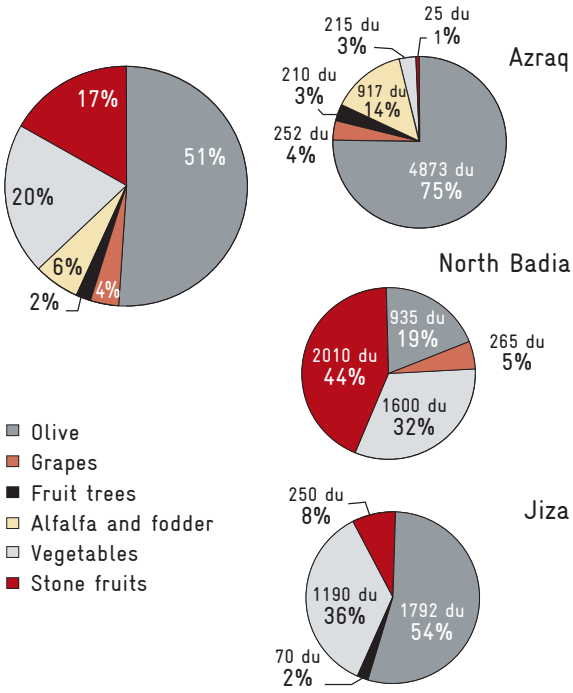

Figure 43: Repartition of irrigated crops in Azraq, North Badia and Jiza.

As shown in Figures 44 and 45, in Azraq region, farms growing alfalfa are abstracting the biggest amount of groundwater (46%) whereas their superficies just represent 39% of the planted area. Highlighted here is the efficiency of water use of professional farms with diversification to fruits, which represent 22% of the irrigated cultivated land but consume only 10% of the abstraction water.

In North Badia and Jiza, family mixed farms of vegetables and trees are large water consumers, consuming 68% of the total abstracted water while covering 58% of the irrigated agricultural area. In comparison, large olive tree farms achieve more water savings; using 12% of the abstracted water while covering 25% of the total area.

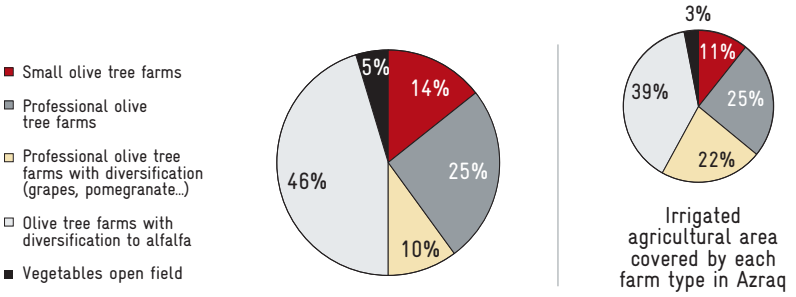

Figure 44: Repartition of water abstraction per farming system and by respective irrigated area in Azraq agricultural region.

Annex 2 | The Existing Farming Systems in Azraq Basin

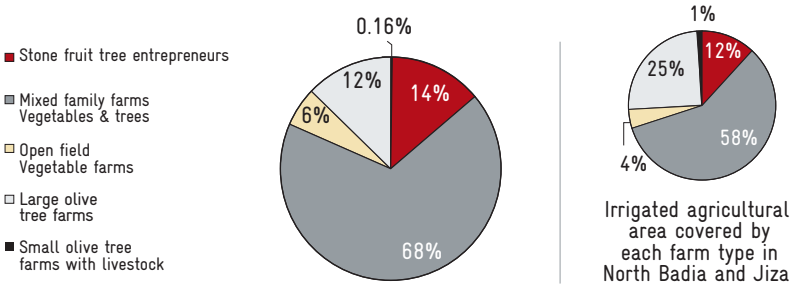

Figure 45: Repartition of water abstraction per farming system and by respective irrigated area in North Badia and Jiza.

Annex 3 | Crop Water Requirements in Azraq Region[77]

The key elements of the current agriculture incentive system[78] are as follows:

– Wholesale pricing scheme that discourages produce quality,

– High transaction costs: taxes, fees, and obtaining export documents,

– Entry barriers to competition: custom duties, fees, and tax protection, and

– Subsidised water for irrigation: first 150000 m^3/y of groundwater pumped for irrigation is free.

A governmental tax increase, which reaches around 60% on irrigation equipment and pipeline nets, is reported to have discouraged farmers from adopting modern irrigation systems, which would have improved the irrigation efficiency, decreased water losses and consequently improved agricultural production and farmers' income[79].

Table 9: Water requirements per crop in Azraq region according to the Ministry of Agriculture.

Water requirement in Azraq Region (m^3/du)					
Crop	Water requirement	Crop	Water requirement	Crop	Water requirement
Tomato	451	Carrot	410	Barley	350
Eggplant	593	Watermelon	765	Alfalfa	512
Squash	438	Pepper	556	Citrus	991
Cabbage	540	Strawberry	410	Banana	1825
Bean	330	Radishes	223	Olive	680
Cucumber	464	Drew	410	Palm	1200
Onion	475	Spinach	220	Grape	680
Potatoes	403	Corn	804		
Lettuce	223	Wheat	438		

77 As supplied by the Ministry of Agriculture adviser for plant production, 2010.
78 Hagan, 2008.
79 Abul Hawa, 2007b.

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