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Farming Systems in the Jordan River Basin in Jordan: agronomical and economic description

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Synthesis document

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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 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.

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.

In this synthesis document, we will firstly do a general –and mainly geographical- presentation of the Jordan River Basin in Jordan then we will present the geographical zoning we used in our description of the farming systems -we will study for each area the main agricultural characteristics-. Lastly, we will discuss about the general dynamic we underlined concerning the farming system and their organization in the Basin[2].

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

[2] To have more detailed information on the water situation in Jordan and on the main water concerns, to have a detailed information on the farming systems, on their agricultural and economic characteristics and on their repartition by area see the main report (under construction)

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 the Jordan River basin located 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.

In spite of the large heterogeneity of the farming systems present in the basin, a general dynamic can be underlined and we can identified several strategies lead by the farmers in function of their means, their capital and their wish…Behind the classical description of the farming systems another classification revealing the farmers strategies can be done.

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

Table of contents

Geographical presentation

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[3] " 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[4] (we will see in more details that most of the irrigated area of the highlands is within basin studied)

The Jordan River Basin in Jordan (JRBJ)

The Basin studied lays at the East of the Jordan River from Tiberius Lake in the north to Dead Sea in the south. We defined 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).

[3] In this report

[4] Figures from the department of statistics.

Figure 1: Hydrographical basin

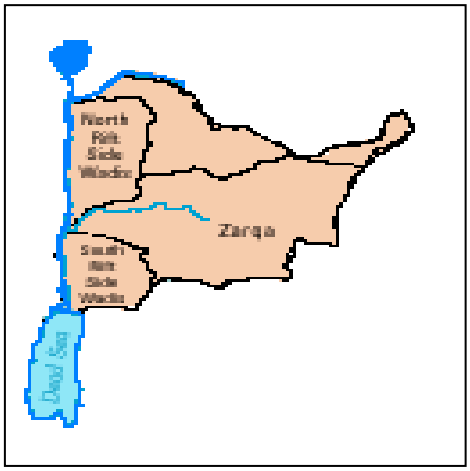
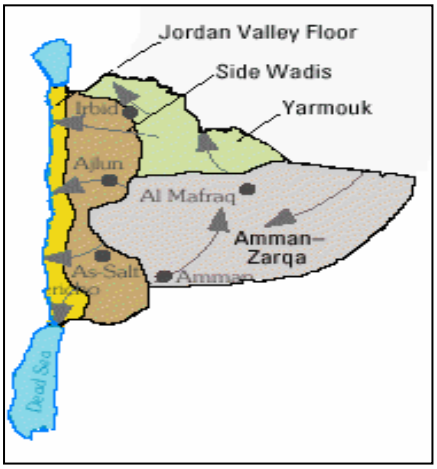


Figure 2: Groundwater Basin



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[5]). These limits will be used to define the Basin studied and named *"The Jordan River Basin in Jordan" (JRBJ)*

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

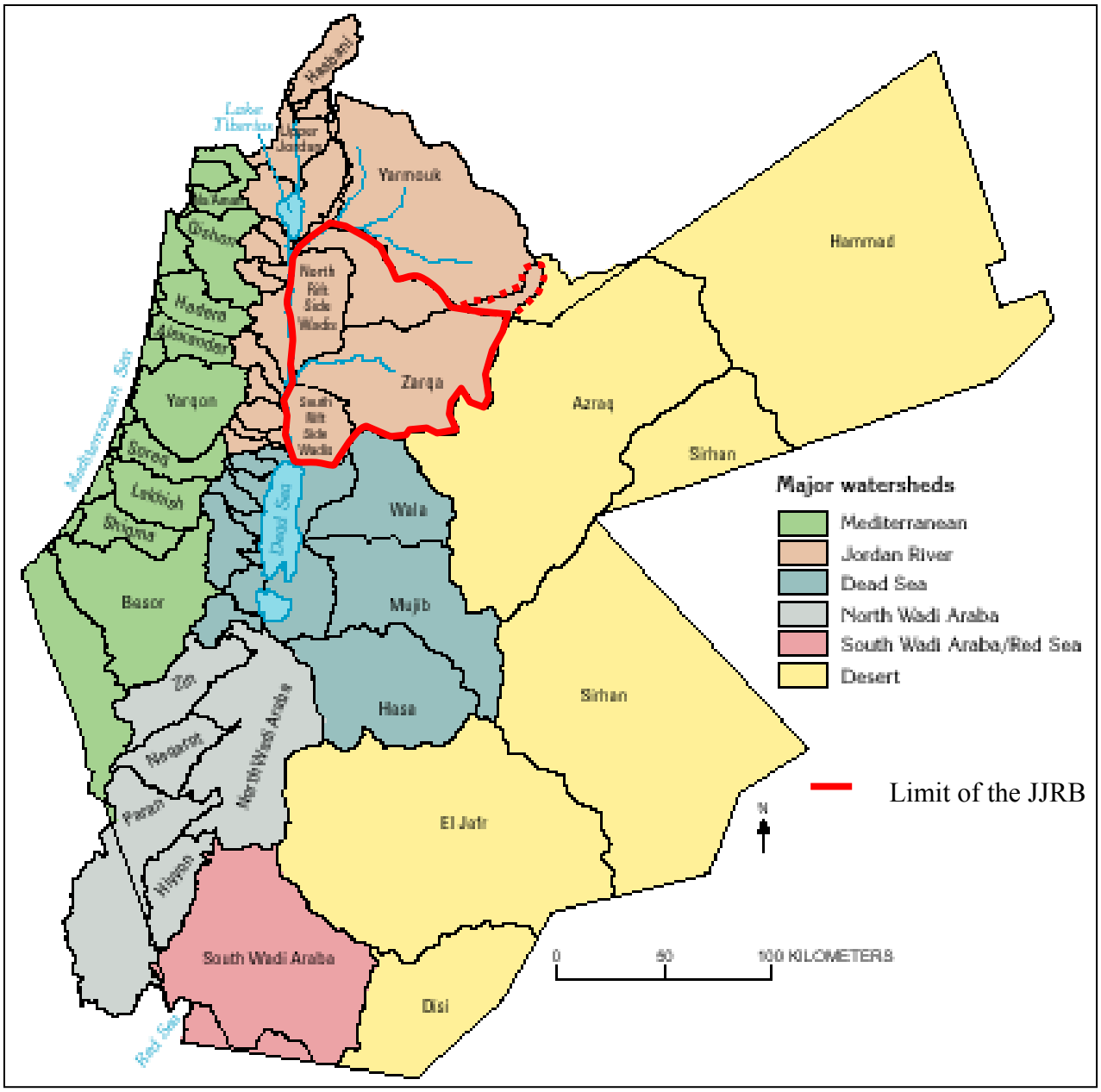


Figure 3: Situation of the Jordan River Basin in Jordan.

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

- ✓ 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)

- ✓ 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.

- ✓ 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 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.

Agriculture in the Jordan River Basin in Jordan

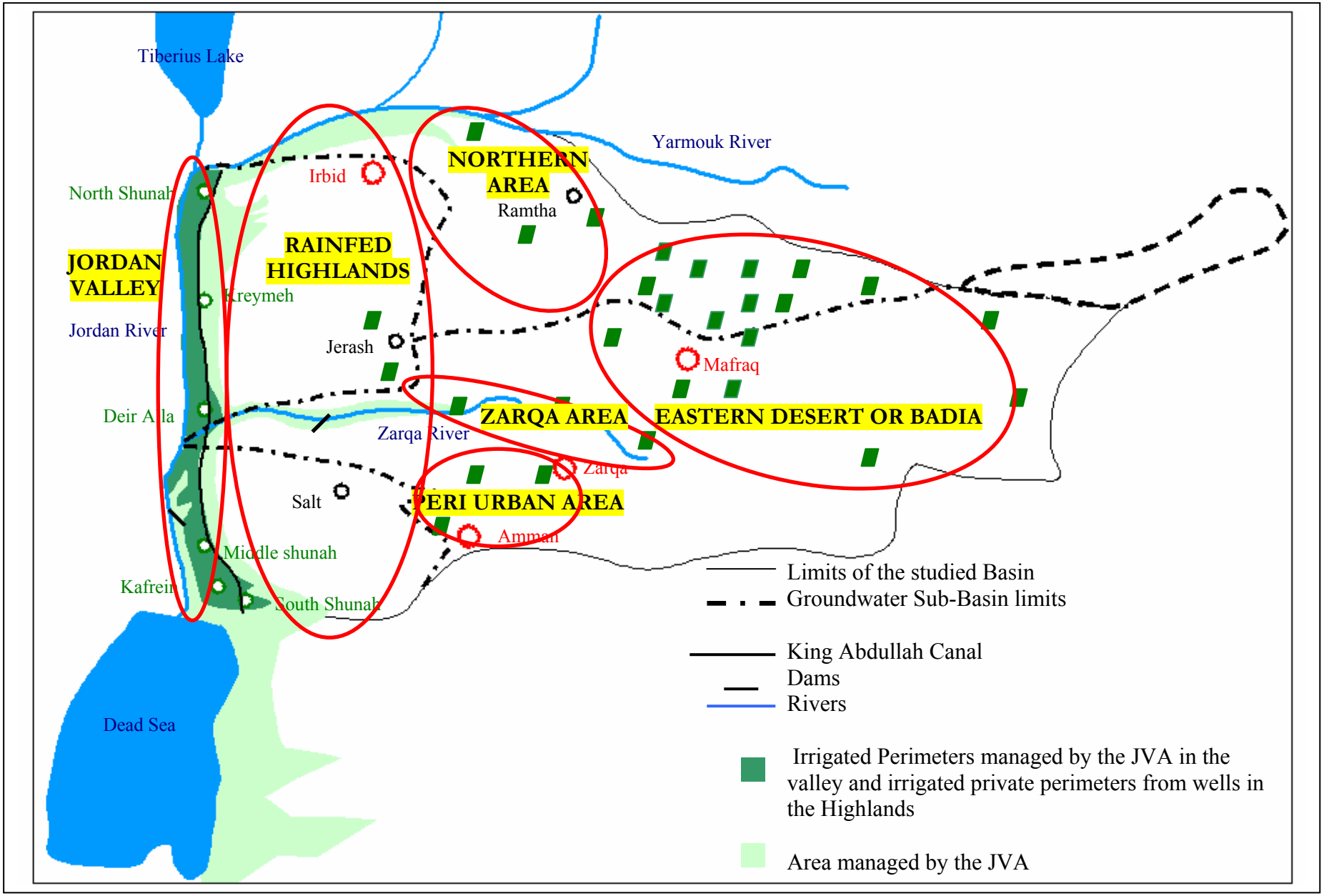
If irrigated agriculture has always existed in Jordan along small rivers called "Side Wadis"; two main successive waves of agricultural development can be identified. Firstly an intensive irrigated agriculture has been developed in the Jordan Valley during the sixties. This one became possible thanks to the King Abdullah Canal which collected (and still collect today) the newly controlled water from the Yarmouk River and from several "Side Wadis".

Secondly, in the seventies, groundwater resources have been identified and new techniques of drilling boreholes appeared. During the eighties, in a favourable economic context, a new irrigated agriculture, exploiting water from ground table, has therefore been developed in a region called Highlands with the support of the government.

Now, around 30 000 dunums are irrigated both in the valley and in the Highlands. But if the surfaces cropped thanks to irrigation are comparable, differences concerning the structure of these two different agricultures[6] are obvious.

Following page:
Figure 4: General map of the Jordan River Basin in Jordan and used zoning.

[6] By agricultural structure, we mean the technical and economic aspects of the agriculture (crops planted, way of cropping, Margin and Profit brought out of the farm….)


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

THE JORDAN VALLEY

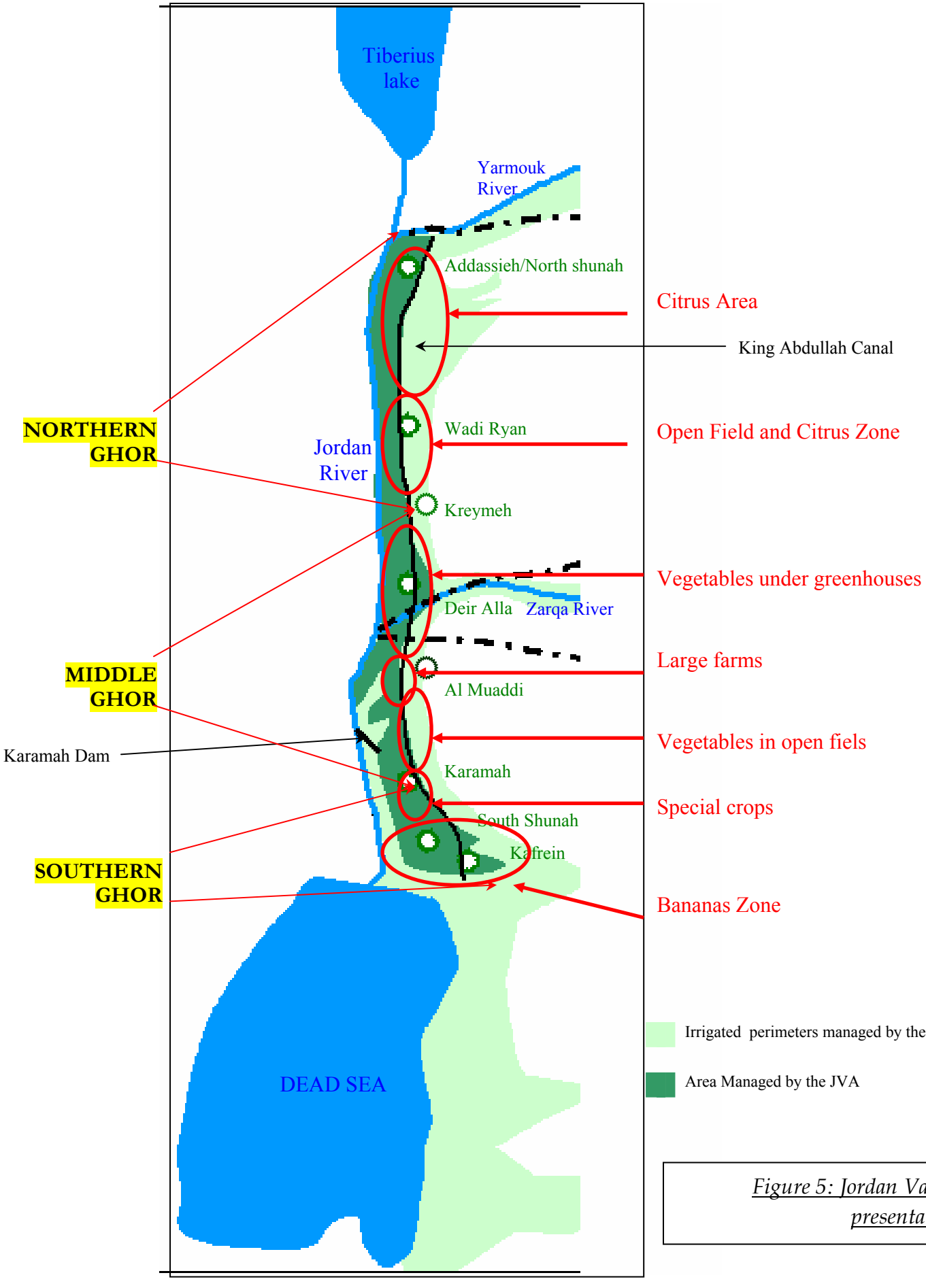
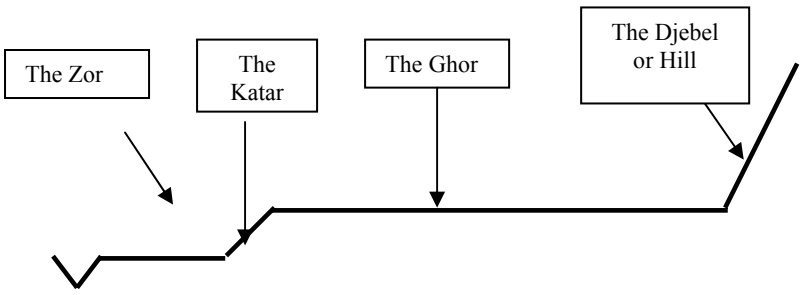


Figure 5: Jordan Valley presentation

A General Morphologic Presentation

The Jordan Valley runs on from the African Rift, which is a collapsed ditch due to the spacing between the African and the Asiatic plates. Altitudes reach 300 to 450 meters below sea level; that is some 1,000 meters below the Jordan Highlands.

Twenty thousand years ago, the collapsed ditch was covered by a large lake, called Lake Lissan, which connected the Sea of Galilee to the Dead Sea. About 15,000 years ago, the lake disappeared slowly and the Jordan River began to dig its bed in the most recent lacustrine deposits. From this period, the Jordan Valley was divided into three different areas, called *Ghor*, *Katar* and *Zor*.



➔The *Zor* area is the flood plain of Jordan river. It is composed of calcareous alluvial soils (loamy sand near the river, clay loam towards the *Katar*). Originally, this area was covered by meadows liable to flooding and by forests of tamarisks and poplar trees[1]. It can be large of 200 meter to 2 Km

➔The *Katar* is made of outcropping calcareous marls. On these badlands, the poor vegetation was dominated by *Ziziphus* for a long time[2]. It is an area of uncultivated land which makes the separation between the Zor and the rest of the valley floor also called the Ghor.

➔On the *Ghor* (also called *Sahel*), the lacustrine deposits, with some alluvial fans, made up deep clay loam soils. The structure of the soil's elements is mostly fine and well-balanced, except near the highlands. Twelve thousand years ago, the *Ghor* was covered by meadows including wild cereals. People who settled in these regions were the ancestors of the first farmers, as it happened in other places in the Middle-East[3]. This zone stretches from the Hills to the Jordan River on a distance included between 15 and 25 Km.

Since this period, the climate became more arid. Nowadays, annual rainfall doesn't exceed 350 mm and the average temperatures are 15°C in January and 30°C in August (fig. 2). But these figures are not homogenous in the valley. In the extreme North, where it is only 2 to 3 km wide[4], rainfall is more abundant (350 mm) and the potential evapotranspiration is quite low (1,230 mm). Further south, were the valley is about 5 km wide, the climate is more arid (280 mm of rainfall, 1,370 mm of potential evapotranspiration).

[1] Lavergne, 1996.
[2] *Id*.
[3] Several Neolithic villages of farmers were found out in the Ghor.
[4] Not including the West bank.

Historical development

- Development of irrigated area in the Jordan valley

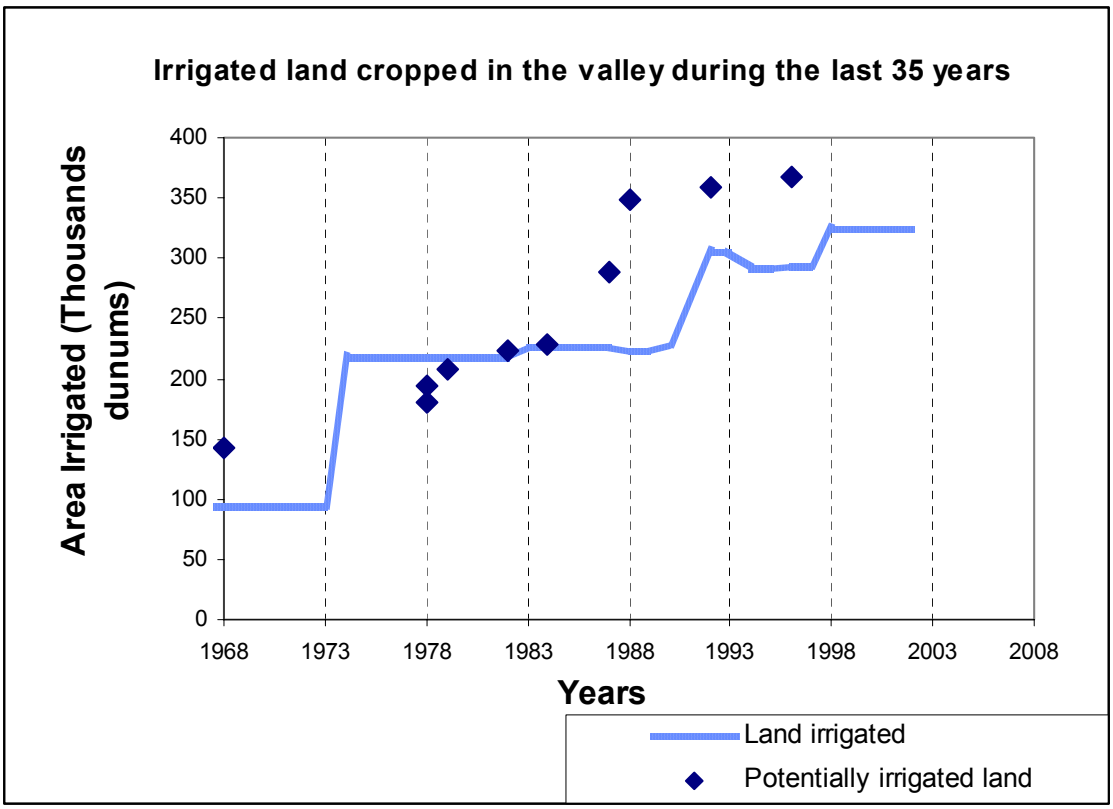


Figure 6: Evolution of the irrigated surface in the Jordan Valley
Source : J. Nachbaur. Non published

Agriculture in the Jordan Valley is the most ancient in Jordan. It has been developed during the 60's thanks to several development project of the Valley.

Until 1968, only the first part of the Canal was in use, then following the different irrigation projects, the irrigated surface increased until now around 300 000 dunums (30 000 ha). Farming in the Jordan Valley is mainly an intensive vegetables farming on small surface (35 dunums on average per farm[1])

- Actual cropping pattern

Crop	Irrigated Area	Non Irrigated Area	Total
Fruit trees	115 200	1 600	116 800
Field Crops	32 800	900	33 700
Vegetables	154 800	900	155 600
Total	**302 700**	**3 400**	**306 100**

Table 1: General cropping pattern of the Jordan Valley

In the Jordan Valley, 99% of the crops are irrigated. Vegetables are cropped on half the surface and fruit trees are very important too.

[1] Range from 15 to 100 dunums for most of the farms

Agricultural Zoning

As we can see on the map presented above we have divided the valley in three main parts, corresponding to the divisions made by Ministries of Statistics, and Agriculture. It allows us to present some cropping pattern evaluation according to the statistics presented by the diverse ministries.

The three main regions are identified by the following terms: Northern Ghors, Middle Ghors and Southern Ghors

1. The Northern Ghors

In this report we will consider that the north of the Valley lies from the Yarmouk River (and the village of North Shunah/Addasyeh) to the village of Kreymeh. This area corresponds to the administrative division and it will be possible for us to use the statistics of the government. *(See the map above)*

In the farming system which follows, we will consider that the North of the Valley constitute a unique zone. However, this region isn't homogeneous and we can quickly present here a more precise zoning. In that way 2 small regions can be described:

- The extreme north of the Valley[1]: A Citrus zone.

In this area, the land is cultivated since the beginning of the century. Large Jordanian families (Ghazami and Al Waked families) and an Iranian sect irrigated the land thanks to wells and thanks to water from the Yarmouk. Bananas and vegetables were the main cultures. Citrus, pomegranate trees and cereals were also cultivated but on smaller surfaces. The construction of the first part of the King Abdullah canal from 1958 to 1962 has deeply modified the land reclamation. The Iranian sect has to abandon its land to the Jordanian state, and while this land was shared between former sharecroppers and agricultural workers or Jordanian from Irbid or Amman, the Al Waked family managed to keep its own land and even to expand it. Surfaces planted with vegetables have newly and quickly been planted with Citrus (mandarin, Clementine and lemon) and **from the early 70's most of the surface was planted with trees**. On clayey soils bananas trees have been replaced by Citrus during the seventies. During the eighties new cultures appeared but stayed really limited because farmers think the market is better for citrus than for other trees.

In these conditions there is an historical background which can explain the repartition of crops in the extreme north of the valley: Citrus and other fruits trees have been early planted in an area where there was no big scarcity of water and where the soil was good. The "water regulations" implemented at the end of the eighties by the JVA confirmed the water rights of the farmers who still have allocation for trees. However, the JVA decided to limit new plantations of Citrus and Bananas, the way used by the institution was to cut back the allocation of water to 2 mm/day of irrigation/du for all the plots which were not cropped with trees at the date of the law (1990)[2]. The expansion of citrus orchards stopped but the former surfaces planted with trees stayed because they were not concerned by this regulation. Now (August 2003) old citrus orchards receive 4 mm/day/du and bananas orchards receive 8 mm/day/du. In this area mixed farms with citrus orchards and vegetables in open field can also be found.

[1] Historical data are drawn from Bourdin , 1999
[2] Jridi, 2002

- The Area located around the villages of Wadi Ryan and Kreymeh: a landscape of vegetables in open field.

The expansion of citrus orchards reached this area later than in the extreme north of the valley (mid to end of eighties) and has been reduced by the regulation enforced by the JVA[1]. Citrus are so really limited in this zone where most of the surface is cropped with vegetables in open field, wheat and olives.

Another observation can be done, in the northern part of the valley, greenhouses are very rare (unlike in the middle Ghor near Deir Alla, as we will see after), it is mainly due to the weather. This one is too cold and the greenhouses don't allow to initiate the production enough early to have significant advantages concerning vegetables prices. It is the same problem at the end of the season, due to a too cold weather; greenhouses don't permit to extend the production in a significant manner to have good repercussions on the Net Profit.

- General Cropping pattern of the Northern Ghors[2]

Concerning the following table, it is drawn from data collected by the department of statistics. The Area covered by such statistics lies from the village of Kreymeh to the North of the Jordan Valley.

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**67**	**72 500**
Olives	4	4 200
Citrus	57.5	62 200
Bananas	2.5	2 800
Others	3	3 300
Seasonal crop	**33**	**35 700**
Barley and Wheat	14	15 100
Vegetables	17.5	19 000
Others	1.5	1 600
Total		108 200

Table 2: Cropping pattern in the North of the Jordan Valley

This table confirms the first observations we have done: citrus is the most frequent crop (57% of the surface), vegetables and cereals are also important (17 and 14% of the total irrigated surface)

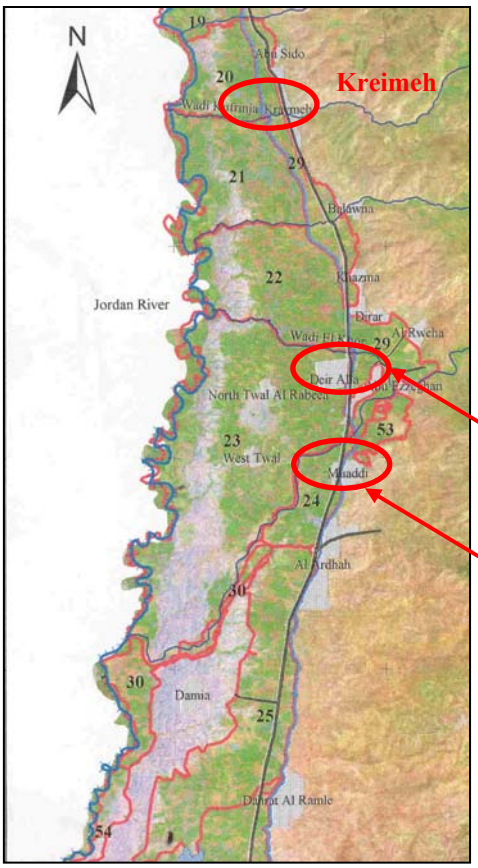
[1] See the previous paragraph.
[2] Data from the department of statistics, 2002

2. The Middle Ghors[1]

In the middle of the valley, the water used is more salty and more polluted than in the north of the valley. Fresh water from the Yarmouk River is mixed with water from the KTD[2] in the Canal then used for agricultural purposes. Soils salty and sandy (there is an excess of calcium and a lack of iron) are badly drained.

Due to this general context, land reclamation is more difficult in the middle of the valley than in the north.

In our report, we define the Middle Ghor as the area situated between the villages of Kreymeh and Karameh *(See maps above and bellow).* This area can be divided in several small regions:



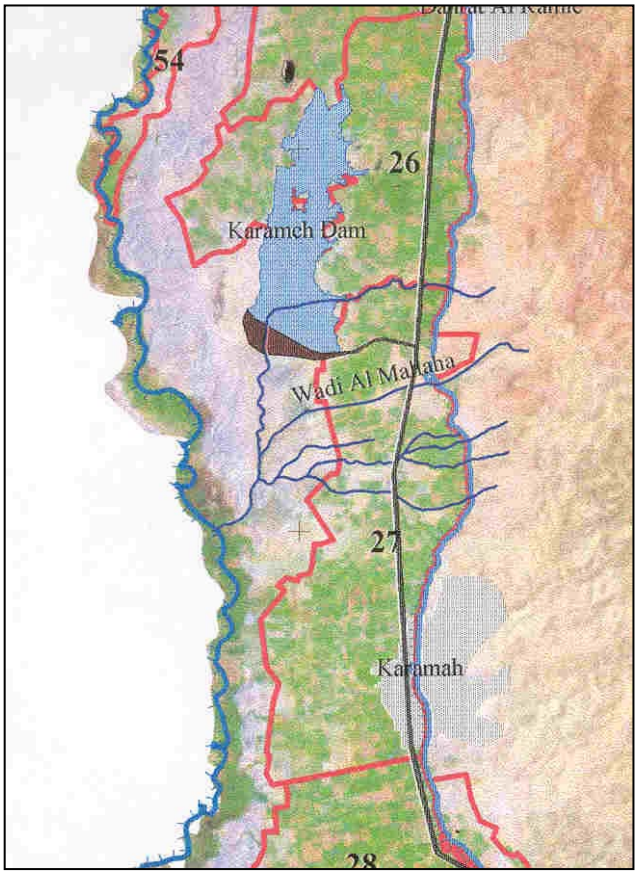
➔**The first one is centralized around Deir Alla**; it lies from the village of Kreymeh in the North to the village of Al Muaddi in the South. This area will be called transition or intermediate Area. If, for more clarity the farming systems will be described inside this global area, we can say that there are two sub-regions: the one located in the north of Deir Alla and the one in the south of this village. These ones differ by the repartition of the farming systems (there are more greenhouses in the North than in the South of Deir Alla[3])

Map 1: *Northern part of the middle Valley*

[1] All maps are from the department of GIS JVA/GTZ

[2] Water stored in the King Talal dam is a mix between fresh water and retreated waste water from Amman and other cities.

[3] An observation has been done during our surveys but it needs to be verified and completed. Indeed the use of greenhouses seems to be a more frequent way of cropping if the water used for irrigation is fresh (water from the Yarmouk which flows in the canal) than if it is mixed water (retreated water from the King Talal Dam and fresh water from the Yarmouk mixed in the canal in the South of Deir Alla). The fact that greenhouses are very rare in the Zarqa Triangle (a perimeter located in the middle of the Jordan Valley and only irrigated with the water of the King Talal Dam) agrees wholeheartedly with the fact that there were a relation between the presence of greenhouses and the quality of the water use for irrigation.



Map 2: *Southern part of the middle valley*

➔ **The second region stretches over between the villages of Al Muaddi and Karameh**. In the farming system which follows, we will consider that this area constitute a unique zone. However, this region isn't homogeneous and we can quickly present here a more precise zoning. In that way 3 small regions can be described.

From the North to the South we can individualize:

➔A non extended zone from Al Muaddi to Damieh in which large farms can be found. These farms are owned by important owners or institutions like the Ministry of Agriculture, the University of Jordan and some princes of the royal family. These farms are mainly planted with citrus or palm trees (even prickly pears) and constitute maybe 70% of the surface in this area. At the South of Damieh village, there isn't anymore citrus farm because soils seem to be too salty.

We can also found a little number of small vegetables farms in open field and some larger farms (with greenhouses). Small farms in open field are the first examples of farms which lie more south[1] and large farms with greenhouses are the last examples of the farms which lie in the area of Deir Allah and Al Muaddi[2]

➔An area which lies between Damieh and Karameh and which is located around the Karamah Reservoir. In this area, most of the farms are vegetables farms in open field cropped by Pakistani (or Palestinian) people. Farms can be small (1 unit) or larger (3 to 4 Units). These farming systems will be described in more precision in the following pages.

➔A particular Area can be identified around the village of Karamah. An individualization of this area is linked to two main reasons which have some consequences on the farming systems present in the region. To the farming system we can found between Damieh and Karameh (vegetables farms in open field –see above) two other main kinds have to be added: farmers who crop classical and particular crops (as Parsley and Mint) on their open field farm and farmers who have greenhouses[3].

The first reason which explains the existence of these two new kinds of farms is linked to the "water situation" of the village. Indeed, and first of all, there are private wells near the village. Moreover, Karameh is located at the end of the KAC which is in use and managed by

[1] See after for a more precise description, systems D1, D2 and D3. p XXX
[2] See after for a more precise description systems C3 and C4.
[3] Farming systems are described with more precisions in the following pages.

the JVA. In that way, and along the 2 of 3 last kilometers of the Canal, the JVA allows the farmers to pump directly in the Canal. The farmers only have to pay a fixed fee of 17 to 20 JD/du/year[1]. This particular access to water allows the farmers who can pay higher water costs to crop particular crops and to crop vegetables under greenhouses, two things which need more water than cropping classic vegetables in open field.

The second reason which can explain the presence of particular crops is a cultural one. In the area and since almost 40 years, Karameh village is an historical region of Parley and Mint production

- General cropping pattern[2]

Concerning the following table, it is drawn from data collected by the department of statistics. The Area covered by these statistics is centralized around the village of Deir Alla located just in the middle of the valley; it lies in the south until the Karameh village and in the North until Kreymeh.

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**27**	**19 200**
Olives	2	1 300
Citrus	16	10 900
Bananas	1	460
Grapes	4.5	3 100
Dates	3.5	1 700
Others		1 700
Seasonal crop	**73**	**52 000**
Barley and Wheat	12	8 300
Vegetables	56	39 900
Others	5	3 800
Total	**100**	**71 200**

Table 3: cropping pattern in the middle of the Jordan Valley

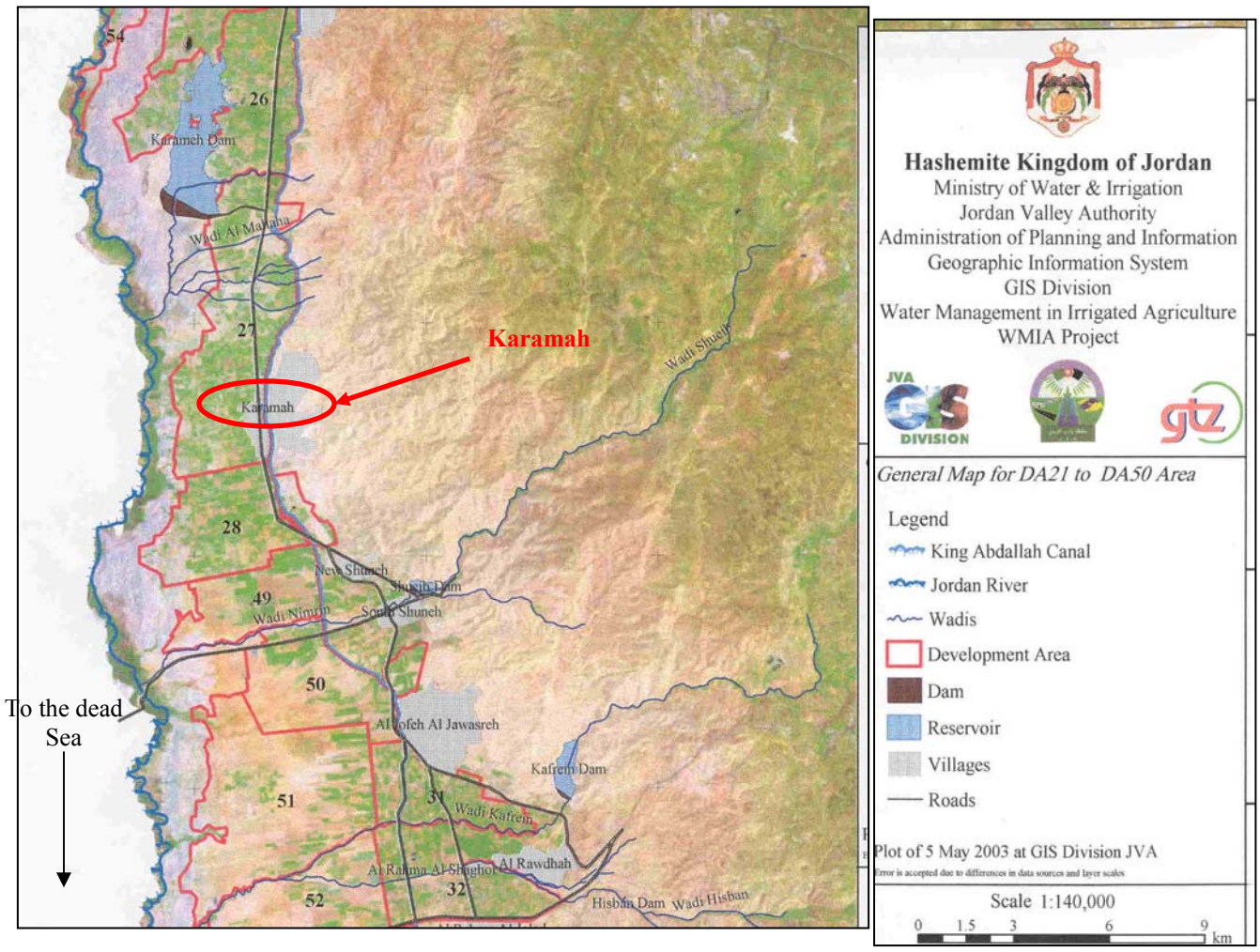
Bananas, Wheat and olive trees are negligible in the area but we can note that grapes and dates are cropped (it corresponds to the large farms described above). Citrus still represent 16% of the surface cropped and vegetables are the major crops with 56% of the surface.

[1] This fee is three times higher than the « normal » fee for vegetables farms. And through our surveys we have evaluated that the quantity of water pumped is appreciatively three times higher than the vegetables- JVA allocation.

[2] Data from the department of statistics, 2002

3. Southern Ghors

- Agricultural Zoning and water consideration



In this report what we call "**South of the Jordan Valley" is the area which stretches over between the village of Karameh and the North of the Dead Sea** *(See the map above)*. The south of the valley is relatively large (more than the north: between 9 and 12 Km in the south against a maximum of 7.5 Km in Deir Alla[1]) but agriculture is less extended. Indeed, the irrigating and irrigated land is located and limited near the mountains. Areas closer to the Jordan River are unfit for the agriculture, that's due to the quality of the soils which are too salty and to the absence of an irrigation network[2]. In that way, the few farmers which are in this "salty' zone irrigate their crops thanks to shallow and brackish wells.

The south of the valley can not be considered as a homogeneous area, indeed this area is notably heterogeneous especially in regard to water consideration. Indeed, if water consideration were really simple in the northern and middle parts of the valley: all the farmers are actually supplied with water from the King Abdullah canal which is managed by the JVA, the situation is more complex in the south of the valley. In that way and due to the existing

[1] These figures are given for the Jordanian side of the valley.
[2] JVA is now working on an extension project of the irrigation network in this area.

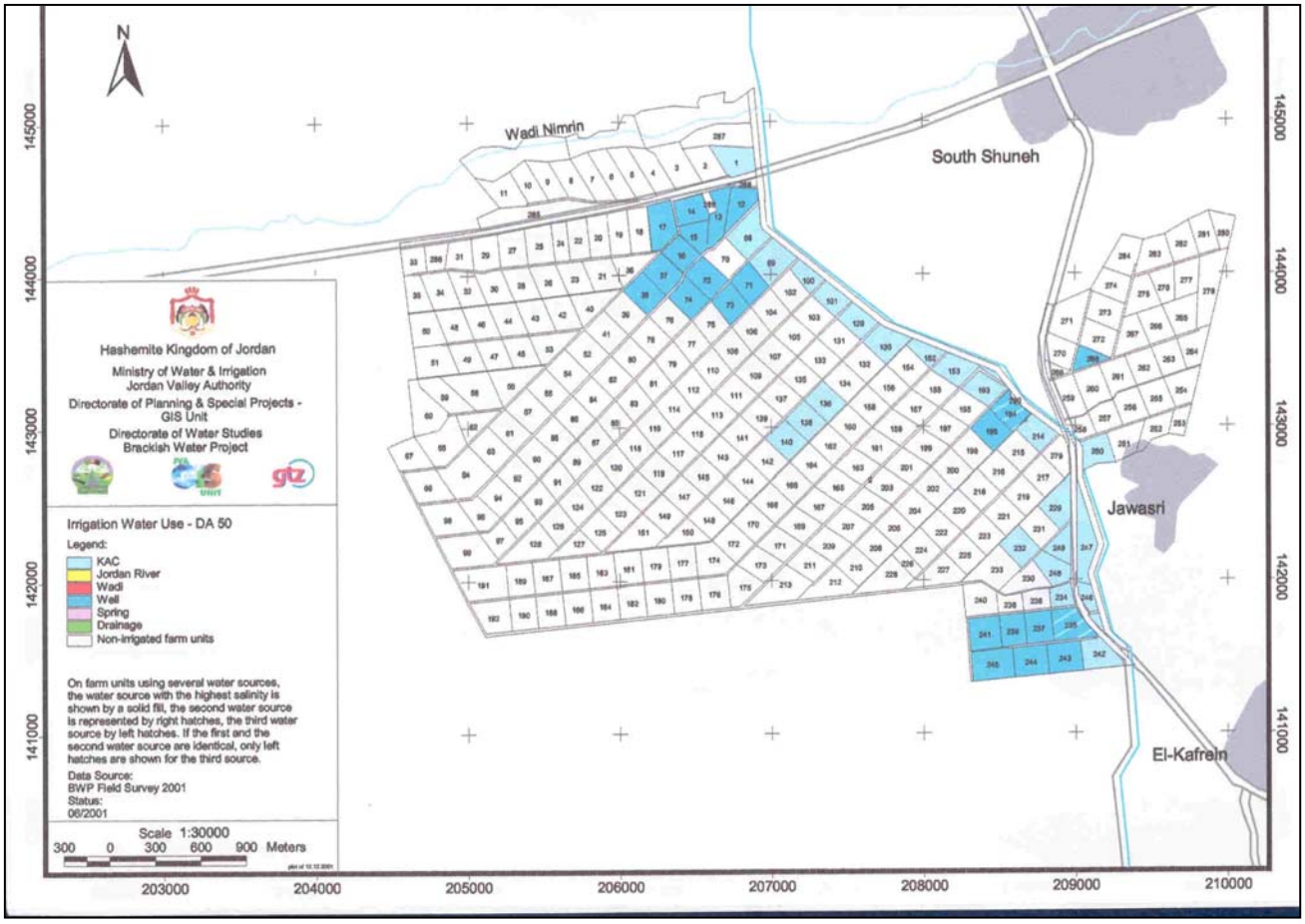
differences in water supply in the southern part of the valley we chose to divide this area in several sub-regions.

First of all, the southern part of the valley as we defined it in this report stretches over along the 14.5 Km-Project of the King Abdullah Canal. This last section of the Canal isn't now in use and the extra water which reaches Karameh (end of the canal section which is in use) flows without any control in the concrete canal[1]. Farmers could simply put their pump near the canal and directly pump inside. On another hand, the same area is supplied with water from several dams built on wadis (Shueib, and Kafrein Dams) and from non-controlled Wadis themselves (Hisban…). In that way, we can distinguish two different sub-regions in the southern part of the valley:

➔ The first one in the north is irrigated thanks to the water from the Shueib dam. This one flows on open channel. This water is free of charge and each farm **OWNS** a share of this water. Farmers also can pump directly in the Canal in which there is some extra water in winter. In this area, we can find a little numbers of vegetables farms in open field or under greenhouses (See the following pages for a more detailed description) and a lot of bananas farms.

On the two maps[2] located on the left page we can see that farm units are principally irrigated thanks to well and water coming from the Wadi Nimri (water is stocked in the Shueib reservoir)

[1] In fact extra water flows out from the canal in use mostly in winter. In summer, gates are closed and the water doesn't reach the 14.5 km-project.
[2] Maps are drawn from Vallentin, 2001


N
Wadi Nimrin
South Shuneh
Jawasri
El-Kafrein
Hashemite Kingdom of Jordan
Ministry of Water & Irrigation
Jordan Valley Authority
Directorate of Planning & Special Projects - GIS Unit
Directorate of Water Studies
Brackish Water Project
Irrigation Water Use - DA 50
Legend:
KAC
Jordan River
Wadi
Well
Spring
Drainage
Non-irrigated farm units
On farm units using several water sources, the water source with the highest salinity is shown by a solid fill, the second water source is represented by right hatches, the third water source by left hatches. If the first and the second water source are identical, only left hatches are shown for the third source.
Data Source:
BWP Field Survey 2001
Status:
08/2001
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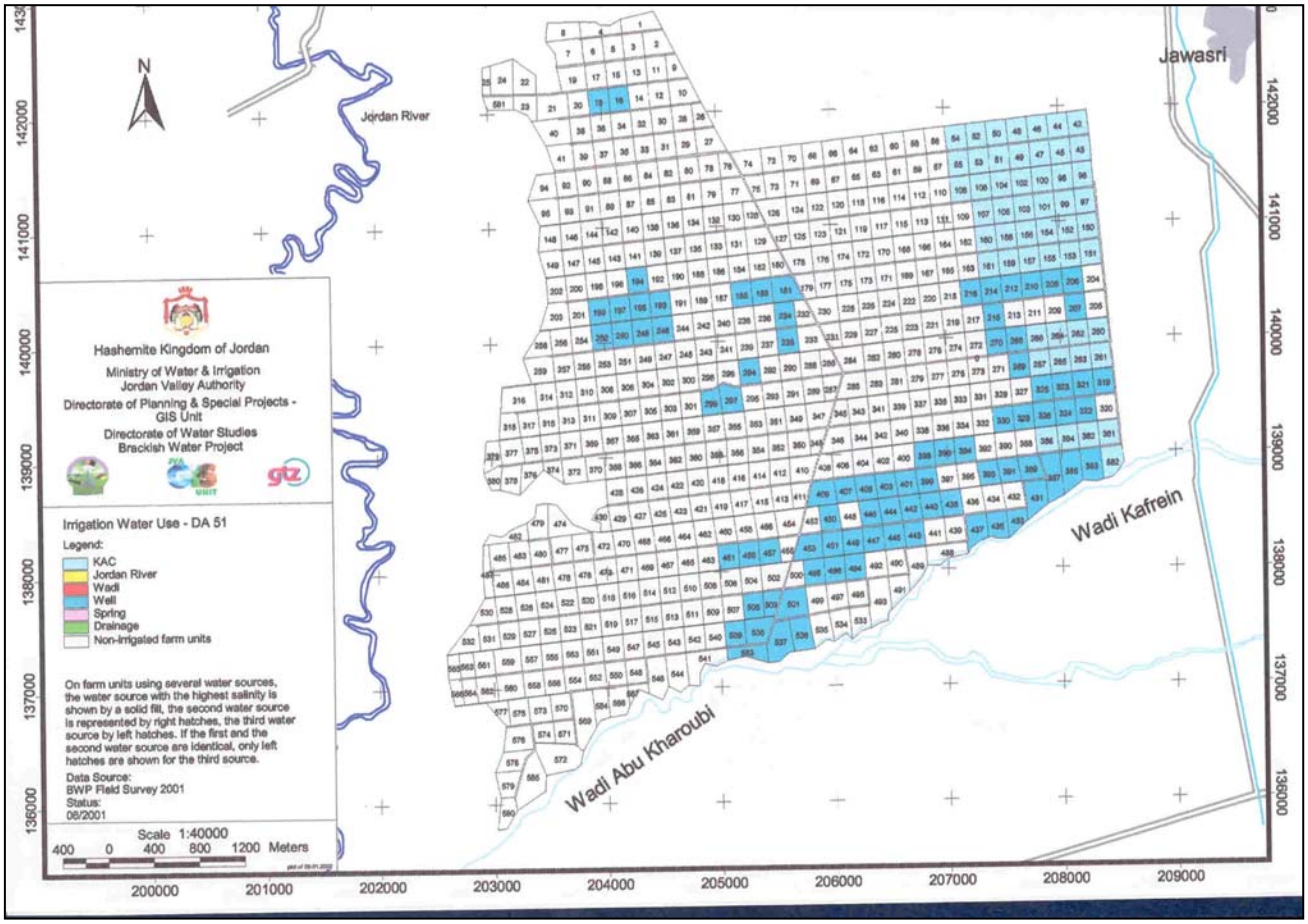
N
Jordan River
Jawasri
Wadi Kafrein
Wadi Abu Kharoubi
Hashemite Kingdom of Jordan
Ministry of Water & Irrigation
Jordan Valley Authority
Directorate of Planning & Special Projects - GIS Unit
Directorate of Water Studies
Brackish Water Project
Irrigation Water Use - DA 51
Legend:
KAC
Jordan River
Wadi
Well
Spring
Drainage
Non-irrigated farm units
On farm units using several water sources, the water source with the highest salinity is shown by a solid fill, the second water source is represented by right hatches, the third water source by left hatches. If the first and the second water source are identical, only left hatches are shown for the third source.
Data Source:
BWP Field Survey 2001
Status:
08/2001
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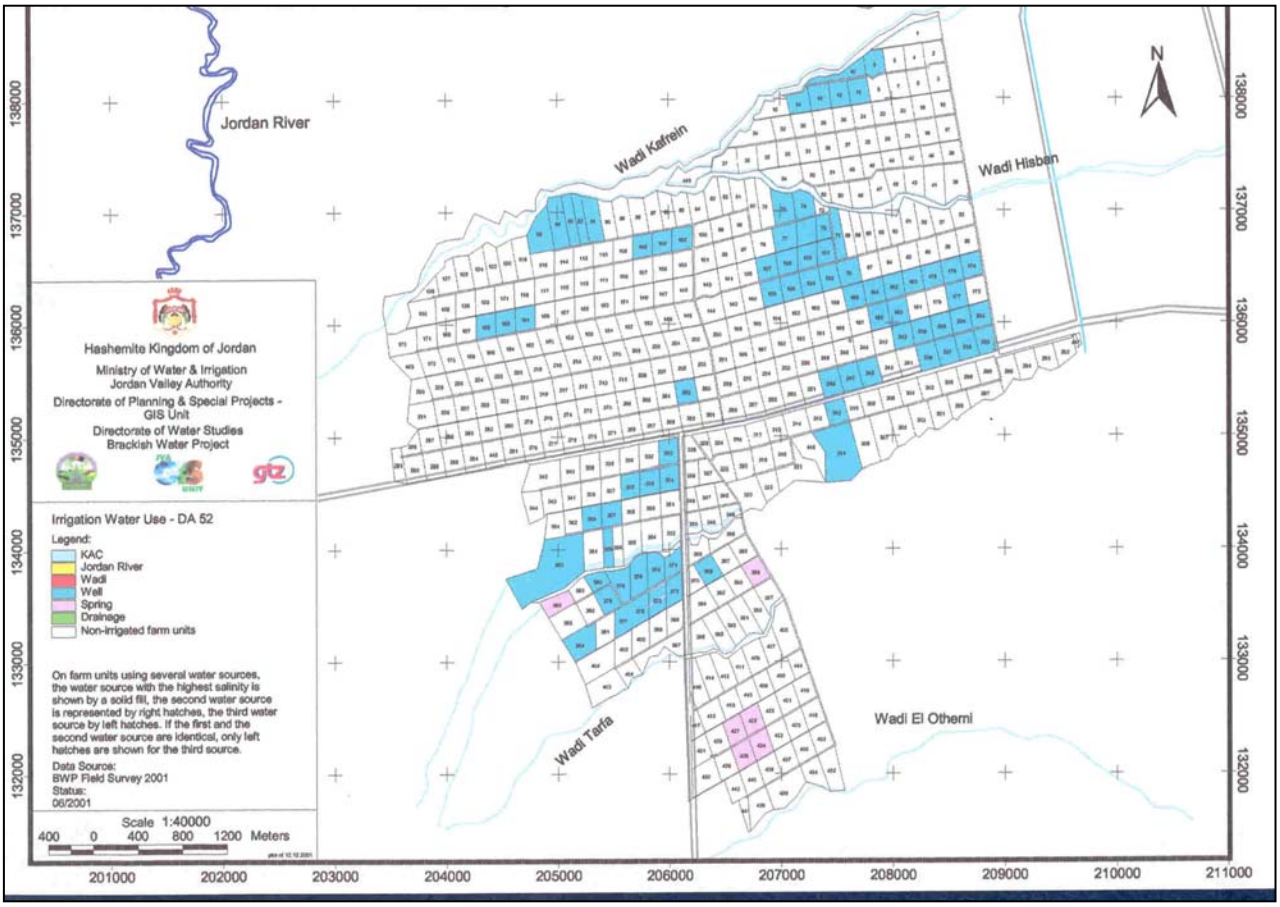
➔ The second area in the extreme south of the valley is irrigated thanks to Kafrein Dam and to Hisban non-controlled Wadi (see maps[1] on the left page), this irrigated area will be named "Hisban-Kafrein triangle". The water used is charged at the same fee that in other places in the Jordan valley (0.015 JD/m3). On another hand, farmers don't pump in the canal because extra water never reaches this southern part of the canal.

One last remark can be done about water consideration: Most of the farmers in the southern part of the valley irrigate their farms thanks to the water coming from Shueib dam, Kafrein dam, King Abdullah Canal, and Hisban Wadi **BUT** they almost all have another source of water. In that way, some farmers have their private well[2], others buy water to well's owner. The relative importance of this "alternative" water in the total amount used depends on the location of the farm (northern or southern sub-region) and on the way of cropping[3], but all the farmers said us that they have to mix the water from the wells with the water of the dams and wadis in a pool to irrigate their farms because the water pumped from wells is too salty and not suitable alone for irrigation. We will see that the richest "bananas farmers" of the Area have even invested in some desalinization plant to increase the quality of the water they pump in the purpose to increase the yield they have in their farms.

[1] Maps are drawn from Vallentin, 2001
[2] Often an illegal one
[3] More details will be given in the description of the farming systems and in the paragraph devoted to the water consideration in the South of the Jordan valley.


Jordan River
Wadi Kafrein
Wadi Hisban
Wadi El Othemi
Wadi Tarfa
N
Hashemite Kingdom of Jordan
Ministry of Water & Irrigation
Jordan Valley Authority
Directorate of Planning & Special Projects - GIS Unit
Directorate of Water Studies
Brackish Water Project
Irrigation Water Use - DA 52
Legend:
KAC
Jordan River
Wadi
Well
Spring
Drainage
Non-irrigated farm units
On farm units using several water sources, the water source with the highest salinity is shown by a solid fill, the second water source is represented by right hatches, the third water source by left hatches. If the first and the second water source are identical, only left hatches are shown for the third source.
Data Source:
BWP Field Survey 2001
Status:
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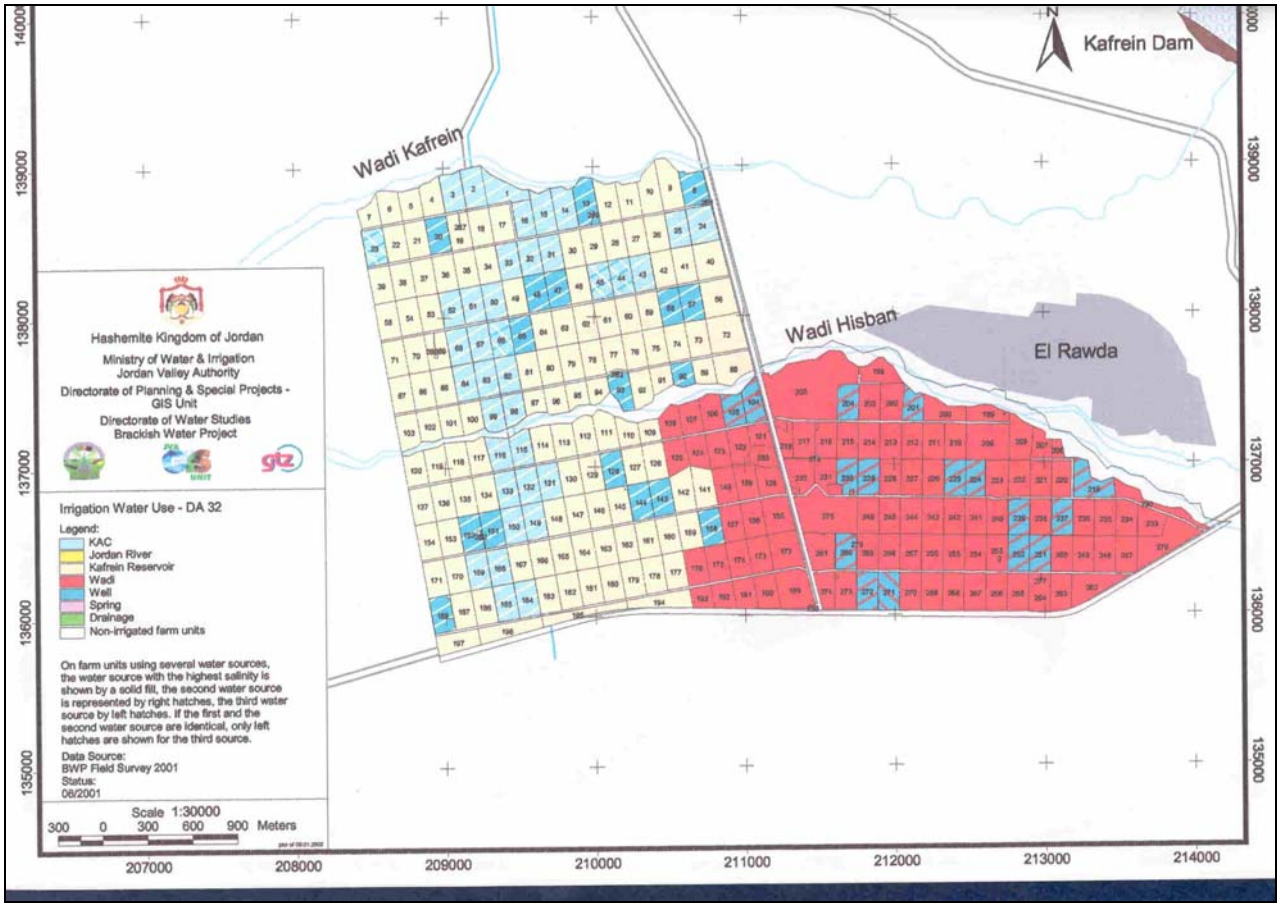
Kafrein Dam
Wadi Kafrein
Wadi Hisban
El Rawda
N
Hashemite Kingdom of Jordan
Ministry of Water & Irrigation
Jordan Valley Authority
Directorate of Planning & Special Projects - GIS Unit
Directorate of Water Studies
Brackish Water Project
Irrigation Water Use - DA 32
Legend:
KAC
Jordan River
Kafrein Reservoir
Wadi
Well
Spring
Drainage
Non-irrigated farm units
On farm units using several water sources, the water source with the highest salinity is shown by a solid fill, the second water source is represented by right hatches, the third water source by left hatches. If the first and the second water source are identical, only left hatches are shown for the third source.
Data Source:
BWP Field Survey 2001
Status:
06/2001
Scale 1:30000
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- Problems faced by the water supply

In this area, the land is owned by members of the large Al Adwan Bedouin family who settled down in the area during the Ottoman Empire by purchasing big plots of land. Added to a herding activity they always have reclaimed some irrigated plots along the Sides permanent Wadis. Since the 60's, they developed bananas plantation by using water from several Wadis flowing in the area (Wadi Shueib, kafrein and Hisban) and private shallow wells. The Area is traditionally a zone where irrigation is free and managed thanks to the tribal law (or Islamic law)

Picture 1: Privates pipes running in the southern part of the valley

During the eighties, the JVA implemented some irrigation project to control the flow of these permanent Wadis thanks to several dams. The JVA try to implement an organized network of water supply it will manage. This attempt addressed and continues to address today the reluctance of farmers in the area. Indeed as they are owner of the land, and due to the Islamic law, they consider themselves as owner of the resources which are on this land: the water is among these resources. In that way, they don't understand why they should pay for water even if there is a network managed by a governmental institution.

In that way, even if the JVA supply some water (coming from the dams it managed) to farmers, most of these ones don't even pay their water bills. Moreover, almost all the farmers have their own pipes and their own "off-farm" irrigation network to take the water where it is (end of the canal, permanent Wadis, open channels…see the picture above). There isn't, like in the North of the valley, a unique water supply network and all the farmers feel free to do what they want with the financial means they have.

- General Cropping pattern[1]

Concerning the following table, it is drawn from data collected by the department of statistics. The Area covered by these statistics lies from Karameh village to the North of the Dead Sea.

[1] Data from the department of statistics, 2002

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**48**	**14 900**
Olives	4.5	1 400
Citrus	6	1 800
Bananas	33.5	10 400
Others	4	1 300
Seasonal crop	**52**	**16 200**
Barley and Wheat	10	3 200
Vegetables	37	11 600
Others	5	1 400
Total	**100**	**31 100**

Table 4: Cropping pattern in the south of the Jordan Valley

We can see on this table than Bananas and vegetables are the two main crops in the south of the valley: bananas represent 33.5 % of the surface and vegetables 37 %. We will see in the model described in the following pages than bananas and vegetables crops are closely linked.

THE HIGHLANDS

General presentation

This Area designed under a « generic name » can be characterized by its heterogeneity, in that way we will describe several regions:

- ✓ Eastern desert or Badia
- ✓ Upper Yarmouk Basin
- ✓ Zarqa Area
- ✓ Uplands Area
- ✓ Amman's area of Influence (cf. general map of the basin)

In the Highlands, two kinds of irrigated agriculture can be found:

- ✓ An old one which has been developed along several Side Wadis thanks to spring and shallow wells. This kind of agriculture will be presented in the two parts entitled *"Zarqa Area"* and *"Uplands Area"*.

- ✓ A more recent one developed in the 70 and 80's thanks to deep wells in the Eastern desert. Moreover we will see that during the 90's there has been a redistribution of the agriculture from "ancient area" in the neighboring of Amman to other areas more distant where the water is less expensive. This new agriculture will be described in the part entitled *"Upper Yarmouk Basin"*

The first characteristic of the farms located in the Highlands, irrigated by groundwater, is their large size: farms are organised by plots of 15 to 30 hectares in average[1]. This large surface is due to the high costs of installation[2]: 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.

[1] 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)

[2] See the main report and annexe I for an evaluation of the initial investment and its consequences.

- General evaluation of the agricultural surfaces[1]

Crop	Irrigated Area	Non Irrigated Area	Total
Fruit trees	240 900	525 400	766 300
Field Crops	41 500	1 278 900	1 320 400
Vegetables	164 100	22 900	187 00
Total	**446 600**	**1 827 100**	**2 273 700**

Table 5: Irrigated surfaces in the Highands

These figures concern all the country but if we based ourselves on the Jordanian Bank of the Jordan River Basin, the total irrigated surface in the Highlands only reaches appreciatively 300 000 dunums (190 000 dunums of fruit trees , 80 000 dunums of vegetables and 30 000 of field crops)

Agricultural Zoning

We have separately analyzed the farming systems in the 5 geographical areas presented above.

1. Eastern Desert or Badia

➔Two Waves of Agricultural Development

In the Area, the development of an irrigated agriculture can be noticed since the mid 70's, but 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), energy costs decrease 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[2].

In this area and in spite of desert conditions (low humidity, wind and dust) modern vegetables culture have been developed thanks to several reasons:

*Low water and land costs,
*Desert lands are easy to reclaim (tractor, plough…),
*Soils are fertile enough,
*Soils are not infected by nematodes, fungus, bacteria…
*No theft of production,
*No consequences of pollutions,
*Nights are cold: there isn't any "problem" of climate

[1] Figures from the department of statistics, figures are in dunum
[2] Moreover, loans of the World Bank could allow some people to invest at preferential rate (7%).

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. A lot of farmers who were cropping in Madaba/Liaduda/Baqaa (in the south of Amman, out of the basin considered) set up near Mafraq at this period. 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 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. 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[1]/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 Mafraq directorate[2]: 0.065 to 0.115 Fils/m3 (0.09 to 0.162 $/m3)

➔General cropping pattern

Concerning the Mafraq Area we can present a rough global cropping pattern.

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**53**	**35 000**
Olives	33	22 000
Apples	7	4 660
Peaches	6	4 000
Grapes	1	330
Others	6	4 000
Seasonal crop	**47**	**21 000**
Alfalfa	0	0
Barley and Wheat	3	2 000
Vegetables and Melon	44	19 000
Total	100	66 000

Table 6: Cropping pattern of the Mafraq Area[3]

We can see on this simple table than seasonal crops represent 47% of the surface cropped, trees are more important (with 53%) and notably olive trees which represent one third of the surfaces cropped in the area of Mafraq.

[1] One Jordanian Dinar (JD) is divided into 1000 Fils.
[2] The way of calculation of this price will follow
[3] Source: James B.Fitch, report for ARD for the surface repartition and Ministry of Agriculture statistics for the surface evaluation in dunum.

2. Upper Yarmouk Basin

Irrigated agriculture in this area is much localized around a little number of wells. Development of irrigated agriculture in this area is relatively recent (since the mid 90's) Farmers who are now here, were located in the south of Amman (near the cities of Madaba, Liaduda, out of our basin of study) and migrated here because of the urban pressure which lead to an increase of water and land prices (this phenomenon has been described in more details in the Mafraq paragraph and will be completed in the Amman's Area of Influence one).

Near the Syrian border, the soil has a really good quality, and farmers doesn't need to use a lot of input to have good yields

➔General cropping pattern[1]

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**58**	**16 800**
Olives	24	6 800
Apples	3.5	1 000
Peaches	3.5	1 000
Grapes	7	2 000
Others	21	6 000
Seasonal crop	**42**	**12 000**
Alfalfa		NEGLICTIBLE
Barley and Wheat		NEGLICTIBLE
Vegetables	42	12 000
Total	**100**	**28 800**

Table 7: Cropping pattern of the Upper Yarmouk basin[2]

We can see in this simple table than vegetables constitute the main irrigated surface: 12 000 dunums (it means 42% of the total irrigated surface) and that olive trees are also important (24% of the surface)

3. Zarqa Area

This Area can be divided in two main regions:

- ✓ The eastern region which lies until the desert.

Zarqa agricultural directorate lies until Azraq in the middle of the desert. In that way, 4/5 of the surface of this administrative Unit isn't a part of the JJRB as we defined it above. By consequences, we faced some difficulties to evaluate the irrigated surface inside the JJRB[3]. Regarding to the satellite map realized by the ARD team, we can see that irrigated area at the east of Zarqa is mainly limited to Dulheil Area.

[1] Source : Department of Statistics, agricultural statistics of 2002
[2] the Upper Yarmouk Basin corresponds to the directorate of Irbid and Ajloun.
[3] All statistics are done by governorate, that isn't relevant here

The development of agriculture in this zone is ancient (already during the sixties) and is linked to a governmental project implemented in the area. This one was designed to irrigate 8000 dunums thanks to groundwater pumped from deep wells managed by the WAJ. This water was brought to the farmers through 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 most of them kept teir nomadic way of life. 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…) which hadn't be studied during our field work.

Added to the 2000 dunums cropped in Dulheil Area, and regarding to the ARD maps and data, 500 others dunums can be added to complete the evaluation of the irrigated agricultural surface at the East of Zarqa and inside the JJRB as defined in this report[1].

- ✓ The Zarqa River.

History and water flow

Zarqa river is the most important of the "sides Wadis" going from the mountains to the Jordan valley. **These Side wadis have been the first places** (and the only ones during a long period) **to be irrigated in Jordan** thanks to some hand made techniques (diversion weirs, earth ditches…) which allow irrigating crops in summer (cf. general description in p…)

Most of these wadis are tapped by dams and diverted to the main canal (KAC) and their water is used for irrigation. The Zarqa River makes no exception: The average flow of the Zarqa river basin (62 Mcm/year) is less than the Yarmouk's but it is entirely controlled by the King Talal Dam and the basin lays for 100% in Jordan. Intensive underground abstraction in the upper basin (Mafraq directorate, east of Zarqa city) reduces strongly the base flow of this river. But meanwhile the King Talal Dam collect the treated waste water of the greater Municipality of Amman (53 Mcm/year). As those waters initially come from different neighboring river basins the abstractions in the upper basin are more than compensated by those tributes. Before reaching the King Talal Dam, and because of its low quality, water from Zarqa River is only used to irrigate forages and trees along the Zarqa river banks. This water is actually a mix between fresh water of the River and retreated waste water from As Samra treatment plant and is not appropriate to irrigate vegetables[2].

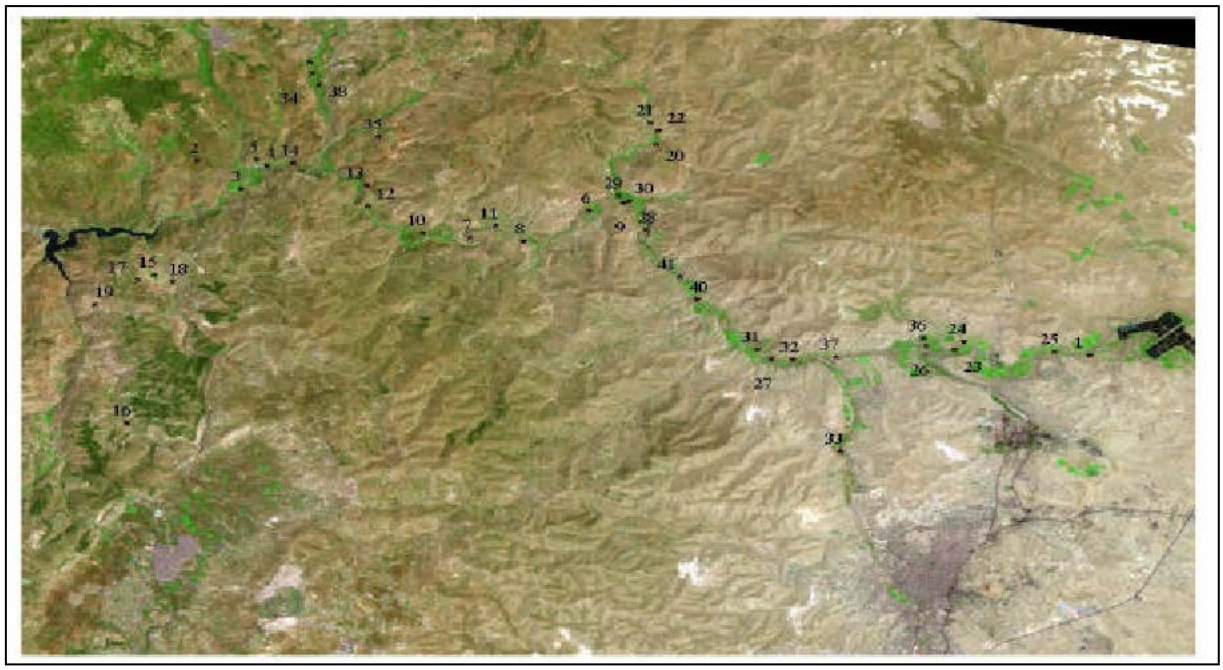
Farms irrigation

Most of the farms along Zarqa River are irrigated thanks to spring and shallow wells (30 to 35 meters deep) located along the Zarqa River bank[3]. Two main kinds of farms (which will be described in much more precision after) can be found: small rented farms cropped with vegetables and larger farms planted with trees (olive or varied other fruit trees: Nectarine, Peaches….). The total irrigated surface along the Zarqa river has been evaluated at 24 000 dunums by the ARD team.

[1] A more precise work will be needed to improve this rough evaluation.

[2] This retreated waste water stored in the King Talal Dam after mixing in the KAC with the fresh water from Yarmouk River will be used to irrigate all the perimeters located in the south of the Jordan valley.

[3]Thanks to survey, the initial investment for the well has been evaluated at 20 000 JD (of 2001). In models, we used a depreciation amount of 120 JD (it corresponds to one tenth of the amount used for deep wells dug up in the eastern desert (for which the investment had been evaluated at 200 000 JD).



Picture 2: satellite map of irrigated Areas along Zarqa River[1]

➔General cropping pattern

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**68**	**29 900**
Olives	52	22 900
Apples	8	3 500
Peaches	5	2 200
Grapes	2	880
Others	1	440
Seasonal crop	**32**	**14 100**
Alfalfa	5	2 200
Barley and Wheat	5	2 200
Vegetables and Melon	22	9 700
Total	100	44 000

Table 8: cropping pattern of the Zarqa Directorate [2]

We immediately see on this table than Olive is the most important crop in the Zarqa directorate (52% of the total irrigated surface) Vegetables represent 22%.

[1] Source: ARD remote sensing study.

[2] Source: James B.Fitch, report for ARD for the surface repartition and Ministry of Agriculture statistics for the surface evaluation in dunum. The problem in this surface evaluation is the fact that Zarqa directorate is very large and lies until Azraq which is not a part of our study (In total surface, nearly 4/5 of Zarqa directorate is out of the hydrographic Basin we consider)

Finally we can note the importance of Apple and Peach trees essentially along the Zarqa River (8 and 5% of the irrigated surface) bank and the importance of Alfa Alfa (5%) essentially upper stream of the Zarqa River (irrigation is mainly done with retreated waste water)

4. Uplands Area

The area we consider here lies between The Jordan Valley and the Eastern desert. Administrative directorates concerned are Ajloun, Jerash and one part of Al Balqa and Irbid ones.

As we said before, this area is a hilly and most of the agriculture is a rain fed one. The major crop is rain fed olives tree. However, some irrigated area exists. They are located along the banks of some little river or near natural springs. Most of the irrigated farms we saw were located near Jerash city.

Like along the Zarqa River, this irrigated agriculture organized around small plots located at the bottom of side wadis, has always existed and constitutes the beginnings of the irrigated agriculture in Jordan.

Added to the vegetables and fruit trees farms we find in this Area, we can mention that there are also small horticultural farms irrigated in the same way (along the small rivers)

Some people said to us that the number of farmers (and of greenhouses) decreases in the area since the end of the 80's, beginning of the 90's. This disappearance seems to be due to a profitability decline of the agricultural activity at this period (80's and 90's) and to a decrease in the water quantity available in the area.

➔General cropping pattern

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**95**	**26 500**
Olives	57	16 000
Apple	5	1 500
Grapes	9	2 500
Others	23	6 500
Seasonal crop	**5**	**1 500**
Alfalfa		NEGLICTIBLE
Barley and Wheat		NEGLICTIBLE
Vegetables and Melon	5	1 500
Total	100	**28 000**

Table 9: cropping pattern of the Uplands Area[1]

We can see on this table than, in the directorate of Ajloun and Jerash, fruit trees constitute the main part of the irrigated surface (95% while vegetables only represent 5% of the surface cropped).

[1] Statistics drawn from the Agricultural Statistics 2002 book from the department of statistics. Directorate of Ajlound and Jerash.

Irrigated olive trees constitutes are very important (57% of the irrigated surface) and we can note an important diversity of trees since the category "other trees" represents 23% of the irrigated surface.

5. Amman's area of Influence

In this area, and due to the proximity of the city of Amman[1], a lot of farmers are growing flowers. Such farms haven't been surveyed and no models are presented here. We focused ourselves on vegetables farms which are much more representative of the agriculture in the Area and in Jordan.

The agricultural development of this area dates of the beginning of the eighties (like for the Eastern Desert and the Upper Yarmouk Basin) and is directly linked to the good economic conditions of the period in the agricultural sector added to the availability of new irrigation techniques (drip irrigation, drilling of wells…)

The agriculture could be defined by the generic term "Peri-urban agriculture"

➔General Cropping pattern

Kind of crop	Irrigated Surface (% of total)	Irrigated Surface (dunums)
Trees crop	**80**	**98 000**
Olives	62	75 500
Apple	2	2 500
Peaches	6	7 500
Grapes	2	2 500
Others	8	10 000
Seasonal crop	**20**	**25 000**
Alfalfa		???
Barley and Wheat		???
Vegetables and Melon	20	25 000
Total	100	**123 000**

Table 10: cropping pattern of the Suburban Area[2]

This table permits us to identify the two main crops in the suburban are: vegetables represent 20% of the irrigated surface and olives trees 62%.

[1] Transport is easy and less expensive

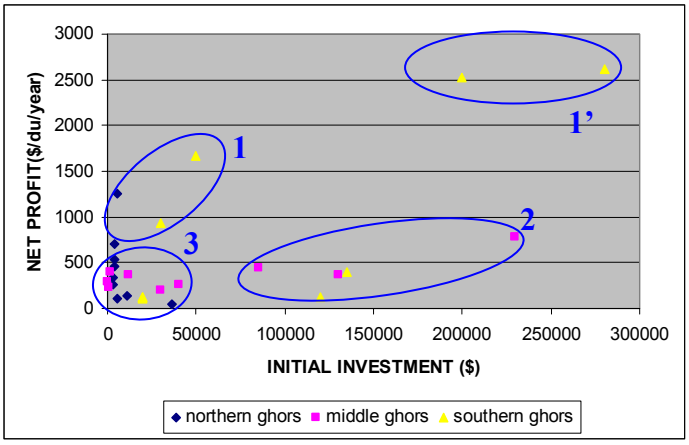
[2] Statistics drawn from the Agricultural Statistics 2002 book from the department of statistics. Directorate of Amman and Baqaa.

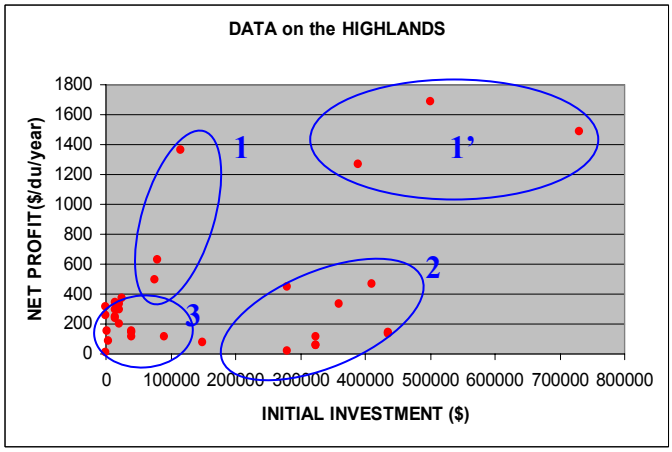
Description of the farming systems and strategies developed by the farmers

"Experimental" classification

Net Profit and Initial Investment

In the following pages, we present some graphics which permits to visualize and to justify the classification of the farming systems done above. These graphics allow us to identify a classification in the strategies developed by the farmers in the Basin.





Figures 7 & 8: Four classes of farming systems according to the Net Profit ($/du/year), the Initial investment done on the farm and the location of the farm

These two charts permit us to visualise four classes of farming systems in the Jordan Valley as well as in the Highlands. Even if the figures are not comparable, the four groups presented on the charts (see the blue circles) reveal the same kind of farming systems and the same kinds of strategies. We will give the characteristics of each class:

- ✓ Sub class 1

This class of farmers correspond to entrepreneur farmers for who agriculture is a secondary activity. The initial investment is low (inferior to 50.000 $/farm in the valley and inferior to 100.000 $/farm in the Highlands). The net profit related is relatively high (around 1.500 $/du/year in the valley and included between 600 and 1.200 $/du/year in the Highlands) This group of farms is constituted by bananas farms in the North of the valley and by fruit trees farms in the Highlands. Farms are extensively managed, and costs of labour and inputs are high.

- ✓ Sub class 1'

This class correspond to entrepreneur farmers for who agriculture is the main activity. The initial investment is very high and depend on the location of the farm (around 200.000 to 300.000 $/farm in the valley and around 400.000 to 800.000 $/farm in the Highlands). The Net profit related is also very high (it reaches 2.500 $/du/year in the valley and 1.500 $/du/year in the Highlands). Farms are very modern and intensive techniques (high level of inputs, qualified and specialized employees) are used to manage the farms. This group of farming systems is constituted by bananas farms in the South of the Valley and by stone fruit trees farms in the Highlands.

✓ Sub class 2

This class corresponds essentially to familial farmers[1] who crop vegetables. The initial investment is high (around 100.000 to 200.000 $/farm in the valley and around 200.000 to 400.000 $/farm in the Highlands). This initial investment corresponds to greenhouses in the Valley and to the well in the Highlands. The Net Profit related is close to 500 $/du/year in the valley and in the Highlands. In the valley the farm is intensively managed, the land can be rented or owned; in the Highlands it is a more extensive way of cropping and the land is generally owned.

Owners who have sharecropping arrangements can be put in this sub classes but the Net Profit is lower (generally inferior to 100 $/du/year)

✓ Sub class 3

This class is really diverse. It is characterized by a low level of investment (inferior to 50.000 $/farm in the valley and to 100.000 $/farm in the Highlands) and a Net profit related inferior to 500$/du/year. Different kinds of farmers can be found in this area:

➔Entrepreneur farmers with citrus plantation extensively managed in the north of the Valley,
➔Familial farmers cropping vegetables in open field in the valley or in the Highlands who mostly rent the land they crop

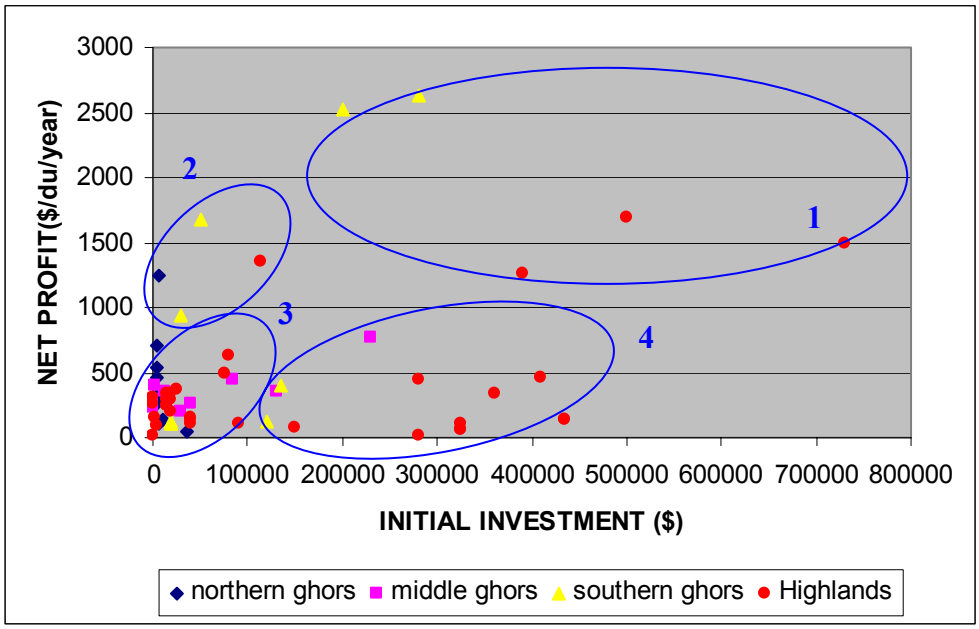
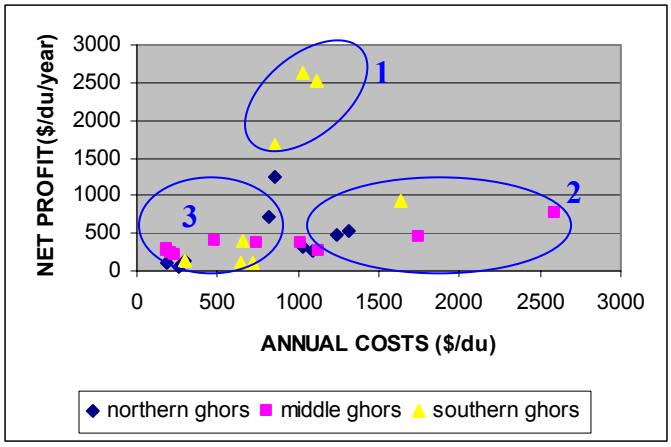


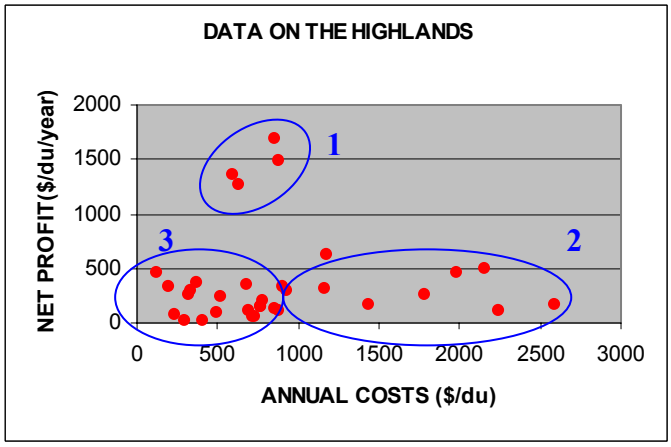
Figure 9: Four classes of farming systems according to the Net Profit ($/du/year) and the Initial investment done on the farm

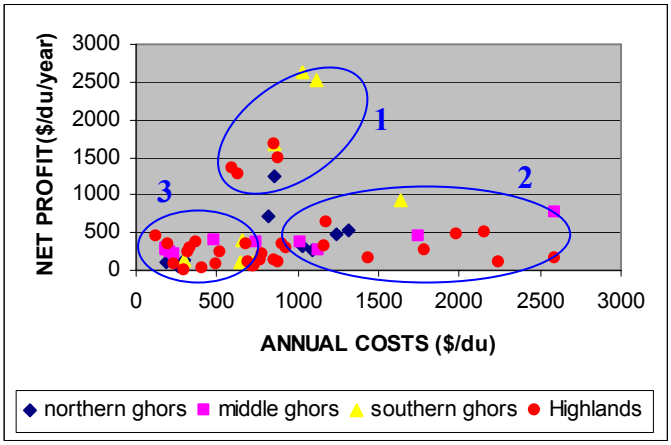
Through the description of theses four sub classes we have seen that the same dynamics can be underlined in the valley as well as in the Highlands. Inside each sub classes the same observation can be done: the initial investment done in the Highlands is higher than in the Valley and the Net profit related is lower in the Highlands than in the Valley. For the same group and for a equivalent strategies, the quotient Net Profit/ Initial Investment is always higher in the Valley than in the Highlands.

[1] Some entrepreneur's farmers can have the same strategies but they are very rare.

Net profit and Annual costs







Figures 10 to 12: Three classes of farming systems according to the Net Profit ($/du/year) and the annual costs

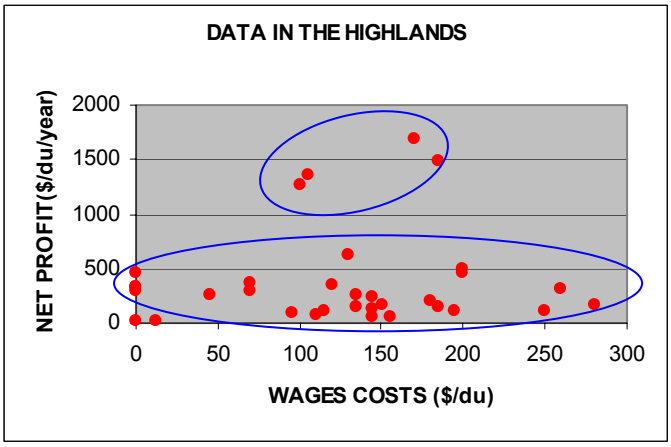
The three graphics presented above permits to differentiate three main classes of farming systems according to the level of intensification of the farms.

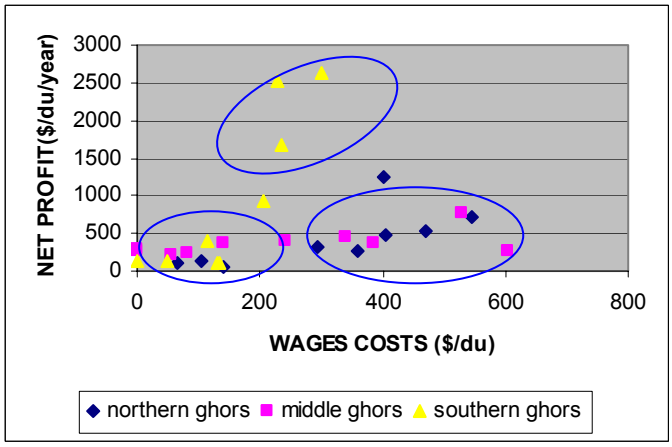
✓ ***Sub class 1***

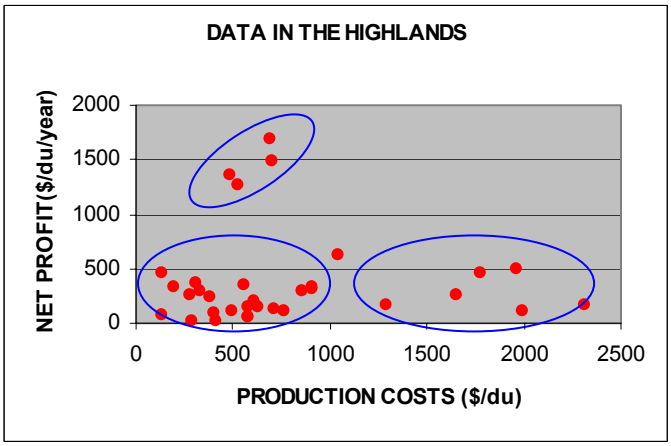
This class corresponds to the farms which are managed in a **very intensive way** in matter of work as well as inputs[1]. The net profit brought out is very high (superior to 1.200 $/du/year) and the annual costs are in the average (between 500 and 1.500 $/du/year). This class corresponds to the farms requiring high initial investment and modern techniques. Bananas farms in the south of the valley, stone fruit trees in the Highlands and vegetables under greenhouses in the north of the valley can be put in this group. The farms concerned are mostly entrepreneur's farms. **This class correspond to the classes 1 and 1' described p.179**

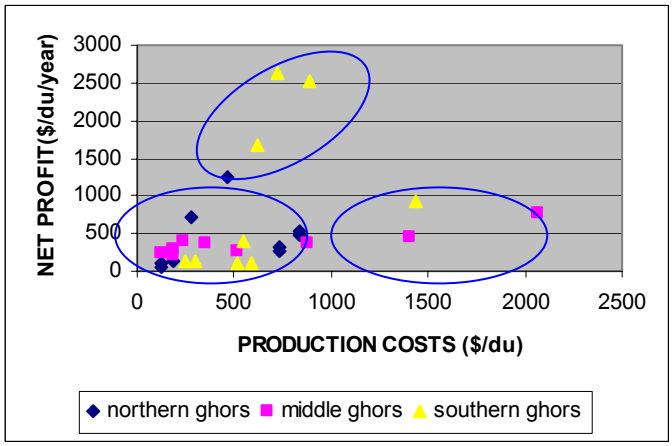
To analyse the two other classes we need more information and we will separate the wages costs and the production cost to present a more complete interpretation.

[1] The surface cropped per permanent worker is high, and inputs are highly used.









Figures 13 to 16: Classes of farming systems according to the Net Profit ($/du/year) and the annual costs

Firstly we can say that the four graphics presented above permits to individualize the sub class 1 we already described.

To distinguish the two other sub classes we will analyse the figures 40 to 43.

➔Concerning the Highlands, two different groups can be done concerning the production costs (the highest costs correspond to the farms where vegetables are cropped under greenhouses; the lowest costs correspond to vegetables cropped in open field). We observed also that wages costs are distributed from 0 to 300 $/du/year according to the farming systems but we can't do any partition: the distribution is continuous.

➔Concerning the Highlands, two different groups can be done for the production costs as well as for the wages costs. Lowest costs correspond to vegetables cropped in open field, highest costs to vegetables cropped under greenhouses.

✓ ***Sub class 2***

In the valley, the sub class 2 corresponds to the **intensive farming systems in matter of labour and inputs**. These systems are costly (the annual costs are superior to 1000 $/du/year). Farming systems concerned are farms where vegetables are cropped under greenhouses. The Net profit brought out is superior to 500 $/du/year (it means that these systems permits to bring out a Net profit higher than the Profit bring out by the systems of the sub class 2). The initial investment is also higher than for the farms of the sub class 3 but as farms are more profitable, farmers will do such investments if they can do it. These farms can be entrepreneur's farms or familial farms

In the Highlands, the sub class 2 corresponds to farms where **vegetables are cropped under greenhouses**. Inputs are generally used (production costs superior to 1250 $/du/year) and the system is more intensive in matter of work than the open field system. Like in the valley, if we considered each area of the Highlands separately, this system (vegetables under greenhouses) permits to bring out a Net Profit higher than the profit brought out by the systems of the sub class 3[1]. Farmers, who mainly are entrepreneur, will do the necessary higher initial investment if they can do it to optimize their revenue.

This class correspond to the class 2 identify in the graphics representing the Net Profit in function of the Initial Investment

✓ Sub class 3

In the valley, the sub class 3 corresponds to the **extensive farming systems** in matter of labour and inputs. These systems permit to bring out a low Net profit (inferior to 500 $/du/year); production and wages costs are also low (inferior to 750 $/du/year). We spoke here of entrepreneurs' farms extensively managed (citrus plantation) or of small familial farms (vegetables in open field in the middle and in the south of the valley, farms are rented or under a sharecropping agreement)

In the Highlands, the sub class 3 corresponds to the farms of **vegetables cropped in open field.** This system is extensive in matter of work (the surface cropped per permanent worker is low) but inputs are generally used (production costs around 500$/du/year). Farms can be owned or rented

In conclusion, we can say that this sub class 3 correspond to the familial or entrepreneur's farms characterized by a low investment (initial as well as annual)[2]

This class correspond to the class 3 identify in the graphics representing the Net Profit in function of the Initial Investment

[1] This observation isn't clear on the graphics presented. Refer for each area to the recapitulative tables of the economic models.

[2] One exception can be presented: the citrus plantation extensively manage in the north of the valley.

Summary and recapitulative table

We can see that the two different representations permit us to elaborate the same classification of the farming systems of the Jordan River Basin in Jordan. By consequence, the graphics presented above and the linked discussion allow us to identify the different strategies of the farmers in the Jordan River Basin in Jordan. These strategies are different according to the areas and according to the economic means of the farmers. Generally speaking, farmers prefer planting fruit trees (bananas and others) and that is for several reasons: prices are higher and more stable and trees constitute an easy way of farming with less labour needs, less input and labour costs (See Appendix VIII and the discussion done above for a comparison of such costs). Moreover, the strategies which permit to maximize the Net Profit are also the more costly and only the farmers who have the capacity to invest in modern and specialized techniques are able to develop them.

In these conditions we can elaborate a grading in the sub classes presented above. In each area, farmers -if they have the financial means to do the necessary investment- will preferably develop a farming system of the sub class 1, then of the sub class 2 and finally of the sub class 3.

Thanks to the description done above we can present and justify the following recapitulative table of the strategies developed by the farmers to maximize their Net Profit.

Strategies to optimize the revenue[54]		First choice	Second choice	Third choice	Fourth choice	Fifth choice
North of the valley	Intensive entrepreneur farmer	Bananas with drip irrigation and high level of fertilizer	Citrus with plot irrigation, high level of fertilizer, new varieties and frequent renewal of the orchard	Vegetables for export under greenhouses		
	Extensive entrepreneur farmer	Citrus with surface irrigation with a low level of fertilizer	Wheat and olive orchards	Renting		
	Familial farmer	Maximum of bananas trees	Maximum of citrus orchards	A varied production of vegetables		
Middle of the valley	Intensive entrepreneur farmer	Vegetables for export under greenhouses				
	Extensive entrepreneur farmer	Citrus with surface irrigation with a low level of fertilizer	Wheat	Renting		
	Familial farmer	Vegetables under greenhouses	Vegetables in open field			
South of the Valley	Intensive entrepreneur farmer	Bananas with drip irrigation and high level of fertilizer Very intensive way of cropping	Vegetables for export under Greenhouses and in open field (rare)			
	Extensive entrepreneur farmer	Vegetables in open field on an owned land, high level of input and work.	Renting or sharecropping			

	Familial farmer	A maximum of banana trees under drip irrigation/ bananas plantation developed in relation with vegetable crops	Vegetables in open field in an intensive way of cropping with a high level of Inputs and work			
Highlands	Intensive entrepreneur farmer	Stone or pipes fruit plantation with drip irrigation and high level of fertilizer	Vegetables for export under greenhouses (rare)			
	Extensive entrepreneur farmer	Stone or pipes fruits under drip irrigation (very rare)	Vegetables under greenhouses on a rented land (situation met only in the upper Yarmouk basin, rare)	Vegetables in open field on an owned land, high level of input and work. A part of the land owned is planted with olive trees It is the more frequent situation	Very large plantation of Olive trees under drip or furrow irrigation	Renting or sharecropping
	Familial farmer	Stone or pipes fruit plantations if the land is in ownership	Vegetables in open field on a rented or owned land. High level of Input			
Poor Farmers		Vegetables in open field, extensive way of cropping on a small surface				

Table 11: Strategies of the farmers in the north of the valley

Conclusion

During the last decade, Jordan reaches “its water crisis”. Water resources are over exploited. Now only a few new exploitable water resources exist and it would require very high investments to exploit them. In this context of water shortage, several projects and policies show the will to decrease the amount of water used in agriculture. For social imperatives, a priority, admitted by all, is therefore given to the Municipal use of water.

In the valley, the main modification for the next few years will be a shift from fresh water to retreated waste water. The price of water, supplied by a governmental institution could also increase but as it is now really negligible this increase won’t have any big consequences on the agriculture and on the farmers in the valley.

In the Highlands, farmers will probably have to face a taxing of the water they pump from the potable ground table. Indeed, a law not yet implemented opens the way to such taxation. The limitation of the actual over-exploitation of the ground water is the major concern if Jordan wants to reach a more sustainable water management. Thus, farming systems in the Highlands will be the more concerned by the future evolutions which will occur in the next few years. We can therefore imagine a decrease in the irrigated surface in the Highlands. Vegetables farmers will have to decrease the quantity of water they pumped and by consequence the surface they crop to keep their farm a little profitable: vegetable farms and irrigated olive orchards will be the first concerned. But, if low profitable crops will be the first touched by the futures evolutions, we can suppose also that the more profitable ones which are the more water consuming will be also concerned. Indeed, some customs protection could disappear with the entry of Jordan in the WTO.

To conclude, in the actual situation, we can suppose that a slight reshaping of Jordanian agriculture will occur in the next few years, a little quantity of water will be saved. However to avoid a worsening of the water crisis in Jordan, deeper changes concerning agriculture and its water use will be necessary. The framework allowing such evolution is already here but the consequences will be important for the country and will only be “accepted” by the different agricultural actors if there is a strong governmental will. It is precisely this will which until now hasn’t been here to allow the enforcement and the application of several measure sand laws which had the aim to limit the water use in agriculture.

We hope this study could support the government programs which will have to support the curtailment through subsidies and/or buy out and to control and enforce the law at the same time.

Table of Tables

Table of Pictures

Table of Figures

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Annexe I: Economic results of the farming systems present in the Jordan River Basin in Jordan[55]

JORDAN VALLEY: NORTHERN GHORS

FARM SYSTEM		Bananas farms	
		Surface irrigation	Drip irrigation
Identifier		A 1	A 2
Renting cost ($/du)		∅	∅
Water use (mm/day/du)		8 mm	8 mm
Water use (M3/farm/year) mean area		57 600	57 600
Land tenure		Absentee owner	Absentee owner
Technique	Irrigation technique	surface	Drip
	Cropping technique	Intensive	Intensive
Range of surface (dunums)		10 to 50	10 to 50
Yield (T/ha)		20 to 40	20 to 40
Gross Output in bad year		1240	1860
Gross Output in good year		1800	2360
Mean Gross Output		**1520**	**2110**
Net Margin in bad year		965	1405
Net Margin in good year		1525	1900
Mean net Margin		**1245**	**1650**
Water costs in bad year		75	75
Water costs in good year		75	75
Production costs in bad year		275	460
Production costs in good year		275	460
Mean production costs		**275**	**460**
Permanent Wages Cost (mean)		205	65
Daily Wages Costs (mean)		340	335
Total Wages Costs		**545**	**400**
Mean Total costs		**820**	**860**
Net Profit in bad year		425	1000
Net Profit in good year		985	1495
Mean Net Profit		**705**	**1250**
Return on Capital for investor's farms (Net profit – owner's salary)		**285**	**830**
Net Profit/Total costs (%)		**86.5**	**123**
Initial investment/farm (mean surface)		**4 000**	**6 000**

FARMING SYSTEM		Citrus farms		
		Small farms	Intensive farms	Absentee Owner
Identifier		B.1	B.2	B.3
Renting cost ($/du)		∅	∅	∅
Water use (mm/day/du)		4	4	4
Water use (M3/farm/year) mean area		33 000	49 500	220 000
Land tenure		ownership	ownership	Absentee owner
Technique	Irrigation technique	surface	localized	Surface
	Cropping technique	extensive	intensive	Extensive
Range of surface (dunums)		< 30	30 to 60	100 to 300
Yield (T/ha)		15 to 20	20 to 25	15 to 20
Gross Output in bad year		230	380	235
Gross Output in good year		360	495	360
Mean Gross Output		**295**	**440**	**297**
Net Margin in bad year		125	210	135
Net Margin in good year		225	290	225
Mean net Margin		**175**	**250**	**180**
Water costs in bad year		19	19	19
Water costs in good year		19	19	19
Production costs in bad year		105	170	105
Production costs in good year		135	205	135
Mean production costs		**120**	**190**	**120**
Permanent Wages Cost (mean)		0	29	55
Daily Wages Costs (mean)		65	77	85
Total Wages Costs		**65**	**106**	**140**
Total costs		**185**	**296**	**260**
Net Profit in bad year		65	105	5
Net Profit in good year		155	180	75
Mean Net Profit		**110**	**142**	**40**
Return on Capital for investor's farms (Net profit – owner's salary)				**10**
Net Profit/Total costs (%)		**57**	**47**	**14**
Initial investment/farm		**550**	**11 000**	**40 000**

FARMING SYSTEM	Vegetables farms			
	Open Field			
	Mulch		Mulch+ Mini tunnel	
	familial	Entrepreneur's farms	familial	Entrepreneur's farms
Identifier	C.1	C.1	C.2	C.2
Renting cost ($/du)	50	50	50	50

Water use (mm/day/du)		2	2	2	2
Water use (M3/farm/year)		14 400	14 400	14 400	14 400
Land tenure		RENT	RENT	RENT	RENT
Technique	Irrigation technique	drip	drip	drip	Drip
	Cropping technique	Mulch intensive	Mulch intensive	intensive	Intensive
Range of surface (du)		5 to 60	5 to 60	5to 60	5 to 60
Yield					
Gross Output in bad year		1140	1140	1635	1635
Gross Output in good year		1580	1580	1890	1890
Mean Gross Output		**1360**	**1360**	**1760**	**1760**
Net Margin in bad year		455	455	840	840
Net Margin in good year		805	805	1035	1035
Mean net Margin		**630**	**630**	**940**	**940**
Water costs in bad year		9	9	9	9
Water costs in good year		9	9	9	9
Production costs in bad year		685	685	800	800
Production costs in good year		780	780	855	855
Mean production costs		**730**	**730**	**840**	**840**
Permanent Wages Cost (mean)		65	0	0	65
Daily Wages Costs (mean)		295	295	405	405
Total Wages Costs		**360**	**295**	**405**	**470**
Total costs		**1090**	**1025**	**1245**	**1310**
Net Profit in bad year		120	185	375	445
Net Profit in good year		415	480	555	620
Mean Net Profit		**265**	**330**	**465**	**535**
Return on Capital for investor's farms (Net profit – owner's salary)					
Net Profit/Total costs (%)		**24**	**32**	**35**	**43**
Initial investment		**3500**	**3500**	**4000**	**4000**

JORDAN VALLEY: MIDDLE GHORS

FARMING SYSTEM		Vegetables farming	
		Greenhouses farm in the northern part of the middle valley	
		Familial farms	Absentee owner's farm
Identifier		C.4	C.3
Renting cost ($/du)		50	50
Water use (mm/day/du)		2	2
Water use (M3/farm/year)		33 600	55 200
Land tenure		Owner/renter	Owner/renter
Technique	Irrigation technique	DRIP	DRIP
	Cropping technique	Intensive 50% OF	Intensive 20% OF[56]
Range of surface		20 to 120	30 to 200
Yield			
Gross Output in bad year		1910	2950
Gross Output in good year		2490	3800
Mean Gross Output		**2200**	**3375**
Net Margin in bad year		595	995
Net Margin in good year		990	1620
Mean net Margin		**795**	**1310**
Water costs in bad year		4	4
Water costs in good year		4	4
Production costs in bad year		1310	1955
Production costs in good year		1500	2175
Mean production costs		**1405**	**2065**
Permanent Wages Cost (mean)		80	220
Daily Wages Costs (mean)		260	310
Total Wages Costs		**340**	**530**
Total costs		**1745**	**2595**
Net Profit in bad year		255	570
Net Profit in bad year		625	980
Mean Net Profit		**440**	**775**
Return on Capital for investor's farms (Net profit – owner's salary)			**605**
Net Profit/Total costs (%)		**25**	**31**
Initial investment		**85 000 (70 dunnums)**	**230 000 (150 dunums)**

FARMING SYSTEM		Vegetables farming			
		Open Field/ classic crops			
		Small rented farm	Large rented farms	Sharecropping arrangement	
				owner	sharecropper
Identifier		D.1	D.3	D.2	D.2
Renting cost ($/du)		42	50	42	0
Water use (mm/day/du)		2	2	2	2
Water use (M3/farm/year)		14 400	52 800		21 600
Land tenure		Rent	Rent	RENT	
Technique	Irrigation technique	Drip	Drip	DRIP	Drip
	Cropping technique	Mulch	Mulch mini tunnel	mulch	Mulch
Range of surface (dunums)		30	100 to 120	30 to 300	30 to 60
Yield					
Gross Output in bad year		630	735	395	380
Gross Output in good year		860	1010	560	510
Mean Gross Output		**745**	**875**	**480**	**445**
Net Margin in bad year		305	245	220	215
Net Margin in good year		475	455	365	305
Mean net Margin		**390**	**350**	**295**	**260**
Water costs in bad year		10	10	5	5
Water costs in good year		10	10	5	5
Production costs in bad year		325	490	175	165
Production costs in good year		385	550	195	200
Mean production costs		**355**	**520**	**185**	**185**
Permanent Wages Cost (mean)		0	30	0	0
Daily Wages Costs (mean)		30	55	0	56
Total Wages Costs		**30**	**85**	**0**	**56**
Total costs		**385**	**605**	**185**	**240**
Net Profit in bad year		280	175	220	175
Net Profit in good year		440	355	365	235
Mean Net Profit		**360**	**265**	**292**	**205**
Return on Capital for investor's farms (Net profit – owner's salary)				**110**	
Net Profit/Total costs (%)		**93**	**43**	**72**	**85**
Initial investment		**12 000**	**40 000**	**250**	**30 000**

FARMING SYSTEM	Vegetables farming			
	Open Field/ particular crops			Greenhouses in the southern part
	Farm in ownership	Sharecropping arrangement		
		sharecropper	owner	
Identifier	D.4 alternative	D.4	D.4	D.5
Renting cost ($/du)	0	0	42	50
Water use (mm/day/du)	3	3	3	8
Water use (M3/farm/year)	21 600 (30 dunums)	21 600	90 000	336 000
Land tenure	Ownership		Owner/tenant	Owner/tenant
Technique – Irrigation technique	Drip	Drip	Drip	Drip
Technique – Cropping technique				2/3 OF[57]
Range of surface (dunums)	<30	30	100 to 150	150 to 200
Yield				
Gross Output in bad year	775	385	385	1160
Gross Output in good year	985	500	500	1575
Mean Gross Output	**880**	**440**	**440**	**1370**
Net Margin in bad year	550	270	210	330
Net Margin in good year	730	365	310	660
Mean net Margin	**640**	**320**	**290**	**445**
Water costs in bad year	40	0	40	10
Water costs in good year	40	0	40	10
Production costs in bad year	225	115	175	830
Production costs in good year	255	135	200	915
Mean production costs	**240**	**125**	**182**	**875**
Permanent Wages Cost (mean)	135	0	0	110
Daily Wages Costs (mean)	105	80	0	30
Total Wages Costs	**240**	**80**	**0**	**140**
Total costs	**480**	**205**	**182**	**1015**
Net Profit in bad year	330	205	210	200
Net Profit in good year	470	265	310	515
Mean Net Profit	**400**	**235**	**260**	**360**
Return on Capital for investor's farms (Net profit – owner's salary)			**115**	**325**
Net Profit/Total costs (%)	**82**	**115**	**73**	**39**
Initial investment	**1500**	**750**	**31 500**	**180 000**

JORDAN VALLEY: SOUTHERN GHORS

FARMING SYSTEM	Vegetables farming			
	Open field			Greenhouses
	Small rented farms	Sharecropping arrangement		
		owner	sharecropper	
Identifier	E.6[58]	E.5	E.5	E.7
Renting cost ($/du)	0	0	0	0
Water use (mm/day/du)	??	??	??	4
Water use (M3/farm/year)	??	??	??	175 000
Land tenure	Owner	owner		ownership
Technique – Irrigation technique	DRIP	DRIP	DRIP	DRIP
Technique – Cropping technique	MULCH	MULCH	MULCH	90% OF[59]
Range of surface	25 to 50	150 to 300	50 to 100	100 to 250
Yield				
Gross Output in bad year	740	370	370	970
Gross Output in good year	950	470	470	1150
Mean Gross Output		**420**	**420**	**1060**
Net Margin in bad year	190	95	135	445
Net Margin in good year	370	165	210	580
Mean net Margin		**130**	**170**	**510**
Water costs[60] in bad year	0	0	0	0
Water costs in good year	0	0	0	0
Production costs in bad year	555	275	235	525
Production costs in good year	625	305	265	565
Mean production costs	**590**	**295**	**250**	**545**
Permanent Wages Cost (mean)	85	0	0	35
Daily Wages Costs (mean)	50	0	50	80
Total Wages Costs	**135**	**0**	**50**	**115**
Total costs	**725**	**295**	**300**	**660**
Net Profit in bad year	60	95	95	345
Net Profit in good year	170	165	145	455
Mean Net Profit	**115**	**130**	**120**	**400**
Return on Capital for investor's farms (Net profit – owner's salary)		**75**		**330**
Net Profit/Total costs (%)	**15**	**43**	**38**	**70**
Initial investment	**20 000**	**120 000[61]**	**20 000**	**135 000**

FARMING SYSTEM	Bananas farms				Mixed farms
	Familial farms		Large intensive farms		
	Owner of well	Purchase of water	**Capital Intensive bananas farms**	**Intensive familial bananas farms**	

		Owner of well	Purchase of water	**Capital Intensive bananas farms**	**Intensive familial bananas farms**	
Identifier		E.3	E.3 alternative	E.1	E.2	E.4
Renting cost ($/du)		0	0	0	0	0
Water use (mm/day/du)		15	15	15	15	
Water use (M3/farm/year)		160 000	160 000	305 000	305 000	
Land tenure		owner	Owner	Ownership/ rent	Ownership/ rent	Ownership
Technique	Irrigation technique	drip	drip	drip	Drip	Drip
	Cropping technique	plants	Plants	Use of tissue	Use of tissue	1/7 of bananas
Range of surface		30 to 50	30 to 50	50 to 100[62]	50 to 100	30 to 60
Yield (T/ha)		35 to 50	35 to 50	50 to 65	50 to 65	15 to 25[63]
Gross Output in bad year		2125	2125	3175	3175	605
Gross Output in good year		3035	3035	4125	4125	895
Mean Gross Output		**2580**	**2580**	**3650**	**3650**	**750**
Net Margin in bad year		1490	690	2485	2320	145
Net Margin in good year		2330	1600	3375	3200	325
Mean net Margin		**1910**	**1145**	**2930**	**2760**	**235**
Water costs in bad year[64]		0	900	0	0	0
Water costs in good year		0	900	0	0	0
Production costs in bad year		530	1435	690	855	460
Production costs in good year		700	1435	760	925	570
Mean production costs		**615**	**1435**	**725**	**890**	**515**
Permanent Wages Cost (mean)		110	85	140	70	0
Daily Wages Costs (mean)		125	120	160	160	130
Total Wages Costs		**235**	**205**	**300**	**230**	**130**
Total costs			**1640**	**1025**	**1120**	**645**
Net Profit in bad year		1270	495	2205	2110	40
Net Profit in good year		2080	1375	3045	2950	170
Mean Net Profit		**1675**	**935**	**2625**	**2530**	**105**
Return on Capital for investor's farms (Net profit – owner's salary)		**1375**	**635**	**2465**	**2370**	
Net Profit/Total costs (%)		**183**	**57**	**254**	**225**	**15**
Initial investment		**50 000**	**30 000**	**280 000**	**200 000**	**20 000**

HIGHLANDS: EASTERN DESERT OR BADIA

FARM SYSTEM		Fruit trees farms[65]			
		Familial farms		Large farms	
		Classic	alternative	Intensive	extensive[66]
Identifier		II.1	II.1	II.2	II.3
Renting cost ($/du)		0	Same characteristics than the classic system II.1 but the system I.1 has to be added to have a global description of the "farmer" activity. The farmer rents 100 to 150 dunums to crop vegetables (14$/du)	0	0
Water use (mm/day/du)		6		6	4
Water use (M3/farm/year)		290 000		430 000	575 000
Land tenure		ownership		ownership	Ownership
Technique	Irrigation technique	DRIP		Drip	Drip
	Cropping technique				
Range of surface (dunums)		100 to 300		200 to 400	400 to 800
Yield (T/ha)		25 to 35		30 to 45	30 to 45
Gross Output in bad year		1550		2160	2020
Gross Output in good year		2260		2920	2730
Mean Gross Output		**1905**		**2540**	**2375**
Net Margin in bad year		1075		1545	1390
Net Margin in bad year		1665		2165	1960
Mean net Margin		**1370**		**1855**	**1675**
Water costs in bad year		0		0	0
Water costs in good year		0		0	0
Production costs in bad year		475		620	630
Production costs in good year		585		760	770
Mean production costs		**530**		**690**	**700**
Permanent Wages Cost (mean)		55		100	115
Daily Wages Costs (mean)		45		70	70
Total Wages Costs		**100**		**170**	**185**
Total costs		**630**		**860**	**885**
Net Profit in bad year		985		1390	1200
Net Profit in bad year		1545		1980	1770
Mean Net Profit		**1265**		**1685**	**1485**
Return on Capital for investor's farms (Net profit – owner's salary)		**905**		**1645**	**1465**
Net Profit/Total costs (%)		**195**		**195**	**166**
Initial investment		**390 000**		**500 000**	**730 000**

FARM SYSTEM		Vegetable farms	
		Large rented farms:	
		Classic crop	Particular crops
Identifier		I.1	I.1
Renting cost ($/du)		14	14
Water use (mm/day/du)		4	??
Water use (M3/farm/year)		215 000	??
Land tenure		RENT	RENT
Technique	Irrigation technique	Drip	DRIP
	Cropping technique	Mulch	
Range of surface		200 to 250	50 to 100
Yield			
Gross Output in bad year		855	775
Gross Output in good year		1135	1055
Mean Gross Output		**995**	**915**
Net Margin in bad year		140	180
Net Margin in bad year		310	380
Mean net Margin		**225**	**280**
Water costs in bad year		75	75
Water costs in good year		75[67]	75
Production costs in bad year		710	590
Production costs in good year		820	680
Mean production costs		**765**	**635**
Permanent Wages Cost (mean)		30	40
Daily Wages Costs (mean)		85	95
Total Wages Costs		**115**	**135**
Total costs		**880**	**770**
Net Profit in bad year		40	55
Net Profit in bad year		180	235
Mean Net Profit		**110**	**145**
Return on Capital for investor's farms (Net profit – owner's salary)			
Net Profit/Total costs (%)		**12**	**18**
Initial investment		**40 000**	**40 000**

FARM SYSTEM		Vegetable farms				
		Large owned farms: System I.2				
		classic	Classic absentee owner	alternative	Classic particular crop	Alternative particular crop
Identifier						
Renting cost ($/du)		0	0	10	0	0
Water use (mm/day/du)		4	4	4	4	4
Water use (M3/farm/year)		215 000	215 000	215 000	215 000	215 000
Land tenure		Owner	Owner	Owner+rent	Owner	Owner+rent
Technique	Irrigation technique	drip	drip	drip	drip	drip
	Cropping technique	mulch	Mulch/extensive	mulch	mulch	mulch
Range of surface		200 to 250	200 to 250	200 to 250	200 to 250	200 to 250
Yield						
Gross Output in bad year		685	685	855	695	780
Gross Output in good year		885	885	1135	900	1025
Mean Gross Output		**785**	**785**	**995**	**797**	**902**
Net Margin in bad year		140	140	135	235	250
Net Margin in bad year		275	275	380	375	405
Mean net Margin		**207**	**207**	**257**	**310**	**327**
Water costs in bad year		0	0	0	0	0
Water costs in good year		0	0	0	0	0
Production costs in bad year		545	545	670	465	535
Production costs in good year		610	610	750	525	625
Mean production costs		**577**	**577**	**710**	**495**	**580**
Permanent Wages Cost (mean)		65	100	65	80	80
Daily Wages Costs (mean)		80	55	80	115	105
Total Wages Costs		**145**	**155**	**145**	**195**	**185**
Total costs		**722**	**732**	**855**		**765**
Net Profit in bad year		5	5	50	50	60
Net Profit in bad year		110	105	220	175	220
Mean Net Profit		**57**	**55**	**135**	**112**	**140**
Return on Capital for investor's farms (Net profit – owner's salary)			**2**			
Net Profit/Total costs (%)		**8**	**7**	**15**	**15**	**19**
Initial investment		**325 000**	**325 000**	**435 000**	**325 000**	**435 000**

FARM SYSTEM		Vegetable farms			
		Sharecropping farms: System I.3		Greenhouse farms System I.4	
		sharecropper	owner	owner	tenant
Identifier		I.3	I.3	I.4	I.4
Renting cost ($/du)		7	0	0	14
Water use (mm/day/du)		4	4	5	5
Water use (M3/farm/year)		30 000	150 000	180 000	180 000
Land tenure			Owner	owner	rent
Technique	Irrigation technique	drip	drip	drip	drip
	Cropping technique			75 % OF	75 % OF[68]
Range of surface		15 to 45	100 to 200	100 to 200	100 to 200
Yield					
Gross Output in bad year		295	400	2215	2215
Gross Output in good year		345	470	2670	2670
Mean Gross Output		**320**	**435**	**2440**	**2440**
Net Margin in bad year		30	15	345	320
Net Margin in bad year		45	25	590	595
Mean net Margin		**37,5**	**20**	**467**	**457**
Water costs in bad year		0	0	0	75
Water costs in good year		0	0	0	75
Production costs in bad year		265	385	1690	1900
Production costs in good year		305	445	1875	2085
Mean production costs		**285**	**415**	**1782**	**1995**
Permanent Wages Cost (mean)		10	0	135	180
Daily Wages Costs (mean)		15	0	65	70
Total Wages Costs		**12,5**	**0**	**200**	**250**
Total costs		**297,5**	**415**	**1882**	**2245**
Net Profit in bad year		10	15	345	-5
Net Profit in bad year		15	25	590	225
Mean Net Profit		**12,5**	**20**	**467**	**110**
Return on Capital for investor's farms (Net profit – owner's salary)			**0**		
Net Profit/Total costs (%)		**3**	**5**	**23**	**5**
Initial investment		**850**	**280 000**	**410 000**	**90 000**

HIGHLANDS: UPPER YARMOUK BASIN/ SYRIAN BORDER

FARM SYSTEM		Vegetables farms				
		Open field	Greenhouses			
			Transition area	Upper Yarmouk basin		
				tenant	sharecropper	Owner of the sharecropper
Identifier		V.1	VI.1	V.2	V.2 alternative	V.2 alternative
Renting cost ($/du)		30	20	30	0	0
Water use (mm/day/du)		2.5	5	5	5	5
Water use (M3/farm/year)		45 000	180 000	55 000	30 000	120 000
Land tenure		RENT	RENT	RENT		
Technique	Irrigation technique	DRIP	DRIP	DRIP	DRIP	DRIP
	Cropping technique	Mulch	25% OF[69]	100% G[70]	100% G[71]	100% G[72]
Range of surface		50 to 100	100 to 200	40 to 50	20 to 30	80 to 100
Yield						
Gross Output in bad year		805	2310	2495	1075	1075
Gross Output in good year		1165	3000	2875	1455	1455
Mean Gross Output		**985**	**2655**	**2685**	**1265**	**1265**
Net Margin in bad year		230	435	300	435	165
Net Margin in bad year		530	965	570	705	545
Mean net Margin		**380**	**700**	**435**	**570**	**355**
Water costs in bad year		210	75	210	0	0
Water costs in good year		210	75	210	0	0
Production costs in bad year		575	1885	2205	640	910
Production costs in good year		635	2035	2415	750	910
Mean production costs		**605**	**1960**	**2310**	**910**	**910**
Permanent Wages Cost (mean)		140	130	220	260	0
Daily Wages Costs (mean)		40	70	60	0	0
Total Wages Costs		**180**	**200**	**280**	**260**	**910**
Total costs		**785**	**2160**	**2590**	**1170**	
Net Profit in bad year		60	250	40	175	165
Net Profit in bad year		340	750	275	445	545
Mean Net Profit		**200**	**500**	**157**	**310**	**355**
Return on Capital for investor's farms (Net profit – owner's salary)						**290**
Net Profit/Total costs (%)		**25**	**22**	**7**	**32**	**36**
Initial investment		**20 000**	**75 000**	**1500**	**750**	**360 000**

HIGHLANDS: ZARQA AREA

FARM SYSTEM		Vegetables farms			
		Sharecropping farms			
		sharecropper	**owner**	**Sharecropper Particular crop**	**owner Particular crop**
Identifier		III.1	III.1	III.1 alternative	III.1 alternative
Renting cost ($/du)		0	0	0	0
Water use (mm/day/du)		16	16	16	16
Water use (M3/farm/year)		70 000	385 000	70 000	385 000
Land tenure			OWNER		OWNER
Technique	Irrigation technique	surface	surface	surface	surface
	Cropping technique				
Range of surface		10 to 25	=/- 100	10 to 25	=/- 100
Yield					
Gross Output in bad year		540	555	470	485
Gross Output in good year		690	705	580	595
Mean Gross Output		**615**	**630**	**525**	**540**
Net Margin in bad year		280	235	125	295
Net Margin in bad year		400	355	425	380
Mean net Margin		**340**	**295**	**275**	**337**
Water costs in bad year		0	0	0	0
Water costs in good year		0	0	0	0
Production costs in bad year		260	315	340	185
Production costs in good year		290	345	420	215
Mean production costs		**275**	**330**	**380**	**200**
Permanent Wages Cost (mean)		0	0		0
Daily Wages Costs (mean)		45	0	145	0
Total Wages Costs		**45**	**0**	**145**	**0**
Total costs		**320**	**330**	**525**	**200**
Net Profit in bad year		195	235	215	295
Net Profit in bad year		305	355	265	380
Mean Net Profit		**250**	**295**	**240**	**337**
Return on Capital for investor's farms (Net profit – owner's salary)			**235**		
Net Profit/Total costs (%)		**67**	**90**	**84**	**166**
Initial investment		**14 000**	**20 000**	**14 000**	**20 000**

FARM SYSTEM		Vegetables farms			Fruit trees farms
		tenant			
		Classic crop	**Particular crop**	**Forage farmer**	
Identifier		III.2	III.2 alternative	III.3	III.4
Renting cost ($/du) land and well		65	65	65	0
Water use (mm/day/du)		16	16	4	6
Water use (M3/farm/year)		70 000	70 000	45 000	215 000
Land tenure		RENT	RENT	RENT	OWNER
Technique	Irrigation technique	SURFACE	SURFACE	SURFACE	DRIP
	Cropping technique				
Range of surface		10 to 25	10 to 25	40 to 50	100 to 200
Yield (T/ha)				80 to 100	30 to 40
Gross Output in bad year		1080	940	280	1695
Gross Output in good year		1375	1165	350	2215
Mean Gross Output		**1227**	**1052**	**315**	**1955**
Net Margin in bad year		250	365	150	1235
Net Margin in bad year		490	545	220	1695
Mean net Margin		**370**	**405**	**185**	**1465**
Water costs in bad year		185	185	0	0
Water costs in good year		185	185	0	0
Production costs in bad year		830	505	130	460
Production costs in good year		885	620	130	520
Mean production costs		**857**	**562**	**130**	**490**
Permanent Wages Cost (mean)		0	0	45	75
Daily Wages Costs (mean)		70	120	65	30
Total Wages Costs		**70**	**120**	**110**	**105**
Total costs		**927**	**682**	**240**	**595**
Net Profit in bad year		195	280	45	1135
Net Profit in bad year		405	405	105	1585
Mean Net Profit		**300**	**342**	**75**	**1360**
Return on Capital for investor's farms (Net profit – owner's salary)					**1320**
Net Profit/Total costs (%)		**32**	**48**	**30**	**227**
Initial investment		**15 000**	**15 000**	**15 000**	**125 000**

HIGHLANDS: UPLANDS AREA

FARM SYSTEM	VEGETABLES FARMS			Mixed farms
	Greenhouses		Open field	
	Owner	Tenant		
Identifier	IV.1alternative	IV.1	III.1 and III.2	IV.2
Renting cost ($/du)	0	30	Cf. above in	30
Water use (mm/day/du)	3	3	Zarqa Area	??

Water use (M3/farm/year)		40 000	12 000		??
Land tenure		OWNER	RENT		Rent/ ownership
Technique	Irrigation technique	drip	drip		SURFACE
	Cropping technique	50% G	100% G[73]		Very extensive
Range of surface		30 to 50	10 to 15		+/- 200
Yield					
Gross Output in bad year		1605	1855		630
Gross Output in good year		1985	2225		865
Mean Gross Output		**1795**	**2040**		**747**
Net Margin in bad year		630	280		350
Net Margin in bad year		885	500		540
Mean net Margin		**757**	**390**		**395**
Water costs in bad year		0	200		0
Water costs in good year		0	200		0
Production costs in bad year		980	1580		285
Production costs in good year		1105	1730		330
Mean production costs		**1042**	**1655**		**308**
Permanent Wages Cost (mean)		90	0		45
Daily Wages Costs (mean)		40	135		25
Total Wages Costs		**130**	**135**		**70**
Total costs		**1172**	**1790**		**378**
Net Profit in bad year		510	160		285
Net Profit in bad year		750	350		465
Mean Net Profit		**630**	**255**		**375**
Return on Capital for investor's farms (Net profit – owner's salary)		**330**			
Net Profit/Total costs (%)		**92**	**14**		**100**
Initial investment		**80 000**	**750**		**25 000**

HIGHLANDS: PERIURBAN AREA

FARM SYSTEM		VEGETABLES FARMS		
		Sharecropping arrangement		Greenhouses
		sharecropper	owner	
Identifier		VII.2	VII.2	VII.1
Renting cost ($/du)		0	0	50
Water use (mm/day/du)		2	2	2
Water use (M3/farm/year)		12 500	75 000	20 000
Land tenure		owner	owner	owner
Technique	Irrigation technique	DRIP	DRIP	DRIP
	Cropping technique			25% G[74]
Range of surface		20 to 30	100 to 200	20 to 60
Yield				
Gross Output in bad year		520	520	1400
Gross Output in good year		645	645	1790
Mean Gross Output		**582**	**582**	**1595**
Net Margin in bad year		145	390	160
Net Margin in bad year		215	510	450
Mean net Margin		**180**	**450**	**305**
Water costs in bad year		0	0	270
Water costs in good year		0	0	270
Production costs in bad year		375	130	1240
Production costs in good year		430	130	1340
Mean production costs		**402**	**130**	**1290**
Permanent Wages Cost (mean)		0	0	100
Daily Wages Costs (mean)		95	0	50
Total Wages Costs		**95**	**130**	**150**
Total costs		**497**		**1440**
Net Profit in bad year		60	390	15
Net Profit in bad year		110	510	300
Mean Net Profit		**85**	**450**	**157**
Return on Capital for investor's farms (Net profit – owner's salary)			**410**	
Net Profit/Total costs (%)		**16**	**350**	**10**
Initial investment		**5000**	**280 000**	**40 000**

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.