INA P-G
Paris-Grignon National Institute of Agronomy

French Regional Mission for Water and Agriculture (MREA) French Embassy

International Water Management Institute (IWMI)

Reclamation's history of the Jordan River Basin in Jordan, a focus on agriculture: past trends, actual farming systems and future prospective.

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Volume I: General presentation of the Jordan River Basin in Jordan and of its water concerns

November 2003

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Acknowledgments

For his kindness and his sympathy, I would like to thanks Thabet, my accomplice of every day who makes possible this work by translating the speeches we had with the farmers.

My best wishes to the MREA team, Rima, Alice, Charlotte, Julien and of course my "boss" Remy Courcier who helped me to find the good rail ways. Working with them was very pleasant. And see you, maybe in a few months, to continue this collaboration….

Thanks to T. Doré, JP. Prodhomme and F. Molle for their supervision!!

Foreword

This work has been realized within the framework of one research program launched by the International Water Management Institute (IWMI).

This international program called "comprehensive assessment" is lead in nine river basins around the world in: China, Ghana, Iran, Jordan, Mexico, Sri lanka, South Africa, Thailand and Tunisia using the same methodology[1]

F.Molle, 2003 present this work one each basin as follow:

"The main purpose of basin case studies is to contribute to addressing Integrated Water resources Management challenges by generating, synthesizing and disseminating useful information and knowledge on basin level water management challenges, for use by practitioners, development agencies, planners, policy makers, and donors. To achieve this goal, the project will include an in-depth analysis and comparison of the historical development and present status of a number of selected basins. The resulting knowledge is specifically aimed at improving the understanding of basin level processes and their interactions, and identifying trade-offs. This will form the basis for exploring, in a participatory manner, the alternatives and scenarios for the future sustainable management of water resources in the basin, and for deriving a set of contextualised options that may be used to address water management challenges.
This multi-disciplinary and comparative investigation is expected to yield several building blocks of knowledge, as well as methodological lessons that will contribute to the Comprehensive Assessment carried out within the framework of the Dialogue on Water, Food and Environment."

In the Jordan River Basin in Jordan, an arid and semi arid catchment, where pressures on water resources are very relevant, the IWMI and the MREA, the French Regional Mission for Water and Agriculture agreed to collaborate in order to carry out the Jordanian Jordan River Basin development study. My seven months internship took place inside the MREA who mainly lead some technical assistance projects to farmers inside the Jordan Valley, in Lebanon and in the Palestinian territories. In the framework of this multidisciplinary study, I mainly worked on the Basin's irrigated agriculture.

The study of the Jordan River Basin in Jordan is a multidisciplinary one, but we mainly have dealt with the agricultural aspects and with the irrigated agriculture which is the most important one concerning the agricultural use of water. After a general presentation of the Jordanian Side of the Jordan River Basin which will deal with geographical and historical stuffs as well as with the actual water situation in Jordan we will focus on the actual existing irrigated farming systems[2]. This volume deals with the general presentation of the Basin and of the main concerns concerning water

In that way a geographical report will be done and we will try to identify for each main zone the relevant irrigated farming systems, their agricultural and economic characteristics, the problems they are now facing and the future evolutions we can expect in a context where water shortage for agriculture will increase.

[1] Described by Molle, 2002 – working paper-

[2] It is not here an exhaustive report on the farming systems of the entire Basin. We only focused ourselves on the irrigated agriculture which is the most important regarding water in Jordan (and which is also the most important on the economic point of view) Only the case of rain fed olive trees has been studied for reasons we will developed after

Abstract and Key words

Jordan faces today a critical situation of water shortage, which, following a strong demographic growth and an increase of the everyday needs of the population will get worse. The development and the exploitation of new water resources have met the increasing demand. However, today only a few new exploitable water resources exist and it would require very high investments and operational costs to exploit them. Continuing, irrigated agriculture has been developed in Jordan for reasons of technical feasibility and economic profitability since the sixties. This consumes today nearly 70% of Jordan's water and contributes only 3% to its Gross National Product. Thus the socioeconomic return of the agricultural use is lower than the one linked to an industrial or municipal one.

In Jordan River Basin in Jordan, two different kinds of agriculture can be identified. First is an intensive irrigated agriculture developed since the sixties in the valley of the river thanks to a channel harvesting the surface waters coming from the Yarmouk River and other secondary rivers called "Side Wadis". The Second kind of agriculture has been developed during the last two decades in the mountains and in the Eastern Desert thanks to private groundwater exploitation.

Due to water shortage and because of social imperatives, the government decided to provide water to urban centers. This policy, accepted by all, will reduce the quantity of water used in agriculture. Thus, the study of irrigated farming systems, their past history and their technical-economic characteristics, achieved in this study permit us to identify various social groups of farmers and different kinds of agriculture. These groups and practices, according to their characteristics and to their location in the watershed, will differently respond to the constraints imposed by the water shortage context and to the related political orientations.

Projects studied and in progress (pressurized irrigation, replacing fresh water with retreated waste water…) as well as recent and not yet enforced measures (taxing private ground water abstraction in the Highlands) reveal the government will to decrease the quantity of water used in agriculture in Jordan. In case of implementation, these measures may slightly reshape Jordanian agriculture but they already provide a framework for deeper changes.

Key words: Jordan, Watershed, Jordan River, Irrigation, Irrigated Agriculture, Water shortage, Agricultural Water Use, Irrigated farming systems, Geographical Zoning, Technical and economic modelling.

Acronyms

*BOT: Build Operate and Transfer

*JVA: Jordan Valley Authority

*JBJRB: Jordanian Bank of the Jordan River Basin

*KAC: King Abdullah Canal

*KTD: King Talal Dam

*MoA: Ministry of Agriculture

*MoWI: Ministry of Water and Irrigation

*M&I: Municipal and Industrial (Use)

*NGO: Non Governmental Organization

*WAJ: Water Authority of Jordan

*WWTP: Waste Water Treatment Plant

Measure unities

*Du: dunum (0.1 hectare)

*ha: hectare

*JD: Jordanian Dinar

*Mcm: Million Cubic Meter

*$: US dollar

*T: ton

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INTRODUCTION

A little word about Jordan

Jordan is classified as an arid to semi arid country, with a total area of 90 000 Km2. Mountains called also[1] " Uplands" crosses the country from the north to the south with a width of 30 Km and a length of 300 Km. In the eastern direction, these Mountains slop gradually to form the Jordanian eastern desert or Badia. On the contrary, in the western direction, mountains slop hardly toward the Jordan Rift Valley.

The Valley is the result of a major geological event incorporating a rifting along a vertical direction going from Tiberius Lake in the north to Red Sea in the south. The Jordan valley is laying in the northern part of the rift valley upstream the Dead Sea. The southern part of the rift valley (from the Dead Sea to the Red Sea) is called Wadi Araba.

Water resources in Jordan are dependent on the rainfall amount. Precipitations range between 50 and 600 mm/year and rainfalls are mostly concentrated in the uplands running alongside the Jordan Valley, in that way, 90% of Jordan receives less than 200 mm/year.

Surface water resources (575 Mcm/year) are mainly the Yarmouk River (40% of the global surface water) and the other eastern tributaries of the Jordan River called also side wadis. Jordan shares the exploitation of the Yarmouk River with Israel and Syria. Groundwater resources (275 Mcm/year) in Jordan are divided in renewable and fossil water reserves. The available water resources are about 850 Mcm/year with a total demand reaching now the 1000 Mcm/year. The gap between water demand and water supply is now covered by an over pumping in both renewable and fossil aquifer.

The current population of Jordan is about 5 Millions inhabitants; 80% of them are concentrated on the Jordanian Bank of the Jordan River basin mostly in the cities of Amman, Zarqa, Irbid, Mafraq, Jerash and Ajloun.

The agricultural sector using around 70% of the total water resources in Jordan is also mostly located on the Jordanian Bank of the Jordan River basin. The irrigated area in the Jordan valley is about 30 300 ha and it is about 44 000 ha in the highlands[2] (we will see in more details that most of the irrigated area of the highlands is within basin studied)

[1] In this report

[2] Figures from the department of statistics.


LEBANON
Damascus
UNDOF Zone
Mediterranean Sea
Tyre
SYRIA
IRAQ
Al Qunayṭirah
Nahariyya
GOLAN HEIGHTS (Israeli occupied)
Lake Tiberias
Nahr al Yarmūk
Haifa
Tiberias
Nazareth
ISRAEL
Irbid
Dar'ā
As Suwaydā'
Buṣrā ash Shām
IRBID
Janin
Netanya
Al Mafraq
AL MAFRAQ
Nābulus
Jarash
Maḥaṭṭat al Jufūr
Tel Aviv-Yafo
WEST BANK (Israeli occupied; status to be determined)
AL BALQĀ'
Az Zarqā'
AZ ZARQĀ'
Maḥaṭṭat al Ḥafīr
As Salṭ
Ramla
1967 Cease-Fire Line
Amman
Jerusalem
Madabā
Azraq ash Shīshān
'AMMĀN
Turayf
Dead Sea
Hebron
De facto boundary as shown on official Iraqi and Saudi maps (alignment approximate)
Kāf
Beersheba
Al Mazra'ah
Al Qaṭrānah
SAUDI ARABIA
Al Karak
AL KARAK
Dimona
As Sāfī
Oron
Aṭ Ṭafīlah
AT TAFILAH
Bā'ir
Mizpe Ramon
Ash Shawbak
ISRAEL
An Nabk
Abū Qaṣr
Al Jafr
Ma'ān
1949 Armistice Line
MA'ĀN
Ra's an Naqb
Yotvata
SINAI
Elat
EGYPT
Al 'Aqabah
Gulf of Aqaba
Ḥaql
Al Mudawwarah
SAUDI ARABIA
Al Bi'r
Boundary representation is not necessarily authoritative.
Jordan
International boundary
Governorate boundary
National capital
Governorate capital
Railroad
Road
0 25 50 Kilometers
0 25 50 Miles
Lambert Conformal Conic Projection, SP 30N/36N
Base 801761 (A05803) 10-91

THE JORDAN RIVER BASIN IN JORDAN:

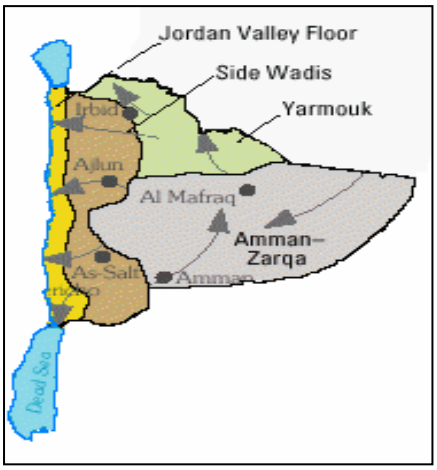
PRESENTATION OF THE MAIN CONCERNS

GEOGRAPHICAL PRESENTATION

The Basin studied lays at the East of the Jordan River from Tiberius Lake in the north to Dead Sea in the south. We define it in function of 4 main hydrographical basins, and limit it to the boundaries of Jordan. In that way, the basin recovers almost all the Amman Zarqa basin (only 5% lays in Syria), all the East bank side Wadis basin and one third of the Yarmouk River Basin (which principally lays in Syria).

Figure 1: Hydrographical basin

Figure 2: Groundwater Basin



We can see on the two maps above, a good correspondence between the Hydrographical basin and the groundwater basin (excepted for the Yarmouk ground table which mainly lays in Syria[1]). These limits will be used to define the Basin studied and named *"The Jordan River Basin in Jordan" (JRBJ)*

[1] We will see later what are the consequences on such situation on the agriculture in this area.

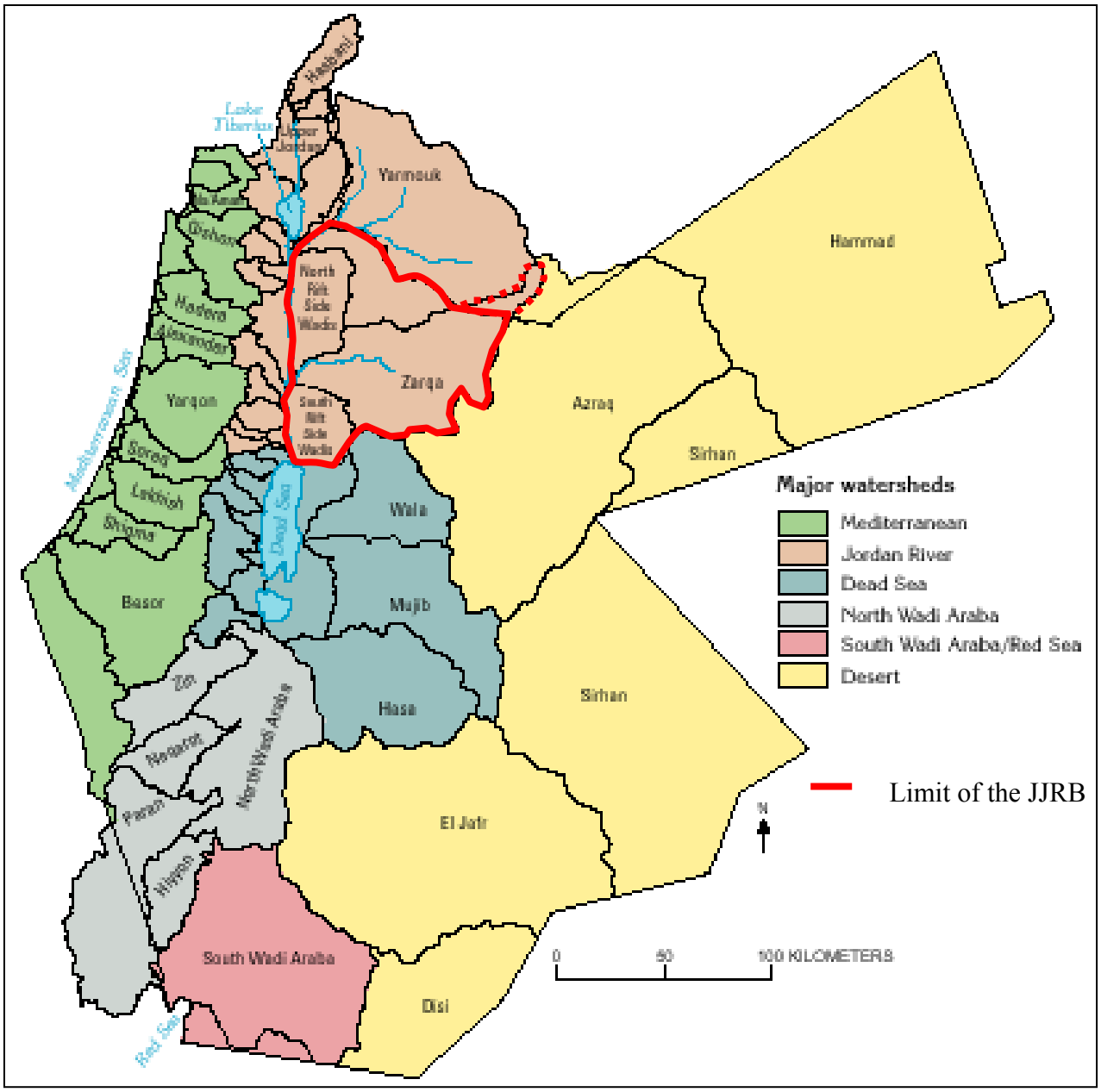


Figure 3: Situation of the Jordanian bank of the Jordan River Basin inside Jordan.

The basin studied as we defined it above can be divided into three main regions

1. The Jordan valley

This valley essentially constitutes with quaternaries sediments lays inside a depressed rift, its altitude is included between -212 m near the Tiberius Lake and -408m at the Dead Sea shore. 100 km long and 5 to 15 km large, the valley has a semi arid hot climate: the average temperature is included between 15° and 22° from November to March and between 30° and 33° in summer; precipitations are very irregular: from 50 mm/year in the south, it can reach 400 mm/year in the north of the valley.

An intensive irrigated agriculture is now developed during autumn, winter and spring. There isn't any industrial activity but we can note some development of tourism (in the neighbourhoods of the Dead Sea and religious tourism…)

As we will see it after, and following the development project of the valley which takes place during the 60's and the 70's, it is now a densely populated area (almost 300 000 habitants)

2. The Uplands, Amman Zarqa Basin (AZB)

It is a central calcareous mountains area with an altitude included between 500 m to 800/1000 meters. A Mediterranean climate prevails (precipitations from 400 to 600 mm/year, hot temperatures in summer, cold in winter, Snowfalls are observed once or twice a year in the zones where the altitude exceeds 600 m).

A rainfed traditional agriculture with olive trees and other fruit trees with some cereals and animals is developed in these mountains. An irrigated agriculture using springs and shallow wells can also be found along permanent rivers (or Wadis).

The rural area are highly densely populated and, moreover, all the major cities of the basin lays here (Amman 2,5 millions, Zarqa 0,8 million Irbid 0,8 million).

"Uplands" are not an agricultural area and most of the industrials and services activities of Jordan take place here in the neighbourhoods of the densely populated big cities.

3. The Eastern Plateau

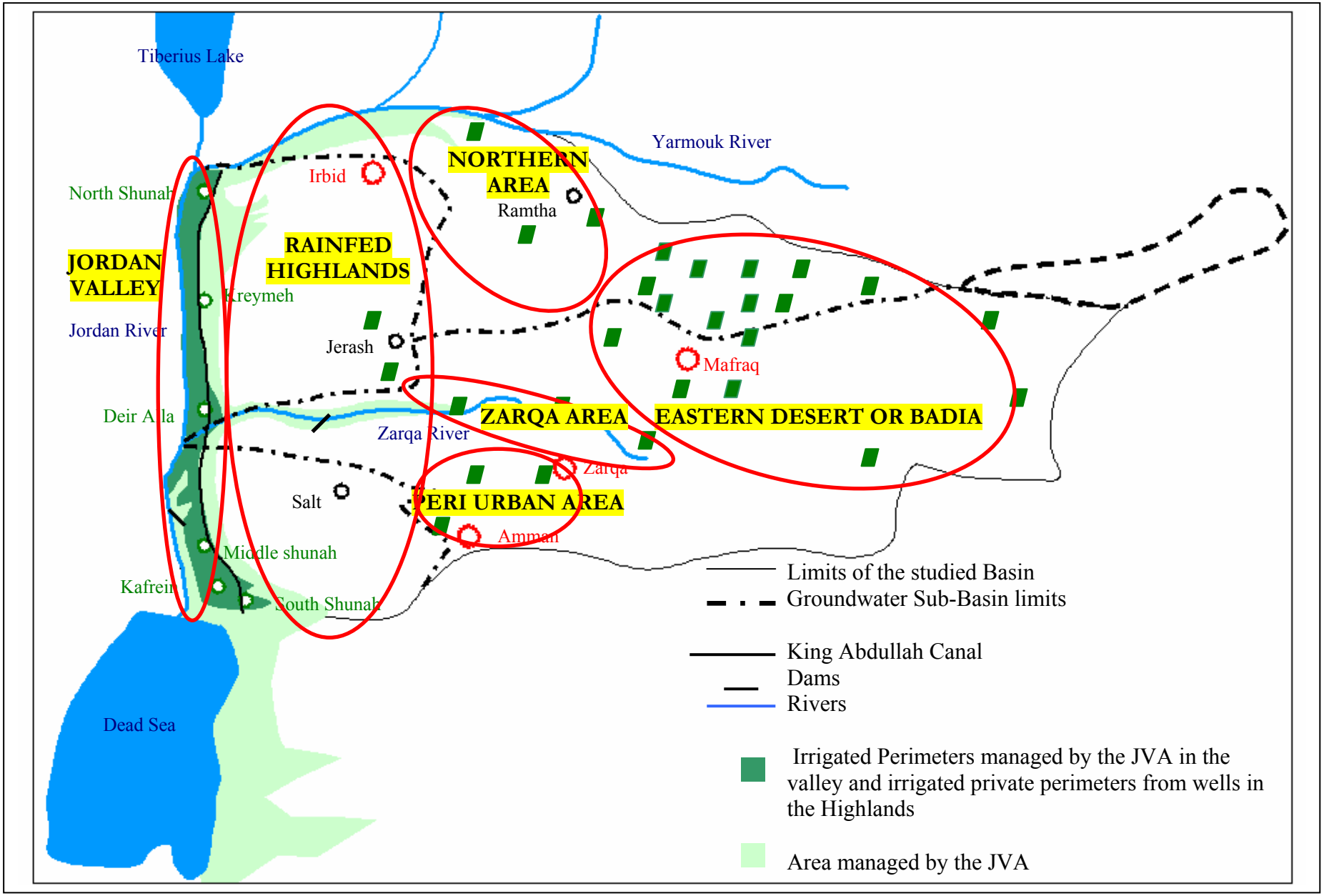
This area lies from the mountains to Saudi Arabia and Iraq. It is characterized by a semi arid and continental climate (with precipitations from 200 to 300 mm/year).

Nomadic herding (sheep's and goats…) and routes to the gulf countries dominated the area but recently (during the 80's and the 90's) a new irrigated agriculture (vegetables, stone fruit trees and olive trees) using deep wells and as well as industries have been developed.

In the following pages, the term "Highlands" will refer to the "uplands" and the "eastern desert". It will refer to all the River Basin in Jordan, Jordan valley excluded.

Following page:
Figure 4: General map of the Jordanian Bank of the Jordan River Basin[1].

[1] In red we can see the limits of the main areas we have considered in our description of the irrigated agriculture in the Basin.


Tiberius Lake
Yarmouk River
NORTHERN AREA
Irbid
Ramtha
North Shunah
RAINFED HIGHLANDS
JORDAN VALLEY
Kreymeh
Jordan River
Jerash
Mafraq
Deir Alla
ZARQA AREA
EASTERN DESERT OR BADIA
Zarqa River
Zarqa
Salt
PERI URBAN AREA
Amman
Middle shunah
Kafrein
South Shunah
Dead Sea
Limits of the studied Basin
Groundwater Sub-Basin limits
King Abdullah Canal
Dams
Rivers
Irrigated Perimeters managed by the JVA in the valley and irrigated private perimeters from wells in the Highlands
Area managed by the JVA

RIVER BASIN WATER RESSOURCES AND HYDRAULIC FACILITIES

As in most of the cases in the Middle East, the resources in the Jordanian Bank of the Jordan River Basin (JBJRB) are around half from surface water and half from ground water.

Surface water

The major tributary of surface water is the Yarmouk River. This water represents the major part of the irrigation water used in the North of the Jordan valley and half of the water resources intended to the city of Amman. The Jordanian shared on this resource decreased from 420 Mcm before 1950 to 190 Mcm now.

The Zarqa River is the second main tributary (62 Mcm/year) controlled by the King Talal Dam which collect also the retreated waste water of the greater Municipality of Amman (80% of treated waste water is reused in agriculture). These resources are used to irrigate the middle and southern part of the Jordan valley.

There are also six to ten small rivers, called "Side Wadis" going from the mountains to the Jordan valley. Most of them are tapped by dams and diverted to the main canal located in the valley and their water is used for irrigation.

The Jordanian share on the upper Jordan River only reaches 20 Mcm/year (according to the peace treaty with Israel in 1994)

Ground water

Three ground water tables can be identified.

➔The Yarmouk one (predominantly located in Syria) represents 40 Mcm/year of high quality water.

➔The Amman Zarqa aquifer represents 84 Mcm/year that is 32% of the national renewable underground resources. The resources mainly come from infiltrations in the mountains around Amman and in the Zarqa – Mafraq eastern plateau.

➔Lastly the Jordan Valley ground table with limited and little brackish resources (21 Mcm) coming from the mountains and the side wadis.

Summary table[1]

Surface Water	Average flow	Controlled resources	**Ground water**	Renewable resource	Total abstraction
Yarmouk river + treaty on the upper Jordan river	190	120	Part of the Yarmouk Basin located in Jordan	27	73
Zarqa river	65	65	Amman Zarqa Basin	84	150
Side Wadis	26	26	Jordan Valley basin	21	23
Upper Jordan River	20	20			
Amman treated return flow	53	53			
Total	**351**	**281**		**145**	**243**

Table 1: Summary table of the JRBJ water resources (Mcm / year)

[1] Salameh, 1993

Hydraulic facilities in the Basin

1. Public Hydraulic facilities in the Jordan valley

The development of the surface water use has been based on the construction of a main canal (King Abdullah Canal = KAC or East Ghor canal) which is conveying mainly the Yarmouk river flow ,diverted in the extreme North of the valley and distributed along the Eastern bank of the Jordan valley. The canal has reached the center of the valley with the initial East Ghor project in 1958 (69 km, end of the implementation work in 1966). Then it was extended by 18 Km in 1978 and after the construction of the main dam on the Zarqa river in 1987, the irrigated area has been increased a new time. To complete the irrigation of the south of the valley reaching the Dead Sea a last project of 14.5 Km was implemented in 1988 and the total length of the canal reached to 110 Km. The capacity of the canal ranges between 20 m3/s at the intake (300 Mcm/year[1]) and 2.3 m3/s downstream.

The King Abdullah Canal collects waters from several Side Wadis which have been controlled thanks to a series of irrigation and development projects dating from 1967

Localization-name	Construction date	Storage capacity Mcm	Construction costs Million JD*	Observations
Ziglab	1967	4.3[2]	0.9	side Wadi in the north
Kafrein	1967 raised in1997	(3.8) 8.4[1]	9.3	Side Wadi in the south
Shueib	1969	2.3	0.3	Side wadi in the south
King Talal Dam (KTD)	1977 raised in 1987	(56) 89.0	34.0	Zarqa river (+Amman treated return flow)
Wadi Arab	1986	16.9	20.0	Side Wadi + storing KAC fresh water
Karameh dam	1997	55.0	56.0	Storing flood water from the KAC. Some salinity. Water not suitable for irrigation
Hisban dam	Planned for 2004	1.0	(1.5)	
Whedah dam	Planed for 2006	110	65.0	Construction starts in 2003

Table 2: Dams in the Jordan Valley

[1] Salameh, 1993
[*] 1 JOD= 1.41 USD since 1997
[2] Salameh, 1993

Picture 1: Karameh Reservoir in the middle of the Jordan valley

Picture 2: King Abdullah Canal in the north of the Jordan valley

Irrigation projects	Completion date	Irrigated areas	Costs million JD	Comments
North Ghor	1996	7.300 ha	12,0	The first to be implemented in the 50's
Middle Ghor	1992	6.454 ha	8,8	Receiving both canal and KTD water
14.5 km extension	1988	5.900 ha	115	Until now only partially irrigated expecting new water resources.
Wadi Arab	1985	4.286 ha	5,0	Directly using wadi Arab and Ziglab dam water
Zarqa triangle	1978	1.421 ha	1,5	Receiving only KTD water
18 km extension	1978	3.691 ha	5,3	First extension to the South
Shueib dam	1968	250 ha	0,3	
Hisban Kafrein	1978	1.659 ha	4,0	Important banana production area
TOTAL		30.961 ha		

Table 3: Irrigation Projects lead in the Jordan valley[1]

2. Public hydraulic facilities in the Highlands

In the Highlands, the agriculture is mainly organized around private investments (drilling wells…). Public investments are very limited. We can however quote a project implemented in Dulheil Area. This project was designed[2] to irrigate 8000 dunums thanks to groundwater pumped from deep wells managed by the WAJ. The water was brought to the farmers thanks to concrete open channels. At present the project permits to irrigate 2000 dunums (ARD Study). One of the aims of this project was to settle Bedouins but it failed and they still live in a nomadic way and the water pumped is now mainly used by many animal farms which can be found in the area. It can be poultry or livestock farms (cows, lamb…).

[1] In this table, the rehabilitation investment are presented
[2] In the lately 60's early 70's.

Other small projects could be quote in other areas but the irrigated surfaces concerned are still limited.

Water development and resources exploitation in the Basin

The water use in the basin is relatively simple. The surface water was almost only used for irrigation in the Jordan valley. Since 1986 a significant part of it has being sent to Amman for municipal uses (around 45 Mcm/year). On another hand, almost all the ground water is exploited in the "highlands" ("mountains area or uplands" and "eastern plateau") and is used there for Municipal and industrial purposes as well as for private farms irrigated from wells.

- Production of the irrigated areas

As an introduction to a more detailed description of the agriculture in the Jordan River Basin in Jordan we can present the following table:

Region in the basin	Production	Area (hectares)	Production (1000t)
Jordan Valley	Citrus	7 600	146
	Banana	1 300	42
	Other trees	1 800	42
	Vegetables	15 500	600
	Field Crops	2 700	5.4
	Other	700	
	Total	**29 100**	
Highlands	Olive	11 700	66.5
	Stone fruits	5 400	96.6
	Vegetables	11 600	579
	Wheat	1 000	2.1
	Total	**29 700**	
Total		58 800	

Table 4: Simplified cropping pattern in the Jordanian Jordan River Basin[1]

We can see that, the production of irrigated areas is clearly different in the two main areas. Citrus and bananas are produced in the Jordan Valley and vegetables also in autumn winter and spring. In the highlands, farmers produce stone fruits (apples, peaches…), olives and vegetables in summer.

- National Water Balance

A detailed evolution of the JBJRB water consumption by sector between 1975 and 2000 will be done during the study. But we can already present a rough national water balance with forecast until 2020 which give an idea of the expected evolution of the water use in each sector of activity:

[1] Figures drawn from the 2003 Agricultural statistics book.

Year	Industrial use (Mcm)	Agriculture use (Mcm)	Municipal use (Mcm)	Total use (Mcm)	Population (Millions)
1990	43 ???	658	227	928	3.45
1995	33	606	240	879	4.29
1998	39	623	236	898	4.70
2005	88	829	382	1299	6.08
2010	113	884	434	1431	7.15
2015	128	877	518	1523	8.38
2020	144	871	611	1626	9.80

Table 3: Repartition of water-use types

One observation can already be done: following the rapid increase of the population, the municipal and industrial water uses will increase much more than the agricultural water which will have to decrease to avoid a too important over abstraction of ground water.

HISTORICAL AND AGRICULTURAL DEVELOPMENT

People settled down in the Jordan River basin thousands of years ago. First villages were constructed during the early Neolithic era; the basin was then conquered by Greek, Romans, Arab, Mameluke and Ottoman. The Jordan River Basin knew fluctuating periods of development and stagnation during its history. The most prosperous agricultural period was the Ommeyade one known for a large production of sugarcane (from the 12th century to the 16th century) .The Ottoman period (from the sixteenth to the nineteenth century) was a period of stagnation. The Jordan valley was almost deserted. The total population of Jordan was about 52 000 inhabitants. This population was spreading through the whole country.

During the last century, the historical changes in the basin have been very rapid. Indeed in less than 50 years almost all the water resources have been controlled following a huge socio-economic development. The water crisis appeared early (middle of the 90's) and has forced the Government to orientate its efforts to "demand management". Further demand management efforts are still necessary in order to reach the sustainable management of the resources.

Two main historical periods can be identified:

The pre exploitation phase: Abundance, water used thanks to artisan techniques (until 1960)

The population in the basin was then very limited (around 200.000 inhabitants), most of them lived thanks to a local agriculture (wheat, olives trees some fruits and vegetables) and herding (sheep, goats and camel). Almost no industry existed but due to the location of the basin, long distance trade, and transport services were significant economic activities (Mecca, Syria, Palestine…).

Springs in the mountains and Side Wadis were the main water resources. They were used by the population thanks to some hand made techniques (diversion weirs, earth ditches…) and some limited complementary irrigation was possible in summer. In the semi-arid areas hand made water harvesting techniques (cisterns, shallow wells, small earth dams…) allowed men and animals to find water. These techniques allowed the survival of a very limited population with nomadic habits, and who was used to live only during short periods at the same place). Farmers worked both on rainfed areas in the Highlands and on irrigated parcels with earth-made canals along the Side Wadis. The population was not able to control big rivers and the irrigation has not been developed a lot. Only during the Ommeyade period (12th century to the 16th century), the very profitable sugar market allowed the development of sugarcane in almost the whole Jordan valley with mills moved with water falls. But this production declined and disappeared when the Antillean production was developed.

In the Jordan valley, and during the late 19th century and the beginning of the 20th century, cadastral surveys and land laws, by establishing ownership on the land, deeply changed the agricultural landscape in the Jordan Valley. The richest Bedouin families of nomadic breeders bought big plots in the valley, on both banks of the river. Rainfed cereals were grown in the Ghor and other areas were mainly used as pastures during one part of the year. This partial land reclamation has led to a settlement of the families, their slaves and their sharecropper; they stay in the Ghor while flocks went in the Highlands in summer. After 1933 and the second cadastre drawn under the British mandate slaves and sharecroppers of the big

families could become more independent: the new land law gave them the opportunity to become owner of a small parcel (almost 50% of the land in the valley was still a Royal property).

Finally, the control of the main rivers with dams, the access to ground water by drilling deep wells-boreholes, the transportation of water by using pumps and pipes and the cement to cover the canals were the techniques that arrived during the sixties and lead to a revolution of the water uses in the region.

The development period: An extension of water resources exploitation 1950-1990

1. A familial irrigated agriculture in the valley 1950-1970

✓ The consequences of the 1948 migration

The development took place first in the valley during the 50's. After the Independence and the 1948 Israeli-Arabic war, Trans-Jordan annexed the West Bank and proposed the Jordan nationality to the Palestinian refugees. But first of all, numerous Palestinian refugees settled down in the valley. This movement should have multiplied the population of the Jordan Valley at least by two or three. Many of the refugees were former farmers from the Palestine coast[1]. They came with their knowledge concerning market gardening and citrus growing, and very often with their cow(s). In order to provide food to their families, many refugees either cleared the Royal lands and began to grow rain fed cereals on it, or settled down nearby small irrigated perimeters (at proximity of permanent Wadis) they try to extend to crop vegetables and trees.

✓ The hydraulic development of the Valley

Furthermore, the political situation was not stable: most of the refugees wanted to go back to their own lands. Jordan, supported by western countries, decided to follow a policy based on the stabilization and the integration of the Palestinian refugees. The government decided to act in the agricultural sector by developing the hydraulic system in the Jordan Valley to transform this one in a large irrigated area. This project had two main facets: the construction of two canals in the *Ghor* (one on each bank of the Jordan River), and a land reform. It was financed by the World Bank. The water was supposed to come from the Jordan River (via the Tiberius Lake[2]), the Yarmouk River and other smaller tributaries. The previous investments have been moderate: concreting of the hand made existing channel, no dams needed, and since the water was supposed to be delivered to the farmers only by gravity, no energetic expense was needed either. The building of the East Ghor Canal (now called King Abdullah Canal) began in 1958 and was achieved in 1966. The canal on the West bank has never been build.

✓ The land reform

In the same time, the land reform aimed to give the irrigated land to small families of farmers who did not have any resources. In that way, the largest surface landowners have

[1] 200 to 250 000 people may have arrived in the Lower Jordan River basin, Jordan

[2] Jordan has no control on Tiberius Lake. Nevertheless, international law gives to Jordan a right on the water stored there, because it can be considered as the Jordan River's spring.

been compensated and could keep was fixed at 20 to 30 irrigated dunums. The redistributed parcels or "Farm Units" (FU) ranged from 3 to 5 hectares. The Jordanian state became owner of all the irrigated land. Farmers never bought any FU: they bought licenses or rights to farm one FU[1] and to avoid any speculation and any purchase of the land by the "Zionists", the market of these licenses was forbidden. Most of the former slaves and sharecroppers bought some licenses, but very often, they were too poor to buy more than a time-share in one FU[2]. Palestinian refugees were helped buy UN subsidies, but most of them refused to buy any license, mainly because they hoped to go back to Palestine. Globally speaking, only few landless farmers actually benefited from the land reform. On the other hand, rich tradesmen and powerful people from Amman, who had no link with the Jordan Valley, bought some licenses, in order to rent them out to farmers.

Some people consider the land law as a failure, because there was no really egalitarian redistribution of the land. Nevertheless, land lords areas decreased, many medium and small farmers stayed and some land less farmers got land. In that way, the hydraulic development of the Jordan Valley allowed the landless farmers to get rid of precarious sharecropping and created a large class of small producers.

- ✓ Generalization of an irrigated familial agriculture of subsistence

The small producers began to grow vegetables under surface irrigation, rain-fed cereals. Many new crops have been developed thanks to the Palestinians' know-how. These kinds of crops required a lot of work and at this time, the work was mainly provided by the family. Cereals were used to feed the family and, usually, the animal(s); the animals which were a source of milk and were used for field work.

Besides the wide development of irrigated familial agriculture, the rich landowners expanded fruit plantations (pomegranate, citrus and bananas under surface irrigation). The most common citrus at this time were Mandarins and Clementine. But, as fruit trees need two times more water than vegetables do, plantations were limited to small areas, in the North (which is less arid) and nearby permanent rivers. Generally speaking, irrigation in the Jordan Valley improved global productivity. Even the smallest farmers were able to produce enough for their families, and many of them could produce a surplus, which was sold on the growing markets in big cities, both in Jordan and in the Gulf.

2. A commercial, specialized irrigated agriculture in the valley 1970-1990

- ✓ Historical context after the "six –days" war

However, the irrigated family-agriculture did not last very long. The dams build on Yarmouk tributaries in Syria (as well as the Six-Day War and all the conflicts that followed - ending with the 1971 Civil War-), had strong consequences on the Jordan Valley stability and on the questions of water and markets.

Water became a strongly limiting factor and Jordan was put in an urge to build very expensive plants, in order to save water. Furthermore, water needs in big cities increased very fast because of the huge arrival of Palestinian refugees. The first step was to build several dams, in order to use winter water in summer. More recently, the dams proved to be insufficient, and it became necessary to find other ways to save water. In order to do this, the

[1] These licenses can be inherited. Thus, many farmers consider their license as title deed.
[2] In 1967 about 500 new farmers landowners had obtained 1 100 ha.

JVA decided to change the water distribution system: canals were replaced with pressurized systems. Thus, it became easier to limit water losses and to control the use of water with water-meters and flow limiters. But these new installations induced many expenses first to replace canals with tubes, but also to build pumping stations all along the KAC and to produce enough energy to run them.

Moreover, because of the Six-Day War, the West Bank, which actually was an agricultural area, was suddenly excluded from the usual markets of Jordan. On another hand, at the same time, many Palestinians fled to big cities in Jordan and in the Gulf[1]. The demand for vegetables and fruits increased, while the supply decreased: **farmers faced a very favourable market**. In addition, the markets were placed under the control of state organizations, which allowed importations only when domestic production was not sufficient. Since this time, agricultural products are sold on State central markets, where they are divided into products for domestic consumption and products for export. It is also at this time that the Jordan Valley Authority (JVA) was funded. Like the Tennessee Valley Authority. JVA has been thinking as a state organization which would be responsible of a comprehensive development of the Valley: for instance, JVA is in charge of water distribution, and of schools and hospitals building as well.

✓ Appearance of new techniques

Many other improvements appeared during the 70's. The use of tractors and pick-ups became very frequent[2]. In addition, farmers began to use hybrid varieties and chemical inputs, in order to insure high yields. Manure is still very frequently used, but it does not come from the farm anymore; it is bought from sheep and goat breeders or from poultry industrial farms. After Nasser's death and liberalization in Egypt, about 30,000 poor Egyptians[3] came in the Jordan Valley to work on the farms. With this low-price precarious labour, the on-farm labour organization changed: very often, only one family member manages the farm, while the rest of the required labour is hired.

✓ The eighties: a favourable economic context

In the 80's, new vegetable farming techniques were developed. Some of them -like drip irrigation[4] (which reduces irrigation labour), fertigation (which replaces manual fertilization) and plastic mulch (which reduces weeding) allowed a strongly decrease of the labour needs. Thanks to greenhouses, farmers could produce expensive winter vegetables. Such techniques are very expensive because they all imply the use of drippers for irrigation. Such an irrigation system implies to have pressurized water and to often irrigate the vegetables. Therefore, farmers had to dig pools to stock the water and to buy individual pumps to put the water under pressure. This way of stocking water should have disappeared after the pressurization of the system by the JVA, but, in the fact, it is still used because of low pressures and the rare water turns.

Good market and the vegetable farming intensification led to a specialization of the farms, which are now turned towards the agricultural market, with a little production of cereals. Presently, and despite high subsidies, most of the farmers who grow cereals are also

[1] Due to the 1967 war, 50 000 to 100 000 Palestinians arrived in Jordan and 1973 to 1986 the Jordan valley population evolved from 60 000 to 124 000 inhabitants.
[2] Motomechanization did have strong consequences only on vegetable farmers, to whom it lightened the difficult soil labors.
[3] Lavergne, 1996.
[4] When we spoke about drip irrigation we spoke about the pipes, the filters, the basin and the drippers used.

breeders. In parallel to the intensive vegetables farming, fruit plantations have also been developed especially in the North of the valley (because of a more clement weather). Fruit trees are rarely planted by tenants because the profitability is postponed. However, more and more farmers rent parcels on which the owner has planted fruit trees. Because fruit plantations need a lot of water, the JVA tried to limit their expansion: farmers should not plant any citrus without a special license. Since the late 80's, the JVA has not delivered any license. And banana plantations or replanting were simply forbidden, because they need even more water. The fact is that this regulation was not very efficient: many influent people went on planting new trees, even without any authorization (Hagan, 1999).

Generally speaking, agriculture was so profitable during these years than many people from other sectors became farmers. For instance, many small landowners from big cities got rid of their sharecroppers and began to manage their land by themselves. The agricultural development was followed by a more global economic development of the Jordan Valley. Many jobs have appeared, such as tractors renting, goods transportation, nurseries, small business, agricultural input trade, and, more recently, public transport. In addition, all the development projects created many administrative jobs.

3. The development of agriculture in the Highlands 1975-1995

As we said before an old agriculture has always existed along the Side wadis: thanks to hand made technique (diversion weirs, earth ditches…) small plots were irrigated thanks to springs and shallow wells. However, the irrigated agriculture has been developed in the Highlands mostly since the mid 70's, and the real boom dates of the early 80's. The two oil crisis (1973 & 1979) could be an explanation to this development: following the crisis, an expanding regional market for vegetables and fruits as well as a large amount of money became available and some people in Middle East took advantages of this phenomenon and could invest in different economic sectors. Moreover, during this period, new resources of water have been identified (groundwater resources) and irrigation techniques (digging of well, drip irrigation…) became widely applicable, in the same time and thanks to the Oil Crisis an agricultural-export-market to the Gulf States has been developed. Therefore agriculture constituted one profitable sector in which the investments have been developed[1].

The first characteristic of the highlands farms, irrigated thanks to groundwater, is their large size: farms are organised by plots of 15 to 30 hectares in average[2]. This large surface is due to the high costs of installation: drilling a well, pumping system, fences, wind protection and irrigation system (always an efficient pressurized "on farm" system). The farms are much bigger than in the valley in which the farms have a surface of 1.5 to 10 hectares (generally between 1/2 Farm unit to 3 farm units). In that way, the 30.000 hectares of irrigated areas in the highlands are organized around 1000 farms of 30 hectares in average while the 25.000 hectares irrigated in the Jordan valley are constituted of 8000 farms of 3,5 hectares in average.

Added to this first "wave" of agricultural development, we can identify a second wave which took place in the mid 90's. This wave consists in a redistribution of the farms inside the Highlands. During this period, a lot of farmers who were cropping in Madaba/Liaduda/Baqaa (in the south of Amman, out of the basin considered) set up in the North east of the Basin further and further from Amman and the urban centers in the eastern desert and near the Syrian border. The main reason of such a displacement is the high price of water in the Area of Madaba/Liaduda/Baqaa due to the urban pressure. Actually, after the

[1] Moreover, loans of the World Bank could allow some people to invest at preferential rate (7%).

[2] This figure is an average range. We will see in the following pages that this figure is well adapted to evaluate the surface irrigated by one well but it lacks precision to predict surface of farms if we consider that one farm is an area cropped by one man (and his family)

First Gulf War, a lot of high-class Jordanian who were living in the Gulf countries came back to Jordan (following the behaviour of the Jordanian government who was the only government to support Iraq). Such population set up in Amman and in its neighbourhood, a bigger urban pressure follows[1]. This phenomenon had big consequences on the agricultural use of water. Actually, owners of wells (in these "agricultural suburban areas) sell around half of the water for an urban use (potable groundwater which reaches the town, especially Amman, thanks to tankers), the other half is used in agriculture but prices are much higher than everywhere in the country: the price of one cubic meter can reached 500 Fils[2]/m3 (0.70 $/m3). In comparison we can present the fee paid in the Jordan Valley: 0.015 Fils/m3 (0.02 $/m3) and the effective cost of water in the Eastern Desert[3]: 0.065 to 0.115 Fils/m3 (0.09 to 0.162 $/m3)

The actual water situation: problematic and prospective

The development of the irrigated agriculture was of course accompanied by an increase of the water resources use in the basin. Due to the development of the population in Amman and to the increase of its economic wealth, it was needed to bring water from other neighbouring basins. The rapid increase of the municipal water use and of irrigated agriculture was managed until 1990-95 through the supply development: new dams, new canals, new wells and new water transfers. But in the 90's it appeared that the national water resources were limited and that all of them were already used. Due to the inevitable development of the water consumption, Jordan reached its water crisis.

1. The Main problems faced by Jordan

A lack of water resources for the cities

With the increase of the urban population and of the municipal water demand, new water resources have always to be found and new investments and rehabilitation works to be done. In the same time cities had to find solutions to decrease their uses: increase in the prices, discontinuous delivery… Leakages and management difficulties used to cause high "unaccounted for" water (more than 50%)[4].

A lack of water resources for the irrigated areas

In the Jordan valley during dry years the government conserved the quantity of water sent to Amman for municipal uses and decreased strongly the water allocations to the farmers (no more allocation for summer crops, reduced allocations of 25% in 1999, 30% in 2000, 50% in 2001 and 2002). A 6.200 hectares area has been reclaimed by the government for irrigated use and is still not used due to the lack of available water.

In the highlands, the withdrawal in the aquifer is being currently 170 to 180 % of the annual recharge, the drop of the water table level forced the farmers to deepen their wells and

[1] This population transfer is evaluated at 400 000 Palestinian and Jordanian.
[2] One Jordanian Dinar (JD) is divided into 1000 Fils.
[3] The way of calculation of this price will follow
[4] In order to reduce these high losses, a very big rehabilitation program (250 Million of USD) has been decided and initiated in 2002 and the management of Amman water utilities has been transferred to a private company in 1988.

the salinity of the water lead many of them to shift to more resistant crops (olive instead of stone fruits).

Increasing costs for the government

The Jordanian government uses all the means at its disposal to provide to all citizens sufficient quantities of good quality drinking water at a price all families can support. In Jordan, the cost of production of municipal water is very high due to the transportation costs[1]. The new water resources are each time further and therefore more expensive than the existing ones. The governmental subsidies that are necessary to assure all these goals at the same time are very high and the very high losses in the systems (around 50% "unaccounted for" water in urban systems) double the costs once more.

The environmental problems

Groundwater and surface water are polluted by agricultural return flow and inefficient sewage system. Due to its overexploitation the water table drops rapidly and some salty aquifers use to contaminate the other aquifers when they reach very low levels.

Due to the context of water shortage, no "wetlands" could be protected. The important oasis of Azraq, closer to the eastern limit of the basin has almost disappeared due to the over exploitation of the aquifer (irrigation and transfer to cities).

One of the main environmental problems is the very rapid decline of the Dead Sea level (0.5 m each year, 15 m in the last 30 years). Only 20% (in average) of the flow in the JBJRB reaches the Dead Sea, but it is almost the same situation in the entire basin (water from the upper Jordan River only reaches it on very wet years like 2003). The important evaporation of the Dead Sea due to its hot weather and an important industrial exploitation (production of potash and other salts) also contributes to the rapid decrease of the Dead Sea level. The disappearance of the Dead Sea has and will have important impacts on tourism with the sea staying each time further from the hotels and some areas around the Dead Sea.

2. Actions developed to remedy these problems

The institutional changes

➔Water policies

After the peace treaty signed with Israel, and after many studies and debates about the Jordanian water resources, the Ministry of Water and Irrigation have published various official documents presenting its: water strategy, groundwater management policy, waste water management policy, water utility policy. It appeared clearly through these policies that the possibilities for the development of new water resources at a reasonable cost are considered as limited and that a better management of the existing resources is the first national objective.

[1] Most of the municipal waters have to be elevated by 1.200 meters (coming from the Jordan valley) or by 200 to 600 meters (boreholes in the highlands) and has to be transported on hundreds of kilometers (from Azraq, Karak, Jordan valley…).

➔Legal reforms

Various laws were adapted in the way of improving the water management in the basin. For example the JVA-law which was amended in 2001 gave the JVA more authority in dealing with any illegal actions regarding water or networks and structures. This law also opened the possibilities of private sector participation.

➔Institutional reforms

One of the main institutional changes was the reinforcement in 1988 of the Ministry of Water and Irrigation in which all the responsibilities of a general water management and planning has been concentrated, leaving the responsibility of the operation of water systems to the two main institutions: Water Authority of Jordan (WAJ) which manages all municipal water & sewage systems and all the highlands resources and Jordan Valley Authority (JVA) which manages the Jordan Valley water resources. Another main change was the reform which allowed the private sector participation in 1999.

➔Private sector participation

In 1999 the management of the Amman municipal water and sewage systems was transferred after tender to a private firm LEMA. This contract as been extended in 2002 and is supposed to end in 2004. The extension of private sector participation in municipal water utilities management is currently being prepared for different cities in the North and in the South of the country. A JVA strategic planning exercise has been concluded with a proposal to transfer an important part of the Jordan valley irrigation network management to a private operator.

➔Environmental controls

A ministry of environment has been created in 2003 and the control of water pollution will be one of its major roles.

➔Regional solutions

Especially just after the peace treaty (1994) and the Oslo agreement (1993) many regional project have studied the possibilities of common investments that could benefit all stakeholders. Ground and sea water transfers, various desalination possibilities, new dams pipes and canals have been considered but the regional process has been declining especially when the “second Intifada” began in the Palestinian Territories in 2000.

More than these general reforms and measures taken at Jordan scale, different “demand management” actions have been taken both in the Jordan Valley and in the Highlands[1].

[1] These measures will be described in the two parts devoted to the valley and to the Highlands.

"Demand management" actions applied in the Jordan valley

➔Water allocations

At end of the 80's, the Jordan Valley Authority had to limit the extension of the irrigated fruit trees (mainly citrus and bananas). Actually, these crops demand higher quantities of water and especially during summer, it is difficult for the JVA with a limited Yarmouk river flow to manage all the demands. A specific allocation, based on JVA estimated water requirements during the irrigation season (8mm/day for banana, 4mm/day for citrus, 2mm/day for vegetables and field crops), is delivered to each farmer, for each crop he decided to plant, but concerning bananas and citrus, the areas being entirely "frozen". It means that a farmer who wants now to plant bananas or citrus can do it but he will only receive the allocation for a vegetable crop: the bananas and the citrus allocation are only delivered for surfaces cultivated with such crops since a long time.

➔Water prices

In order to limit the water consumption and to cover a bigger part of the operation and maintenance costs, the JVA increased several times the water price and used rapidly increasing tariffs when the water consumption increases. In this way the water price for fruit trees is higher than for vegetables and higher for bananas than for citrus. But most of the technicians agree that the water price (from 0,01 to 0,03 USD/m3 with an average around 0,02 USD/m3) is still very low and does not cover the operation and maintenance costs and does not really convince the farmers to save water.

➔Modernization of the irrigation system

The whole Jordan valley water delivery network has been shifted between 1987 and 1996, from open canals to underground pressurized pipes. This system allows a higher efficiency, decreasing water losses and allowing a higher control (limited flows, general water metering…). With providing pressurized water, this delivery system facilitated the shift to pressurized "on farm" systems that are more efficient especially the drip irrigation which is used now in 2/3 of the valley.

The management of 110km canal, receiving continuously water from different sources (dams, wells transfers…) and distributing it to cities and irrigation perimeters (thanks to 28 pumping stations, gravity lines…) is complex. An electronic automatic control and management system has been installed to ensure the dynamic regulation of the canal (SCADA). A computerized water management system was also necessary to manage the complex demand of all the users. Due to this systematic centralized control, the efficiency of all the system has been improved and in particular the water losses decreased.

➔Use of marginal water for irrigation (brackish and treated waste water)

The farmers have developed traditional solutions to use brackish water for irrigation. They choose the crops, the periods, the techniques and in the same time they mix different type of water and leach the soils… Now, for example, 21 farmers in the south of the valley are using local Reverse Osmosis plants to desalinate water themselves in order to irrigate fruit trees and vegetables.

The surface water from the Zarqa basin (around 62 Mcm/year) mixed with the treated return flow from the Amman area (around 50 Mcm/year), and kept during a long period in the

big King Talal reservoir, is finally mixed in the King Abdullah Canal with "fresh water" coming from the North and distributed without any restriction to the farmers in the southern part of the Jordan valley. In this way a significant volume of water is reused at a very large scale. Some problems for agriculture, especially algae development and salts should be better addressed but this large scale reuse is a success and is supposed to be rapidly extended due to the expected growth of the treated waste water volumes that is expected.

Due to the expected increase of available treated waste water, the extension of its use in the Jordan valley is considered. But some possible impacts on sensitive crops and the possible negative reactions of the farmers have delayed until now the planning of such a project.

➔Rented farms

Due to the recent exceptional series of dry years (98 2001), JVA has rented hundreds farm units (+- 1000 has) and kept them without any crops in order to limit the agricultural water consumption. This action was done during two years and the cost of such an action is estimated to 500 000 USD/year.

"Demand management" actions applied in the highlands[1]

The reduction of the over exploitation of the aquifers is clearly the major concern if Jordan wants to reach a more sustainable water management. Considering the first priority given to municipal water, various solutions are being studied as:

➔Drilling wells limitations

Picture 3 & 4: Drilling well

[1] This paragraph will be developped in the part devoted to the agriculture in the Highlands

Jordan always had a well licensing system but it is not effective at limiting abstraction. About one third of the licences actually have no quantitative limits (it corresponds to wells dug before 1984). The limits set on most of the other two thirds of the licences authorize annual abstraction of either 50 000 (for 46% of the wells) or 75 000 m3 (for 21% of the wells), but these license limit are not actually enforced by the government. The current average abstraction of the wells located in the eastern desert has been evaluated at 220 000 M3. On another hand, relatively few new agricultural licences were issued after 1992; however licences have been issued for purposes of cleaning or deepening existing wells or to construct new wells to replace old wells that failed. This last kind of licence has been accompanied by a clause on water abstraction: if the well originally had no stated quota, he has been limited to the 50 000 m3 level, a limit which isn't enforced by the state either.

Moreover, the majority of the licences do not limit the area that may be irrigated a lot of licences even stated that the well owner is required to irrigate at least 25 percent of his farm area, this shows that at this period, the government was really trying to encourage more irrigation rather than abstraction

As there is no payment for the water used above the limits, the farmers are not forced to take into account the water scarcity at Jordan scale, consequently he tends to use more water than he would if he had to pay for. In these conditions, the first thing to do is to install operational water meters on ALL wells[1] and enforce the licence abstraction limits. Many wells already have water meters but most of them are not read and many are not working as well. Moreover, even if water meters exist and they are read, even if some abstraction limits have been decided (through licensing wells) and even if the law exist, nothing is actually done to enforce it and to charge the over volume pumped.

➔Wells buy-out

In parallel a policy of wells buy-out could be lead by the government. The objective would be to encourage the low-water-value producer to quit farming and to leave the water in the ground. As we will see in the following pages, vegetables farmers would be mostly concerned[2]. This purchase of land/well done by the government would compensate the farmers for the investments they have done on their farm. The amount of such purchase has to take into account the investment on the farm and all the fixed equipment, the present value of the expected net income on the farm and the market value of the farm.

➔Abstractions limits

Most of the licenses define maximum quantities of water pumped, and water meters are installed in almost all the wells but the half is out of use. Until now, while there has been growing concern about over abstraction, the WAJ has not really attempted to enforce license limits on abstraction and most of the wells actually exceed the limits fixed by the licenses. The farmers feel not concern buy these limits which have never been implemented.

[1] A meter and his installation are charged to the farmer between 250 and 520 JD, depending on the size of the well.

[2] Economics analysis will permit us to know precisely which farmers could be the target of such policy. On another hand, during our economic analysis, we will use the same scheme than the ARD work: we will estimate the Gross margin and the Net profit per cubic meter of water.

The first real attempt appeared very recently with the 85-2002 "by law"[1] in which the government decided to charge fees for volumes abstracted above 150.000 m3/year (100.000 m3 in Azraq area). The fees are not very expensive (0, 0178 US$/m3 on average) even if higher tariffs have been decided for the unlicensed operative agricultural wells (which were not controlled until now) and most of the ancient licenses are limited to 50.000 and 75.000 m3. But, in case of field-implementation, and knowing that until now all the agricultural wells were operated free of charge, this decision may be a very important first step in the right direction of a limitation of water abstraction for an agricultural use

➔Treated Waste water use

One means to limit the abstraction of ground-water for an agricultural use in the basin should be to shift to a treated waste water use for irrigation. Main problems faced are the current location of the irrigated farms which are generally far away from the waste water treatment plants and the farmers' reluctance to accept the difficulties inherent to the use of such low quality water (filtration, problems on the emitters, health hazards, marketing restrictions…).

But, anyhow, in an area close to the main "Amman Waste Water Treatment plant", the ground water level is declining quickly, the water becoming salty and such a shift could be developed easier thanks to a public support.

➔Taxes on private water sales from agricultural wells

In order to control the competition between private water vendors (distributing water from rural wells) and the public water utilities in the city of Amman, a new tax of 0.178 US$/m3 has been decided and applied in 2002. This tax concerns private vendors who are selling water by tankers for a municipal or potable use.

➔Private participation

After the first management transfer that gave to a private company (LEMA Lyonnaise des Eaux) the responsibility of the management of municipal water and sewage in Amman for 1999-2004 period, other management transfers are being prepared for the water utilities in some Northern and Southern cities. The transfer of the management of the irrigation system in the Jordan valley has been announced in 2003 for 2004.

Two new investments (transportation of Disi water to Amman, rehabilitation of the Herbert As Samra treatment plant) have been made through a BOT (Build Operate and Transfer) contract. In these two projects some private companies finance a part of the needed investment. These two projects will permit to deal with higher volume of water resources

[1] See Vol.III to evaluate what could be the consequences of this by law on the different kinds of irrigated farms in Jordan

➔Irrigation Advisory Service/limit of surface cropped

Another way which can be studied is a limitation of surface cropped (after 1990, most of the licences specified a limit of 100 dunums on the area to be irrigated with the well). Such a program less direct can permit to limit the water abstraction but will be less easy and more time consuming than the metering system accompanied by a taxation of over-pumping water. Finally, an Irrigation Advisory Service could be implemented. This one will permit to extend a technical support to increase the irrigation efficiency.

Until now, no technical assistance concerning irrigation techniques have been provided to farmers. Some experiments in Jordan proved that around 30% of the water used in agriculture could be saved by using proper techniques (mostly tensiometric scheduled irrigation). In that way, an USAID project initiating in 2003 will developed a technical assistance team and some reductions in water consumption (around 5%) are expected.

The necessary water reallocations and new management practices (2000 2020)

1. The curtailment of ground water use for irrigated agriculture

The over exploitation of the aquifers is clearly the major concern if Jordan wants to reach a more sustainable water management. Considering the first priority given to municipal water, various solutions (presented above) are being studied as:

- Enforcement of license abstraction limits
- Taxes on ground water use for agriculture
- Wells buy-out by the government
- Extended technical support to increase the irrigation efficiency (Implementation of an Irrigation Advisory Service).

2. The evolution of Jordanian agricultural productions

Due to the signed WTO and Euro-Mediterranean agreements to open the Jordan market, and due to the necessary curtailment of ground water use for irrigated agriculture, the future of some of the major Jordanian crops is limited. In that way, some of the main concerns are:

- The banana production with Jordan Valley surface water and underground water which is a high water consuming production.
- The olive production with underground water in the highlands. The rainfed olive trees in the mountains are competitive and may be extended. The value of the "irrigated" olives is really too low to justify the use of high quality groundwater.
- The export of high value fruits has also to be questioned when it uses high quantities of ground water

3. Next investments for new water resources

If most of the efforts may come from water demand management actions, some investments are planned:

- ✓ Disi aquifer

An important unrenewable (or fossil) aquifer, called DISI, exists in the Jordanian southern desert... Currently, around 50 Mcm/year are extracted for the municipal water of the city of Aqaba and to irrigate around 3.500 hectares in the region. The transportation of 50 to 100 Mcm/year of this very high quality water has been decided and a BOT contract is now negotiated. In the same time, the decrease of the current agricultural use of this aquifer is planned.

- ✓ Desalination plants

Various projects exist to extend the desalination capabilities. The sea water desalination is studied but the brackish water desalination plants may be realized earlier (south of the Jordan valley, Maïn, various small R.O plants for isolated villages...)

- ✓ Wehdah dam or Unity dam

The Jordanian big project to control the Yarmouk floods has been finally decided in 2001. It is supposed to be used to supply the greater municipality of Irbid and other cities in the North with potable water. But it will also produce around some 50 Mcm/year extra water and will regulate the Yarmouk river flow facilitating the irrigation in the Jordan valley.

- ✓ Red Sea-Dead Sea project

This project may transfer 800 Mcm/year of Red Sea water to the Dead Sea which is 400 m below the sea level. This allows the production of electricity that could be used to desalinate 800 Mcm/year. This project might at the same time "save the dead sea" which is disappearing and produce a highly strategic new water resource. Its very high cost and the need for a regional agreement (Israel, Jordan and the Palestinian Territories share the Dead Sea) have delayed until now the decision of this very important project for the future of the region.

4. The management practices

In order to support the local efforts to solve the main water management problems, new solutions have been developed in the world but they did not reach Jordan until now due to its particularities.

- ✓ Water Basin management

Due to the importance of the capital Amman and of all the cities concentrated in the highlands of this basin and due to the lack of water resources, a large part of the water used there comes from other basins (Azraq, Karak,…) This situation will be extended when new important basin transfers will be completed (Mujib, Tannour, Disi,…). Thus the lack of water resources is so severe that the main regions (Jordan valley, mountains, eastern plateau, southern desert…) cannot manage their own water resources.

- ✓ Users participation

The traditional organization of the Jordanian society does not offer a lot of space for adapted organizations. Representants of users are difficult to find. For example the farmers in the Jordan Valley or the farmers in the highlands have no true organizations. NGOs which could have represent the inhabitants of the cities as a group of users of the water utilities are also not developed in Jordan.

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RESUME ET MOTS CLES

La Jordanie connaît aujourd'hui une situation critique de pénurie en eau qui, suite à une croissance démographique forte et à une augmentation des besoins courant de la population, va aller en s'aggravant. Si jusqu'à maintenant le développement et l'exploitation de nouvelles ressources ont permis d'assurer cette demande croissante, il n'existe aujourd'hui que très peu de nouvelles ressources nécessitant en outre de très lourds investissements pour être exploitées. D'autre part, l'agriculture irriguée qui s'est développée en Jordanie depuis les années 60 pour des raisons de faisabilité technique et de rentabilité économique consomme aujourd'hui près de 80% des ressources en eau du pays et ne contribue seulement qu'à 3% de son Produit National Brut. Le retour socio-économique d'un tel usage est donc beaucoup plus faible que celui lié à une utilisation de l'eau à des fins industrielles ou municipales.

Sur la rive Jordanienne du bassin versant du Jourdain, deux grands ensembles agricoles peuvent ainsi être identifiés. Tout d'abord, une agriculture irriguée intensive développée dès les années 60 dans la vallée même du fleuve grâce à un canal récoltant les eaux de surface provenant du Yarmouk et d'autre rivières secondaires. Ensuite, une agriculture qui s'est développée au cours des deux dernières décennies dans les montagnes et dans les déserts de l'Est grâce à l'exploitation de nappes souterraines à l'aide de puits privés.

Dans le contexte actuel, la volonté, affichée par le gouvernement, imposée par des impératifs sociaux et admise par tous, d'améliorer la disponibilité en eau pour les centres urbains ne peut se traduire que par une diminution de la quantité d'eau utilisée à des fins agricoles. Ainsi, l'étude des systèmes de production irrigués actuels, leur histoire passée et leur caractérisation technico-économique réalisée dans cette étude permet d'identifier divers groupes sociaux d'agriculteurs et différents types d'agricultures. Ceux-ci, en fonction de leur caractéristiques et de leur localisation au sein du bassin versant répondront de différentes façons aux contraintes imposées par le contexte de pénurie en eau et aux orientations politiques jordaniennes qui en découlent.

Les projets à l'étude et en cours -remplacement d'eau fraîche par des eaux usées retraitées…- et les récentes mesures prises et non encore appliquées par le gouvernement -taxation de l'eau pompée dans les nappes au niveau des puits privés des Highlands- révèlent en effet une volonté de diminuer la quantité d'eau allouée à l'agriculture en Jordanie. Ces mesures laissent pour l'instant envisager un remodelage léger de l'agriculture jordanienne mais les jalons d'un changement plus profond sont d'ores et déjà posés.

Mots clés: Jordanie, Bassin versant, Jourdain, Irrigation, Agriculture irriguée, Pénurie d'eau, Usage agricole de l'eau, Système de Production irriguée, Zonage géographique, Modélisation technico-économique.