# 5 Current Water Management in The Lower Jordan River Basin, A Technical And Social Perspective

## *5.1 Irrigated Agriculture: Agro-Ecological Zoning and Farming Systems*

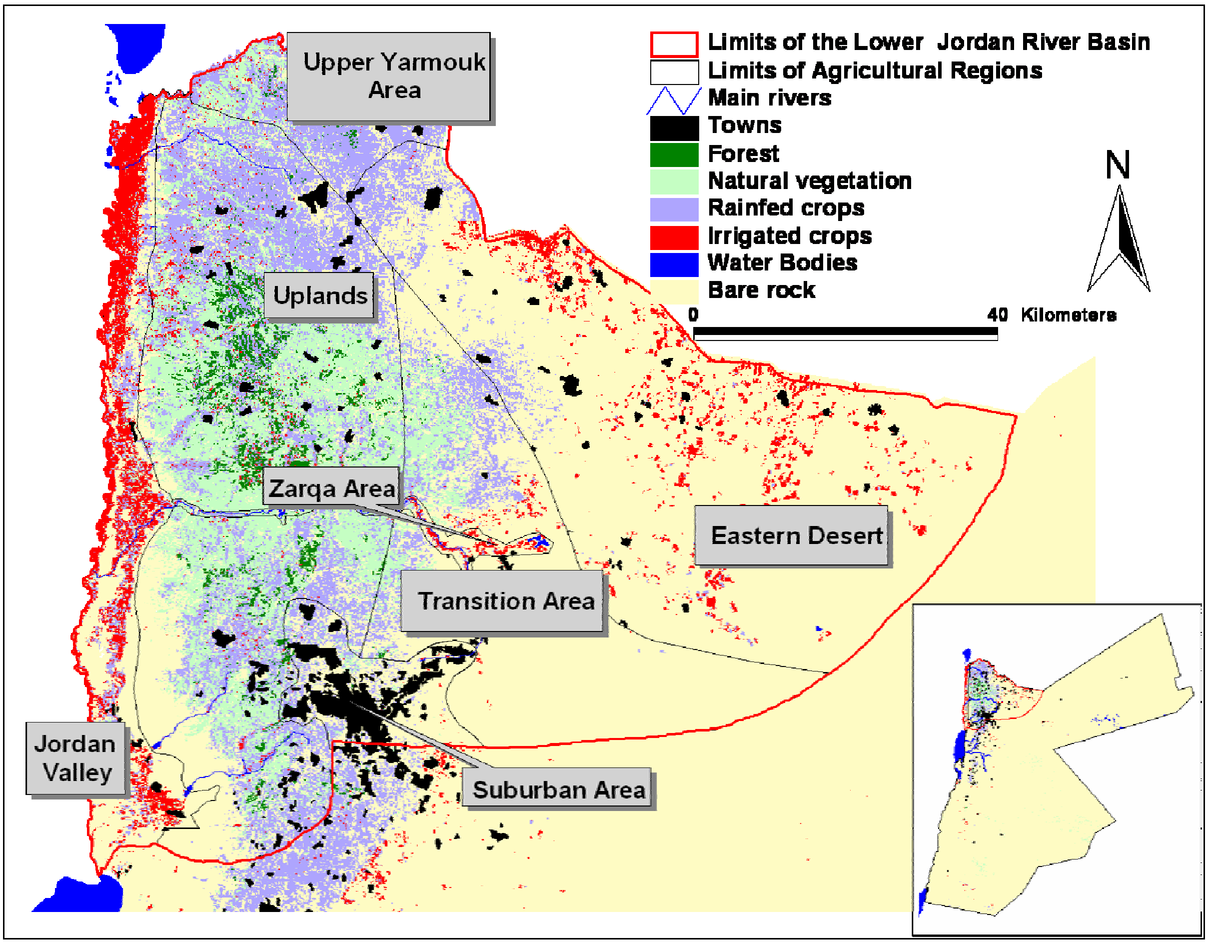
### 5.1.1 Land-use Mapping and Methodology

In 2004, the MWI and the GTZ carried out a land-use mapping based on two mosaics of LandSat images, dated August 1999 and May 2000, respectively (THKJ et al., 2004). Land-use was segregated in ten different classes: bare land; forest; water; natural vegetation; irrigated annual crops (vegetables and cereals); irrigated deciduous trees (mainly stone-fruit trees); non-deciduous irrigated trees (olives, bananas, citrus trees); rainfed annual crops; rainfed deciduous trees and non-deciduous rainfed trees (Figure 5-1). These data were compared with other sets of data presently available (Taha and Nasser, 2001; directorate-wise evaluation of the Ministry of Agriculture and the Department of Statistics -www.dos.gov.jo-; ARD and USAID, 2001a) and used to calculate best estimates of irrigated areas within the Lower Jordan River Basin (see Appendix).

In the same time, farming systems were analyzed in order to identify the different types of farms found in the valley and in the highlands (Appendix 8 lists the main characteristics of each type of cultivation found in the Lower Jordan River Basin and Appendix 9 summarizes the different strategies adopted by the different kinds of farmers depending on the region considered). Understanding the socioeconomic processes occurring at this micro-scale will allow us to depict the different realities of irrigated agriculture in the Lower Jordan River Basin and to better foresee the adjustments and the strategies developed by farmers in a changing context. By complementing this micro-level analysis with regional data (statistic data, satellite image analysis, etc.) we can assess the possible evolution of regional irrigated agriculture as a whole and the related changes in the current social dynamics. This will be presented in chapter 6 according to different scenarios.

In order to sketch out farming systems that combine typical cropping patterns with socioeconomic characterization (profile of the farmer, land tenure, labor use, costs, etc.), 80 farm surveys were carried out during the spring of 2003 (30 in the Highlands and 50 in the Jordan Valley). Farming systems were then modeled in economic terms based on crop budgets whose consistency with other studies Hunaiti (2001; Salman (2001a); ARD and USAID (2001c) was checked. Figure 5-1 maps out the different agricultural regions of the LJRB on the basis of the climatic conditions; the vegetation; the source of irrigation water (surface or groundwater) and the farming systems.

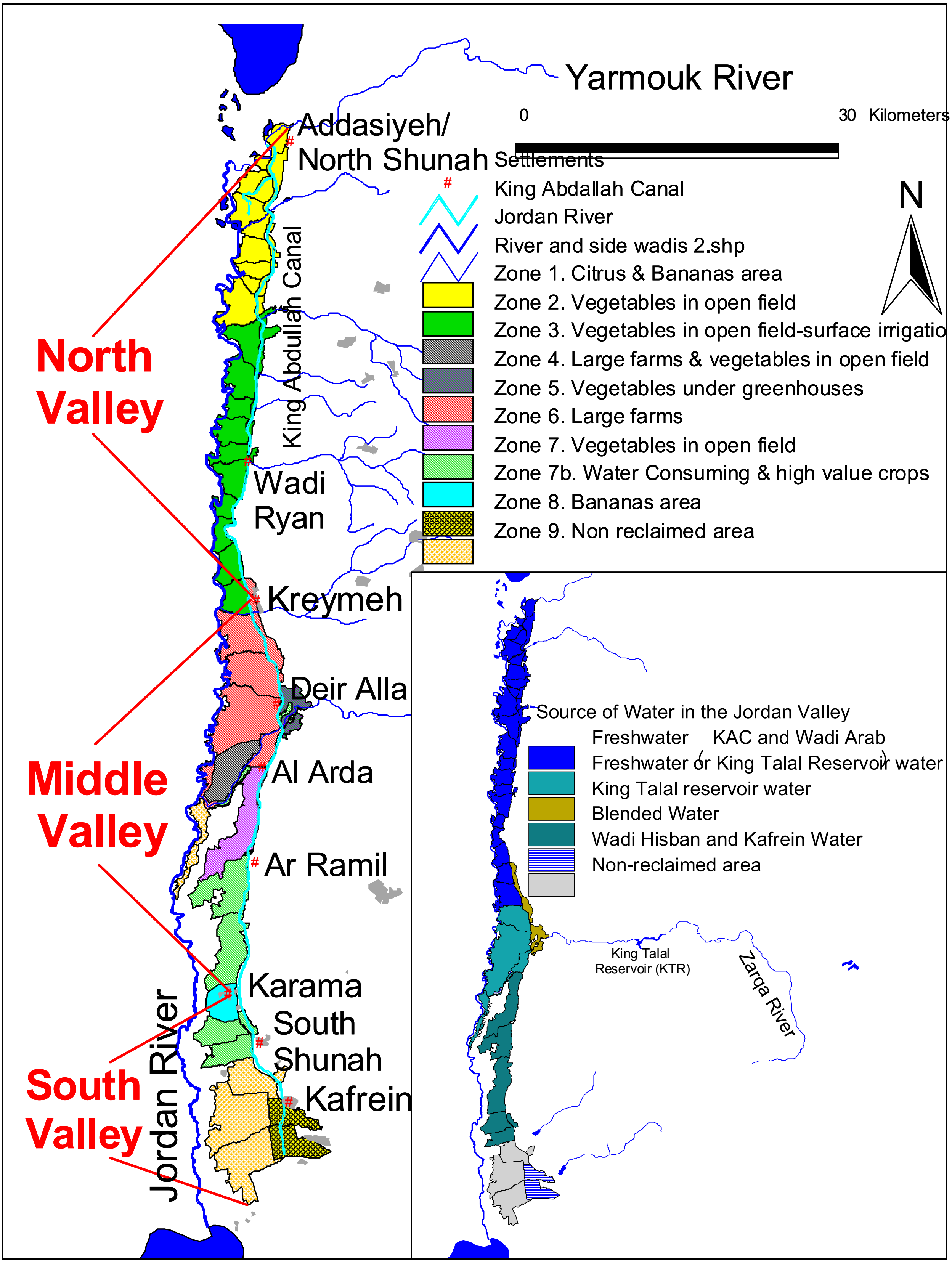
*Figure 5-1. Agricultural Zoning of the Lower Jordan River Basin in Jordan*




### 5.1.2 The Jordan Valley

From north to south, chapter 2 identified three agro-ecological regions in the Jordan Valley. Those sub-regions partially tally with the JVA main administrative divisions (directorates; chapter 5.2) and differ one from another by their cropping pattern (). In the north, citrus is the major crop (57% of the cropped area); vegetables and cereals represent 17 and 14% of the total irrigated area, respectively. In the middle of the valley, vegetables are widespread (56% of the total area); citrus still represent 16% of the irrigated area; banana, cereals and olive trees are negligible. In the south of the Jordan Valley, banana and vegetable account for 33.5 and 37% of the cropped area. Figure 5-2 maps in further details the farming systems of the Jordan Valley and identifies ten zones whose boundaries do not tally with JVA administrative limits. Figure 5-2 also presents the source of water for each region of the Jordan Valley and Box 5-1 briefly analyse the possible relationships between farming systems and water quality.

*Figure 5-2: Agricultural Zoning in the Jordan Valley*




Surveys in the Jordan Valley identified five main categories of farming systems: 1) family farmers who either own or rent the land and grow vegetables in open field or under greenhouses if they have enough investments capacities; 2) entrepreneurial farmers who can invest in vegetables in open field but more commonly adopt capital- and labor-intensive techniques like greenhouses with a high return on investments; 3) citrus orchards cultivated in the north of the Jordan Valley and managed either by the family who owns the land or by absentee investors interested in the social rather than the economical value of their farm; 4) profitable bananas cultivated in the extreme south and the extreme north of the valley by family farmers or entrepreneurs; and finally, 5) some poor farmers with more extensive vegetable cultivation, associated with small orchards. The profitability of similar farming systems varies significantly with the location of the farm, notably due to the quality of water supplied (Table 5-1 and Box 5-1)

*Table 5-1. Profile of main Farming Systems in the Jordan Valley.*

| Farming systems | **Vegetables farms** | | | | |
|---|---|---|---|---|---|
| | **Family farms** | | | **Entrepreneur's farms** | |
| | Open field vegetables | | Vegetables under greenhouses | Vegetables in open field | Vegetables under greenhouses |
| Location# | Zone 2 | Zone 7 | Zone 5 | Zone 2 | Zone 5 |
| Type of water | Freshwater | Blended water | Freshwater | Freshwater | |
| Land tenure | Rent/Ownership | | Rent/ownership | Rent | Rent/Ownership |
| Farm area range (ha) | 3-6 | | 2-20 | 3-6 | 6-10 |
| Number of family workers | 2-5 | | 2-5 | 1-2 | 1-2 |
| Net benefit (US$/ha/yr) | 4,300 | 3,100 | 4,250 | 3,800 | 7,500 |
| Net benefit (US$/farm/yr) | 19,350 | 13,950 | 46,750 | 17,100 | 60,000 |

| Farming systems | **Citrus farms** | | | **Banana farms** | | | **Poor farmers** |
|---|---|---|---|---|---|---|---|
| | Family farms | | Absentee owners' farms | Family farms | Entrepreneurial farms | | Mixed farms |
| | 'Intensive management' micro-irrigation | 'Extensive management' surface irrigation | | | | | |
| Location# | Zone 1 | | | Zones 1 and 8 | Zone 1 | Zone 8 | Zones 1; 3; 7 and 8 |
| Type of water | Freshwater | | | Freshwater | | Freshwater or desalinized water | Fresh or blended water |
| Land tenure | Ownership | | | Ownership | Ownership | Ownership | Rent/Sharecropping |
| Farm area range (ha) | 3-6 | | 1-20 | 1-5 | 1-5 | 20 to 40 | 1-3 |
| Number of family workers | 3-5 | | 1 | 3-5 | 1-2 | 3-5 | 4-10 |
| Net benefit (US$/ha/yr) | 1,400 | 1,100 | 400 | 17,650 | 9,750 | 10,600* | 1,200 |
| Net benefit (US$/farm/yr) | 6,400 | 4,950 | 4,000 | 52,950 | 29,250 | 318,000 | 2,400 |

# Location corresponds to the zones indicated in Figure 5-2.

* Indicates the return on investment (Net revenue per hectare is evaluated at $26,250/ha/yr)

*Box 5-1. Source of Water; Water Quality and Farming Systems in the Jordan Valley (chapter 5.2)*

Figure 5-2 maps the source of water in the Jordan Valley. In the north of Deir Alla (Development Areas -DA- 1 to 21 and 33 to 39), farms are irrigated with freshwater from the Yarmouk and other northern side wadis through the King Abdallah Canal (KAC). In the middle of the valley, some areas east of the KAC (DA 29 and 53; 1,650 ha) known as the Zarqa triangle are supplied with blended water directly coming from the King Talal Reservoir (KTR) through the Zarqa Carrier 1. Still in the middle of the valley, west of the KAC (DA 22 to 24 and 30), some areas are supplied with freshwater from the KAC; others with blended water directly from the KTR through the Zarqa Carrier 2. South of Deir Alla and up to Karamah (DA 25 to 28 and 49); farms are supplied with blended water pumped in the KAC (water from the KTR joins the KAC through the Abu-Zighan open channel in Deir Alla). South of Karamah, farms receive water from southern side wadis (see below). Finally DA 50 to 52 are un-reclaimed.

The generalization of the use of blended water in the south of the Jordan Valley in the late 1980s/early 1990s had several consequences on agriculture. Some farmers of the Zarqa Triangle notably moved northwards: land renting costs have increased in regions where freshwater is still used for irrigation. The fear of new conditions and the lack of knowledge on the impacts of treated wastewater use on the profitability of the sector partly explain this behaviour that has also been motivated by other technical reasons: 1) water from the KTR is increasingly saline as volumes of effluents increase (chapters 4.12; 4.14 and 5.14): this reduces farmers' possibilities in terms of crop choices (cucumbers, highly tolerant to salts, have for example progressively replaced tomatoes in the south of the Jordan Valley and high return crops like beans and strawberries are too sensitive to stand saline water) and requires that large volumes of water are used to leach the soils (while water is increasingly scarce); 2) treated wastewater has a high content in organic and mineral solids: this increases the risks of filters and emitters clogging; triggers more frequent cleaning of farm ponds and irrigation networks (especially if the water is directly supplied from the Zarqa carriers and do not sediment in the KAC); requires the water to stay longer in the pond for further sedimentation and makes irrigation less adapted to crop needs.

Some production (high value vegetables, citrus, bananas) cannot stand treated wastewater but; in most of the cases, surveys in the Jordan Valley illustrated that the quality of water is marginal (compared to other crucial factors like the investment capacity and the type of management) in explaining the differences among farming systems of vegetables in open field or under greenhouses. This might be due to the facts that 1) most vegetable farmers have adopted drip irrigation techniques that are well adapted to treated wastewater use (it limits the risks of contamination for both the product and the farmer; form a water bulb around the root-zone and concentrates salts outside the bulb [Massena, 2001]); 2) farmers supplied with TWW benefit from larger water supplies than farmers receiving freshwater (post-1999 water allocations have not been reduced)[55] and from higher mineral content fertilizing the crops. Chapter 6 discusses the scenario of increasing freshwater transfers from the Jordan Valley to Amman and the impacts of a subsequent shift from freshwater to treated wastewater irrigation in the north of the Jordan Valley.

#### 5.1.2.1 Vegetable Farming Systems

Vegetable farming systems are the most common farming systems in the Jordan Valley, they are very diverse and, in general, very intensive on small areas (3.5 ha in average since the land reform of 1962). More than 20 vegetable species are grown in the Jordan Valley (tomatoes, potatoes, eggplants, zucchini, cabbage, cauliflower, onions, lettuce, *melokhia,* a local spinach, green beans are the most common). The diversity of crops is higher in the north of Dair Alla where the climate is wetter and rainier; where soils are better and deeper and where good quality water is relatively abundant (chapter 2).

There are two main cropping seasons (October-January and February-May) and the harvest period lasts over eight months (November-June) depending on the crops and the sub-region considered. Vegetables are generally packaged in polystyrene boxes (more rarely in cardboard if the production is exported) and most of the production is sold on the central markets of Amman and Irbid where prices fluctuate significantly on a daily, seasonal and annual basis (chapter 4.1). During the production peak, importers from Turkey also buy some products (notably tomatoes) at the farm gate and transport them by trucks. Farmers generally diversify their production to smoothen the effects of prices fluctuation on the profitability of their farms. Cropping patterns are more varied in family farms where farmers aim

[55] Impacts of an increasing supply of treated waste water on soil salinity and soil leaching requirements are not well known.

at mitigating the risks they incur than in entrepreneurial farms where the entrepreneur aims at maximising his revenue.

Most farmers use drip irrigation systems and plastic mulch. They also have a farm pond with pump and filters (often of poor quality) to settle, clean and re-pressurize the water that comes from the collective network and meet the daily water requirements of their crops (chapter 5.2). With such system, a permanent worker can supervise up to 3 hectares with the help of daily labourers (often women; chapter 4.3) during peak periods (seedling, harvest, packaging, etc.). In open fields, farmers commonly use mini-tunnels to protect vegetables from the cold and from insects. They then fetch higher prices despite increasing labour costs (the plastic must be temporarily taken off for chemical treatments): mini tunnels significantly increase net revenue in family farms, notably during years when market prices are low (not shown).

*Family Farming Systems: Vegetables in Open Fields*

These systems are largely spread all over the valley (principally Zones 2 and 7 and less in Zones 1 and 5; Figure 5-2). Land can be owned or rented. Landowners are mostly Jordanian with their origin in the valley itself: they are *Ghawarneh* (from the Ghor) who benefited from the land reform of 1962 and did not invest in costlier and more intensive production techniques. Farmers originating from the West bank (Al-Zenaiti and Al-Turkmani tribes notably) and who have moved to the East bank of the Jordan Valley in 1948 also own some land, notably around Wadi Ryan (Nims, 2001; chapter 3). Tenants can be either Jordanian from the neighboring mountains, Palestinian, or even Pakistani[56] and are more common in the south (Zone 7) than in the north (Zone 2).

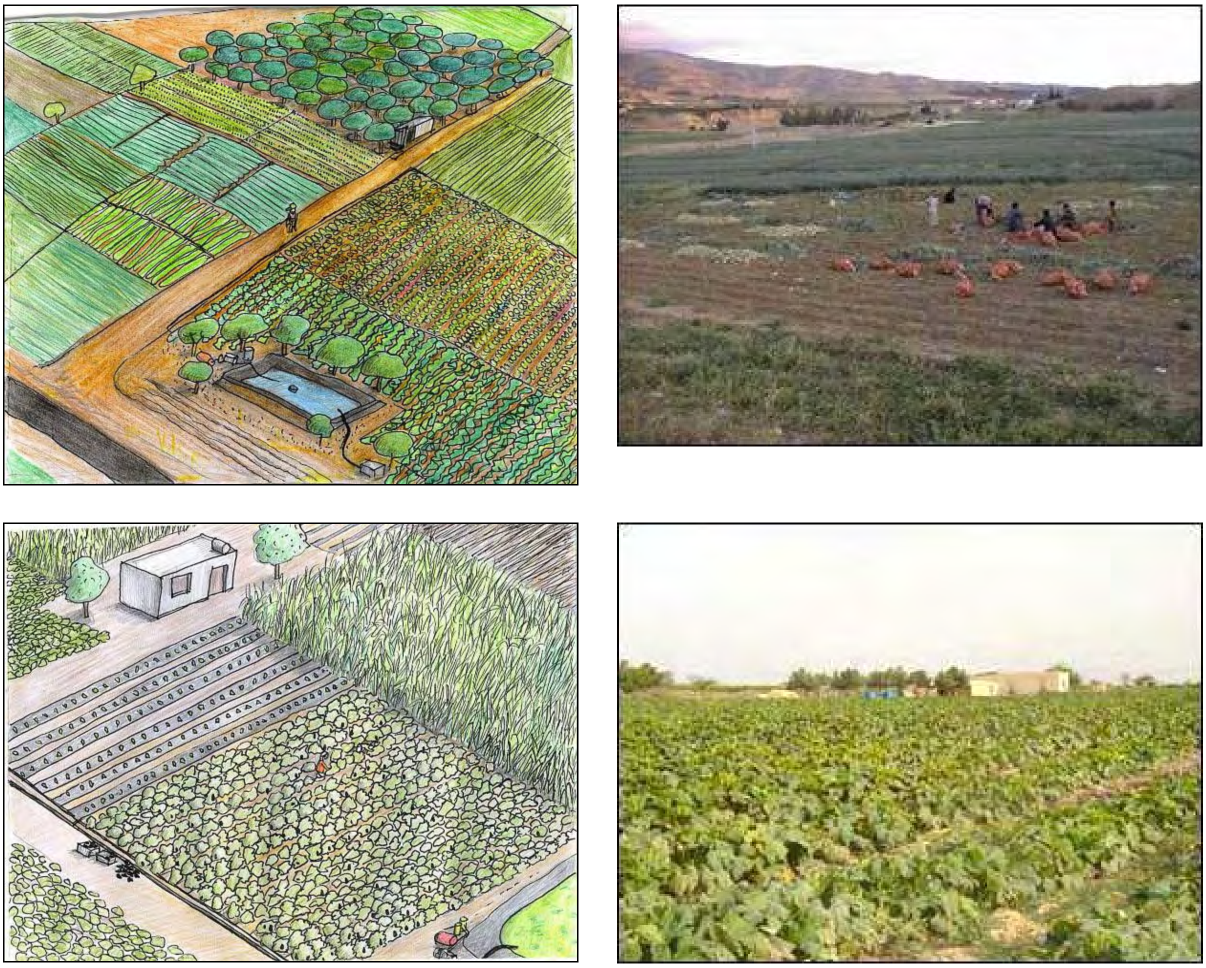
Field work is entirely done by the family with the help of daily workers if necessary (in rare cases, some permanent workers can be found in the largest farms). Farms have an area of 3 to 6 hectares (sometimes up to 12 ha if the land is leased). Crops grown are very diverse and there are two main cropping seasons (first seedlings are done in October/November: *Tashrini crops* of squash, onion, pepper, cabbage, cauliflower and eggplant, etc.; the second crop is planted in January/February: *Khamsini crops* as tomato, squash, potato, pepper, etc.).[57]

[56] Most Pakistanis are located between the villages of Al-Ramil and Karamah and kinship relationships are strong among this community. Some of them arrived in Jordan during the 1970s and work now, with their families, on farms larger than average (6 to 12 ha); others during the 1990s and have smaller farms.

[57] Potatoes are mostly found in the north of the valley while pepper and eggplant are more common in the south (the latter stand higher temperatures and have long harvest periods). Vegetables can be harvested until June in the north of the valley while only maize can stand the heat of the months of May and June in the south of the valley.

Near the village of Karamah (Zone 7b), some farmers have long cultivated mint, parsley and other high added value herbs by pumping water from a communal well. Farms are small (below 3 ha) but yield an average $4,000/ha/yr and a good revenue per capita (about $5,000/ca/yr)

*Figure 5-3. Family farms: vegetables in open fields in the north (top) and the south of the Jordan Valley (bottom) (Source. R. Courcier, 2004)* [58]



On-farm investments remain limited; most farmers rent the land preparation equipment and some of them (notably in the south of the Jordan Valley) own trucks to transport their products. Yields are similar in the north and the south of the valley but better quality products in the north fetch higher prices. The net income averages $3,100/ha/yr in the south and $4,300/ha/yr in the north and does not depend on land tenure (there is no significant differences between owned and rented farms; Table 5-1). Inter-annual fluctuations are high and most open field vegetables farmers are in precarious conditions with a high level of indebtedness (Box 5-4). In the south, farmers hardly enjoy revenues of $2,200 per capita and per year (e.g. the salary of a permanent worker paid on a monthly basis): the household lives below the poverty line. The situation is slightly better in the north of the valley but farmers still depend on other sources of revenue (notably public pensions in a country where public institutions employ between a third and a half of the working population; chapter 2) and often have secondary activities (shop keepers, bus drivers, etc.). Irrigated agriculture is embedded in a multi-economy, part-time farming is still common and has to be understood in the wider choices of the kinship network that are all the more important since farming systems have a low profitability (chapter 4.3).

[58] The farm ponds in the two drawings allow re-pressurizing water for the on-farm drip-irrigation system. Water quality is lower in the south (algae in the pond) than in the north (chapter 5.2).

*Entrepreneurial Farms: Vegetables under Greenhouses*

Between Wadi Ryan and Al-Arda (Figure 5-2); a few small entrepreneurs who cannot invest in greenhouses cultivate vegetables in open fields. They generally rent 3 to 6 ha and act as farm managers while the field work is done by permanent workers (mostly Egyptians) and daily laborers during the peak periods. The benefit per hectare ($3,800/ha/yr) from these entrepreneurial farms is slightly lower than in family systems in the north of the Jordan Valley but is not shared among several family workers. The revenue per capita is high ($10,000/yr) and the household often has other sources of revenues.

But, most entrepreneurs take up vegetable cultivation under greenhouses and white plastic[59] dominates the landscape of the middle of the Jordan Valley (Zone 5; Figure 5-4). Between Kreimeh and Deir Alla, greenhouses cover 70% of the total irrigated area (20% are vegetables in open field; 10% citrus orchards). In the south of Deir Alla (up to Al-Arda), the proportion of greenhouses fall down to 50% while the share of vegetables in open field increases to 40% (citrus areas still representing 10% of all irrigated area in the region).

Historically, greenhouses appeared in the vicinity of Deir Alla and progressively spread both southwards and northwards. This can be explained by: 1) favourable climatic conditions; 2) good quality soils (chapter 2); 3) the presence of agricultural research stations where many experts and many farm investors have worked; 4) the proximity of Amman (1 hour drive) allowing entrepreneurs to easily supervise the work and market the production; 5) and a long agricultural history.[60] Cultivating vegetables under greenhouses with treated wastewater is possible but yield lower aggregate benefits than with freshwater: along with lower soil quality, hotter climate and shorter history of irrigation, water quality explains why there are more greenhouses in the north than in the south of the Jordan Valley. North of Kreimeh and south of Al-Arda, greenhouses are very rare (open field vegetables dominate the landscape): the climate is too wet (and too windy) or too hot, respectively, for greenhouses to induce significant gains in production through humidity and temperature control. Farmers are reluctant to invest in costly techniques as they would not fully enjoy their benefits.[61]

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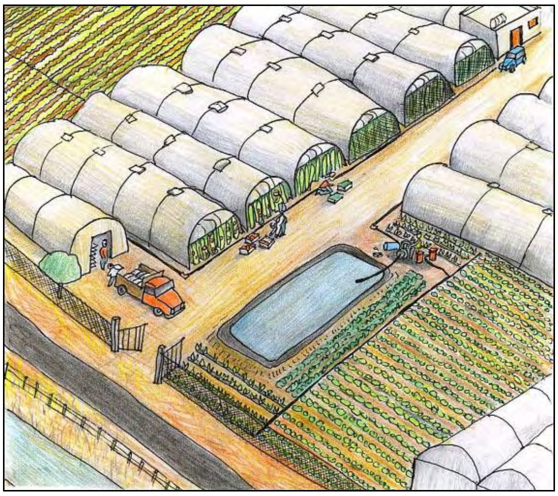
[59] Nurseries producing vegetable plants and more rarely bananas and citrus trees use black nets and can be found all along the valley.

[60] Traces of some of the earliest settlements in the Jordan Valley can be found in the vicinity of Deir Alla (chapter 3): the Ghor is larger there; water is available (springs; wadis) and conditions are propitious for both livestock farming and agriculture. Moreover, Deir Alla was located at the tail end of the KAC until 1978 (chapter 3 and V.2) and the JVA might have pushed farmers to use extra water there as there were no plans to use it further downstream. This is currently observed in Karamah where JVA perimeters end up now: JVA sells water in surplus of the normal allocations to farmers to increase revenues from water charges (this illustrates the engineer-based vision that freely flowing water is 'lost' and the disregard that most water managers in Jordan have for environmental water requirements –chapter 4.4 and V.6). Extra water availability in Deir Alla may only have acted as a positive incentive to cultivation under greenhouses.

[61] However, some farmers north of Kreimeh attempt to intensify their production and adopt greenhouses to shade high return crops like strawberries, melons or beans. In the south of Al-Arda, a few rich entrepreneurs own large farms (10 to 20 ha) and often a well to complement JVA allocations. They cultivate high value vegetables under greenhouses on one third of their farm for export markets (high quality pepper, potatoes, etc.). The owner is closely involved in farm management, marketing and commercialization and all the daily work is done by permanent employees. These systems yield $4,000/ha/yr (this is lower than in the north of the valley) but ensure total revenue of about $60,000/yr to the entrepreneur.

*Figure 5-4. Greenhouse farms in the middle of the Jordan Valley (Source. R. Courcier, 2004)*



The village on the foreground is Deir Alla

Greenhouse production requires higher initial investments and closer management than open-field production (a plastic house typically covers 650 m² (500 m² of effective cropped area), and costs about $2,100)[62] but allows producing vegetables in winter (when prices are at their highest). Farmers usually have greenhouses only on part of their farm, according to their investment capacity. The main crops are tomato, cucumber, melokhia (local spinach), melon, hot and sweet pepper, eggplant (export production like bean and strawberry also exist). Intensive management techniques (large quantities of chemicals, pesticides and fertilizers; yearly soil sterilization to avoid contamination by viruses, bacteria, fungus, nematodes and insure an average productivity; crops growth along vertical wire-stakes) ensure yields about four times higher than in open field. However, yields progressively decrease after 5 years of cultivation under greenhouses (this might be due to increasing soil salinity and a lower efficiency of the soil sterilization) and farmers have to periodically shift to plots where they previously cultivated vegetables in open fields, incurring extra operating costs. This is made possible because many farmers rent the land they crop: the large extent of land leasing and the mobility that characterizes the Jordan Valley agriculture have many social but also technical consequences (soil quality degradation; water thefts, difficulties to implement water and producer associations, etc. chapter 5.2 and VI). As the number of greenhouses increases and the average farm area decreases, alternating cultivation in open fields and under greenhouses will become increasingly difficult.

Most greenhouses are developed by medium entrepreneurs, referring to themselves as *Muzare'* (chapter 4.3), with farms of 6 to 10 hectares (more rarely up to 20 ha). All the work is done by permanent employees, mostly Egyptian.[63] The smaller entrepreneurs are closely involved in the management of their farm. Larger and richer entrepreneurs appoint a manager with knowledge in agricultural engineering and often produce high value crops for export. Entrepreneurs can either own or rent the land they crop and generally own trucks for transporting the production and the land preparation material. About 80% of their farm is covered by plastic houses (the remaining 20% are

[62] Few farmers use raised up greenhouses which can shade bananas and grapes (they cover 0.3 to 0.5 ha and allow a better control of temperature, humidity, wind and pests). Others have small tunnels shading three to four rows of vegetables.

[63] Each permanent worker can take care of about 10 greenhouses.

vegetables in open field yielding $3,800/ha/yr; see above). Initial investments and operational costs are high ($20,000/ha and $25,500/ha/yr, respectively) but greenhouses yield high net return $7,500/ha/yr and the revenue per capita is very high ($60,000/yr)

Greenhouses can be found in family systems too. Farms are smaller (2 to 20 ha of which 50% in open field); investments and operational costs slightly lower and half the work is done by the family who rent all the land preparation material and the trucks to transport the production. Family systems are slightly less profitable than entrepreneurial systems ($4,250/ha) but still allow a net benefit per family worker well above the poverty line (average of about US$15,000/yr).

*Box 5-2. Large landowners in the Jordan Valley*

Large farms owned by institutions (Ministry of Agriculture; University of Jordan) and large private landowners can be found between the villages of Al-Arda and Ar-Ramil (Zone 6). Citrus and palm trees (even prickly pears) dominates the landscape where few vegetables in open field and under greenhouses can also be found. Some large Jordanian families managed to secure their land during the 1962-land reform and can own up to 200 to 300 hectares, divided in several units of 2 to 20 hectares. Some plots are directly managed by the family; others leased out or sharecropped. Typically, a lessee chooses to cultivate vegetables in open field or under greenhouses according to his investment capacities. Sharecroppers are generally low income Jordanian, Palestinian or Pakistani cultivating vegetables in open fields.

5.1.2.2 Citrus Farming Systems

Citrus orchards are mainly concentrated in the extreme north of the valley (Zone 1 and to a lesser extent zone 2 and 5 in Figure 5-2) where irrigation has a long history. Since the beginning of the century, large Jordanian tribes (notably Ghazawi and Al-Waked tribes) irrigated their land thanks to water coming from the Yarmouk or through local springs to irrigate bananas and vegetables. They also cropped rainfed cereals for livestock.

*Figure 5-5. Citrus in the extreme north of the Jordan Valley (R. Courcier, 2002)*

The construction of the KAC (1958-1968) and the land reform of 1962 induced major changes in land tenure and cropping methods.

Citrus (lemon, orange, mandarin, clementine, etc.) progressively replaced vegetables (and bananas to a lesser extent, on clay soils) and became the dominant crops in the region from the early 1970s onwards (in the 1980s, citrus slightly spread in Zone 2, but hotter climate and shallower soils limited this expansion). Expansion of citrus orchards on good quality soils took place when good quality freshwater was plentiful. It was slowed down in the early 1990s after JVA froze the existing quota system according to the cropping pattern at that time (THKJ and JVA, 1988a): citrus orchards planted after 1991 would only receive the vegetable allocation of 20 $m^3$/ha/day. In 2004, however, in contradiction to its policy to reduce demand, the JVA legalized citrus orchards planted between 1991 and 2001, granting them the citrus allocation instead of the vegetable allocation they were receiving earlier.

Like in vegetable farms, citrus farmers diversify their cropping pattern to mitigate the risks of a market prices fluctuation that has dramatic effect on farms profitability. Most farmers are owners of their plots (Ducros and Vallin, 2001). Farmers rent all the equipment needed for land preparation and transport. Generally, there are 300 trees per hectare surrounded by date palm or olive trees protecting the orchard from the wind. Trees are mature after 5 to 10 years; can produce until 25 and, except for harvest (September to February), need low management (pruning in February/March; 2 to 3 weeding between April and October). Like vegetables, fruits are packaged in polystyrene boxes and mainly sold on the central markets of Amman and Irbid. Two main kinds of farms, differing by their type of management, can be identified:

- *Family farms with an area of 3 to 6 hectares.* Management by retired civil servants, shop keepers, old farmers or widows is generally extensive (surface irrigation, low use of inputs) but can be more intensive (drip or open tube irrigation, use of fertilizers, chemical treatment are generally neglected by farmers due to their high price) if the family is closely involved in the agriculture sector. Most of the work is done by the family and there is often one permanent employee in the second system. The net income averages US$1,100 and US1,400/ha/yr in extensive and intensive family farms respectively (Table 5-1).

- *Prestige farms developed by absentee owners.* Farms cover an area of 1 to 20 hectares and can be divided into several noncontiguous plots. On-farm investments are minimal, all the work being done by a few permanent employees. There is often a villa (and sometimes a swimming-pool) in the farm. For these urbanites, the recreational, social and prestige value of the orchard is more important than its low economic value: the net income averages US$400/ha/yr.

*Figure 5-6. Citrus farm in the north of the Jordan Valley (R. Courcier, 2004)*

Generally speaking, profitability of citrus orchards is now very low (some family farmers begin to plant other types of trees such as guava, mango, papaya or date: it requires high investment but such production can fetch much higher prices than citrus); the more extensive the management the lower the expected revenue. Citrus farming systems have been highly affected by the changing conditions faced by Jordanian agriculture (notably price decrease and overproduction; chapter 4.1) but they had been far more profitable during the 1980s and early 1990s (GTZ, 1995).

5.1.2.3 Banana Farming Systems

Except for some small areas in the extreme north of the valley and along side wadis (Zone 1; 356 ha); most banana plantations (1, 138 ha) are located between the village of South Shunah and the Dead Sea shore (Zone 8) where the Ghor is 9 to 12 km large (Figure 5-2). Most of the land in this region is owned by the large Al-Adwan Bedouin tribe (*Ashira*) who installed part of its *dirah* (chapter 4.3) in the south of the Jordan Valley during the Ottoman Empire by appropriating large plots of land. In addition to their traditional occupation of livestock farming they now irrigate large plantation of bananas. Banana is the most profitable—and the more water-consuming—crop grown in Jordan. This profitability, however, is partly due to custom tariffs which make imported banana costlier: banana producers are thus subsidized by consumers.

*Figure 5-7. Banana landscape in the south of the Jordan Valley (J.-P. Venot, 2003)*

Irrigated areas are concentrated at the foothills of the mountains and large ranges of land remain un-reclaimed due to shallow salty soils, hot climate and lack of water (Zone 9).

The last section of the KAC (the 14.5 km-irrigation project completed in 1988) begins in the village of Karamah and crosses the region but no secondary pressurized network is yet in place (chapter 5.2): water flows freely to the tail of the KAC in winter and is stopped at Karamah where gates are closed in summer. It is common to see private pipes running along the road from a water source (the KAC, a spring, a wadi) to a farm (Figure 5-8).

*Figure 5-8. 'Off-farm' irrigation network in the south of the Jordan Valley (J.-P. Venot, 2003)*

Most farmers receive water from the three main wadis of the region. In the northern part, waters from the wadi Shueib are stored in a small reservoir and diverted into open concrete channels. Water is used free of charge by farmers and shared on the basis of customary rights dictated by tribal rules of water management (chapter 3 and 4.13).

Since the late 1980s, the attempts of the JVA to set up a public water supply network for which farmers would have to pay (as in the north and middle of the Jordan Valley) face a strong local opposition: the conflict between a traditional system of management and the willingness of the state to expand its centralized approach to resource use and management is building up. This has been recently illustrated by the eruption of violent conflicts in June 2007 when government officials attempted to collect land and water fees and to expel 'illegal encroachers' that were using governmental land and public wells (Al Anbat, 2007; Al-Arab al-Yawm, 2007 and Al-Dustour, 2007).

During winter, farmers can also directly pump water flowing freely in the KAC. The extreme south of the valley is known as the 'Hisban-Kafrein triangle' and is irrigated with water from the Kafrein reservoir and from the uncontrolled Wadi Hisban (water is charged at $0.02/m$^3$ like in the north and middle of the Jordan Valley). Many farmers also tap saline groundwater and mix it to surface freshwater (some large intensive banana farmers have desalinization plants).

*Figure 5-9. Banana Farm in the south of the Jordan Valley (Source. R. Courcier, 2004)*

Two main kinds of farms: family and entrepreneurial farms, differing by their type of management, can be identified. The more intensive the management is, the more profitable the farm is. Generally speaking, farming systems are less intensive (in work and inputs: chemicals are regularly applied all the year long and sheep manure once a year or once every other year) and less water consuming[64] in the north than in the south of the Jordan Valley where farmers are more closely involved in farm management and daily work (cold winter and winds in the north have negative impacts on yields: farmers are less interested in intensifying their production). Most farmers are owner of their plantation. Seedling are preferentially done in March (1,100 trees/ha; the density increases year after year as one to three small shots are kept around the 'mother plant' every year), once the weather is hot enough not too affect the young plantation (some farmers also plant in September). Harvest can begin 9 months after plantation in the most intensive farms and after 12 to 14 months in others and is done all the year long (prices are at the highest between December and March when there is no other fruits on the market). The production is generally sold to wholesale dealers taking care of transportation and maturation (farm gate prices depend on the size of the clusters)

- *Family farms* have an area of 1 to 5 hectares, generally with drippers but sometimes only irrigated by furrow, and are entirely covered with bananas. Half of the work is done by the family, the other half by daily-paid or permanent workers. Banana orchards require high initial investments

[64] In the south of the Jordan Valley, farmers generally supply between 10 and 20 m$^3$/ha/day from side wadis, open channels and private wells (in comparison the JVA allocation never exceeds 7 m$^3$/ha/day in the northern and middle directorates where JVA rules of water allocation apply; THKJ and JVA, 2004; chapter 5.2)

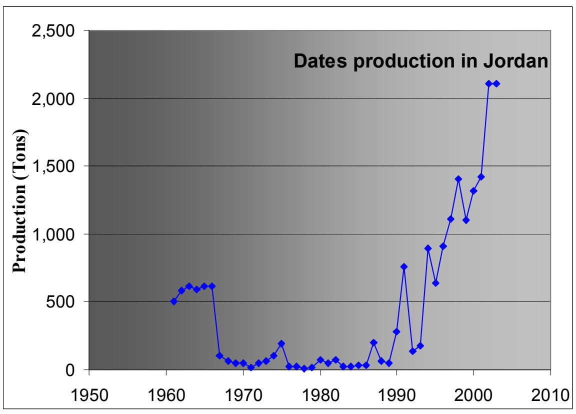
($10,000 to 20,000/ha) but they ensure lofty returns: the net benefit averages US$17,650 ha/yr in family systems.

- *Entrepreneurial banana farms* are slightly different in the north and the south of the Jordan Valley. In the south, farms are large (20 to 40 hectares) and drip irrigated. Only a quarter of the farm is a banana plantation: the remaining is left fallow or sharecropped by vegetables farmers (this is needed to restore the fertility of the soil strongly impacted by a 4 to 6 years banana cropping [see below for a description of sharecropping farming systems in the Jordan Valley]). The family is closely involved in farm management and all the field work is done by permanent and daily employees. In the north, farms are smaller (1 to 5 ha), generally drip irrigated and the owner supervises the plantation by regularly coming in the farm. Entrepreneurial farms yield a net benefit of about US$9,750 and $10,600/ha/yr in the north and the south of the Jordan Valley, respectively.

*Box 5-3. Plantation of Date Palm Trees: a Viable Alternative to Citrus and Banana Farming?*

Since the mid 1990s, date palm tree orchards have dramatically expanded in the middle and the south of the Jordan Valley (mainly in Zone 6) and dates production boomed (Figure 5-10). Date palm trees have several advantages: they are well adapted to sandy soils, are low water consuming (they need less water than citrus); and stand saline water (the potential yield is reached if Ec does not exceed 2.7 dS/m [FAO, 1985]): they can easily be irrigated with treated wastewater, likely to be increasingly used for agriculture in the Jordan Valley (chapter 4.2 and VI). Date palm tree orchards require high investments ($8,500/ha) on large farms (15 to 20 ha): farmers are rich entrepreneurs owning land and investing in a true 'agricultural company'. They are closely involved in marketing and in the commercial aspects of farm management. All the work is done by permanent qualified employees generally supervised by a member of the owner's family. Trees begin to produce after 5 to 6 years, reach maturity at 10 and can produce until 30. With adapted post-harvest work, date palm tree orchards yield very high returns (up to $25,000/ha/yr) and could constitute attractive alternatives for some rich entrepreneurs currently having banana orchards whose future profitability is threatened by decreasing freshwater availability and above all a possible lift of the current custom barriers (chapter 4.1 and VI). Family farmers and small entrepreneurs are unlikely to shift to date production due to their lack of investment capacities and more studies on the production chain of dates are needed to assess the potential of production in Jordan and to see if this would be a viable alternative to the current problems of the Jordanian agriculture sector (notably over production of citrus).

*Figure 5-10. Dates production in Jordan (after Medagri, 2003) and young palm trees in the middle of the Jordan Valley*




#### 5.1.2.4 Poor farmers with Mixed Farms

Impoverished communities persist in the extreme north, the extreme south and the middle of the Jordan Valley (Zone 3) where most of these fragile farming systems are concentrated but poor farmers can be found all along the valley. Farmers can be ancient slaves (*'abid*) of noble Jordanian tribes; Palestinian refugees of 1948 living now in the Jordan Valley; old farmers and widows, etc. Farmers are generally sharecroppers (sometimes tenants) of 1 to 3 hectares (in the north few farmers benefited from the 1962-land reform and own the land they crop). They have kept a small herd (sheep, goats, more rarely a cow) constituting a living capital to be used during bad years. Sharecropping arrangements are more common in the south of the Jordan Valley than in the north (more propitious for agriculture) and allow minimizing risks for farmers who do not have the necessary investments capacities to rent the land and purchase inputs at the beginning of the cropping season.

Classically, the land owner (or the lessee) brings the land and makes the advance for any operational costs (wages, if any, excluded). The work is done by the sharecropper's family (daily workers might be employed for peak periods). At the end of the cropping season, the production is sold (most of the time, to the owner of the land who is an agricultural merchant in the central market and fetches commissions on sales); the owner gets a refund for half the advances made and the remaining is shared on an equal basis among the owner and the sharecropper.

Initial investments and operational costs are low: land preparation, weeding, maintenance of irrigation canals (many poor farmers do not have micro-irrigation systems) are done manually (with spade and hoe) and farmers use little fertilizer (they prefer applying manure from their herd). Farmers diversify their cropping pattern to mitigate risks linked to the market and they choose low labor-intensive crops (e.g., trees and extensive vegetables: tomatoes, eggplant, zucchini, maize, etc.) to be able to face labor peaks with the family workforce and to work outside the farm. Due to more favorable conditions (chapter 2); mixed farms are more common in the north than in the middle and the south of the valley: farmers plant trees, which require less work and less inputs, on areas as large as possible according to water availability. Finally, farmers often have a small plot of cereals to feed their animals (Millet and Moreau-Richard, 2004). The net revenue of these systems reaches only about US$ 1,200/ha/yr (a dairy cow can bring an additional $600/yr) and does not allow a household with no secondary revenue to live above the poverty line. Farmers strongly rely on kinship relationships and on the ties they maintain with their extended family and are highly indebted (Box 5-4; chapter 4.3)

*Box 5-4. Indebtedness in the Lower Jordan River Basin*

During the last 20 years, agents and market commissioners acquired a prominent role in the Jordanian agriculture sector (chapter 4.1 and 4.13). In 1988, the 53 agents in the local market were bound to the thirty largest families of Jordan and 6 to 7 families controlled the market as an oligopolistic network (USAID, 1988). Many farmers are financially dependent on the commission agent and "contractually bound to him, unable to market their produce with any other agent until they pay their debt (USAID, 1988)". As agents and market commissioner finance most marketing costs, farmers also lack information on prices and are highly subjected to price's volatility. In 1988, 77% of agriculture loans were supplied by the private sector, against the image of the state as the only provider of modernity (USAID, 1988), and pushed farmers into a large scale 'debt trap' . The Jordan Valley Farmer Union (JVFU) and above all the Agricultural Credit Corporation (ACC) are two other major institutions lending money to farmers. More than half the loans (both in value and number) contracted to ACC are contracted by farmers located in the Lower Jordan River Basin and the total number of contracted loans represents two thirds of all agricultural holding in the country. Finally, Salman (2001b) reports that almost half the loans are accorded to large farmers managing more than 6 ha and mostly to landowners. Further, two thirds of the loans accorded by ACC are seasonal loans (to purchase inputs, seeds, etc.); 30% short terms loans and 5% long terms loans (ACC, 1999). It is thus difficult for poor farmers to invest in costly techniques (more than 80% of contracted loans amount to less than $7,000) to intensify their production. In 2001, the land-market has been opened in the Jordan Valley for Jordanians only: this could have strong consequences on the Jordan Valley agriculture as many small owners who can not invest in costly techniques could now sell their land to larger and richer entrepreneurs (the absence of any land-market until 2001 is one of the reasons of the persistence of small extensive farming systems.

### 5.1.3 The Highlands

The term Highlands used in what follows refers to the whole Lower Jordan River basin, Jordan Valley excluded. Six sub-regions have been identified: the Eastern Desert, the Upper Yarmouk, the Zarqa River, the Uplands, the Suburban area and a Transition zone between Mediterranean Uplands and Eastern deserts (Figure 5-1). Just like in the valley, farming systems are very diverse but, generally speaking, farming systems in the Highlands are more extensive than in the Jordan Valley: farms are larger (20 to 25 ha); net revenue per hectare (for similar crops and/or farming systems) generally lower and initial investments higher (due to needed investments in a deep well). The same three kinds of farmers: family farmers; entrepreneurs and poor farmers can be found in the Jordan Valley and in the Highlands. Three main types of agriculture in the Jordanian Highlands are described in what follows (the extent of those is summarized in Appendix):

- A thirty years old irrigated agriculture that expanded thanks to groundwater exploitation in the Eastern Deserts of the LJRB and whose sustainability can now be questioned (chapter 4.2; 5.13 and VI)
- A city-induced irrigated agriculture in the Upper Yarmouk, the Suburban and the Transition areas.
- A traditional Mediterranean agriculture in the Uplands, along small side wadis and along the larger Zarqa River.

#### 5.1.3.1 <u>The Eastern Desert: An Agricultural Pioneer Front?</u>

Following a past tradition of the British Mandate, several government projects have aimed, since the 1960s, at settling Bedouins: first, the Water Authority of Jordan (WAJ) dug deep wells and managed open channels networks in the region of Wadi Dulheil. This was the first incentive for irrigation development in the Highlands of a nation in construction and following a *modernization paradigm.* In most cases, large publicly managed projects failed but Bedouins took up the idea and drilled their own wells in an attempt to appropriate land (chapter 3 and 5.13). They kept part of their herd.

Irrigation had its heyday in the late 1970s and early 1980s: the two oil crisis of 1973 and 1979 provided an to agricultural development in the Jordanian deserts with an expanding regional market for fruits and vegetables. Remittances from Jordanians (notably from Palestinian origin) living in the gulf increased and were partially invested in the agriculture sector. The expansion of a modern fruits and vegetables agriculture supplying both the local and regional markets expanded, despite unfavourable desert conditions (low humidity, wind and dust, etc.), and thanks to 1) the identification of groundwater resources; 2) decreasing energy costs; 3) the development of modern irrigation-and-cropping techniques (deep tube wells, drip irrigation, greenhouses); 4) low land and water costs; 5) good quality soils (fertile, easy to reclaim, non infected); 6) the absence of direct consequences of polluting farming practices (farmers frequently change the plots they crop), and 7) limited risks of theft, etc.

*Figure 5-11. Landscapes of the Eastern Deserts of the LJRB*

Agriculture development in the eastern desert witnessed a second boom when farmers left the vicinity of Amman in search for cheap land and cheap water.

Two thirds of all irrigated areas in the Highlands of the LJRB are located in the Eastern desert region (11,990 ha): 50% are olive trees; 33% stone fruit trees and 15% vegetables.

Surveys led to the identification of four main categories of farming systems (Table 5-2).

They include settled Bedouins who have taken up vegetable (and sometimes fruit-tree) cultivation, and urban-based entrepreneurs involved in high-value fruit production and closely managing their farm, although they often reside in Amman. Both Bedouins and entrepreneurs sometimes also maintain olive orchards in parallel. Other absentee owners adopt more extensive agricultural systems (with open-field vegetables or olive trees) and employ a manager. Finally poor sharecroppers have low profitable open field vegetable farms. The main differences between these faming systems are the degree of capital use and intensification, and the direct/indirect type of management.

*Table 5-2. Profile of the Main Farming Systems of the LJRB Highlands*

| | Settled Bedouins | | | Stone-fruit tree entrepreneurs | | Absentee owners | | Poor Farmers |
|---|---|---|---|---|---|---|---|---|
| | Family vegetable farm | Mixed farm-vegetables and olive trees | Family fruit-tree farms | Intensive entrepreneurial farmer | Intensive-absentee owner - stone-fruit trees and olive trees | Prestige olive tree farm | Extensive open-field vegetables | Extensive open-field vegetables |
| Land tenure/water access | Rent | Ownership | Ownership | Ownership | Ownership | Ownership | Ownership/Rent | Sharecropping |
| Farm area range (ha) | 20-25 | '20-25'+'10-15' | 10-20 | 25-35 | 40-80 | 15-35 | 20-25 | 1-5 |
| Net benefit (US$/ha) | 1,100 | 621 | 6,900 | 16,000 | 14,850 | 300 | 600 | 500 |
| Net benefit (US$/farm) | 24,750 | 21,750 | 103,500 | 480,000 | 891,000 | 7,500 | 13,500 | 1,500 |
| Number of wells | 1 | 1 | 1 | 1 | 2 | 1 | 1 | One, on a share basis |

*Settled Bedouins*

These farmers are Bedouins who settled down during the 1970s, 1980s and even 1990s. Following governmental settlement policies, they partly gave up their livestock activity and entered agriculture. Farmers can either be landowners or can rent the land they crop. In all cases, the household participates in farm work. Three main farming systems can be identified (Table 5-2).

- Vegetables in Open Fields: a Family System

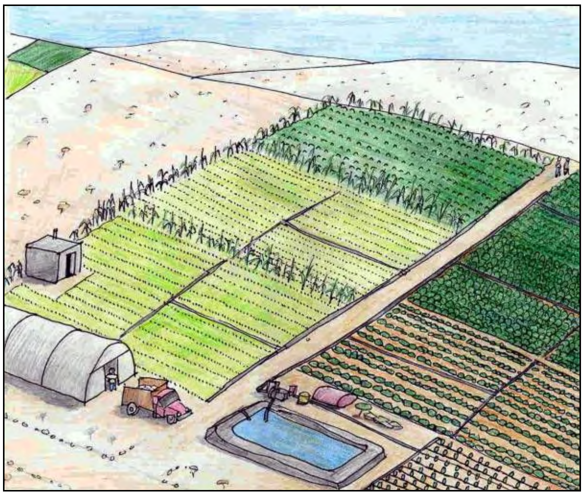
Farmers are Bedouins who settled down in the region in the 1980s after giving up their livestock activity. By lack of investment capacities or because they did not manage to have an authorization to dig a well, they rent both the deep well they use and the land they crop (on average, renting contracts last 15 years). Farmers always cultivate the maximum area (on average 20 to 25 ha) they can irrigate according to the quantity of water they can pump from the well they rent. Most of the time, farming is family-based: half of the work is done by the tenant's family, the other half by permanent employees, seconded by daily workers if necessary. In these regions, there is no pressure on land and most farmers change the plots they crop every year to avoid land degradation (salinization, decreasing organic content, contamination by fungus or nematodes, etc.).[65] The crops grown are much varied: tomato and watermelon principally, and pepper, zucchini, cabbage and cauliflower.[66] There are two cropping seasons: the first one during spring (March to July) and the second one in summer, from August to October/November. These systems have a low profitability.

- Mixed Farms: Family System

Generally, there are two main plots, contiguous or otherwise: vegetables are cropped on 20 to 25 hectares and there is an olive orchard on 10 to 15 hectares (with, at times, other fruit trees such as peach and nectarine). If the plots planted to vegetables and olive trees are distant, the farmer will often own two wells (otherwise the orchard will be supplied with water from the well meant for watering vegetables). The family keeps part of its livestock activity and it is not rare to see small herds (50 heads, goats and sheep) grazing in the vicinity of the farm. Cereals (wheat and barley) are often grown for the animals (Figure 5-13). The household may have sources of revenue other than agriculture.

Cropping systems are similar to those of extensive open-field farms described above, but watermelon is less common (high consumption of fertilizer/chemical, risk of soil contamination). Farm profitability is low, with a net income averaging US$800/ha/yr of vegetables.

*Figure 5-12. Family farm of open field vegetables in the Eastern Desert (R. Courcier, 2004)*

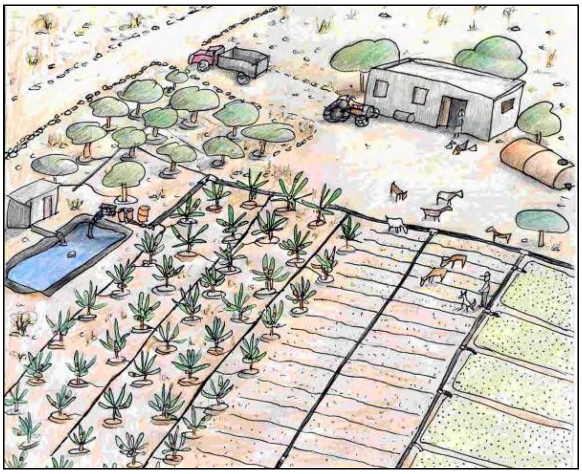


The net benefit per hectare averages US$1,100 and the net income per family worker is lower than $2,500/capita/year: the household lives below the poverty line.

[65] Each legal well is given a license mentioning the area that can be irrigated with the water from the well. Transfers of water to distant plots are thus illegal, yet common. No sections have yet been taken.

[66] Yields are generally lower than in the Jordan Valley for all crops but tomato called the *bakarah haloob* (dairy cow) by farmers of the Jordanian highlands

*Figure 5-13. Mixed Farms of Settled Bedouins (R. Courcier, 2004)*



The olive orchard is managed by the family (harvest is a traditional family gathering, sometimes done with the help of daily workers) and its profitability reaches (for trees at maturity) US$300/ha/year, significantly increasing the agricultural revenue of the family. Agricultural activities do not provide revenues higher than the poverty line, and farmers rely on other sources of revenue derived from the wider economy.

- Family Fruit-Tree Farms

*Figure 5-14. Family fruit-tree farm (J.-P. Venot, 2003)*

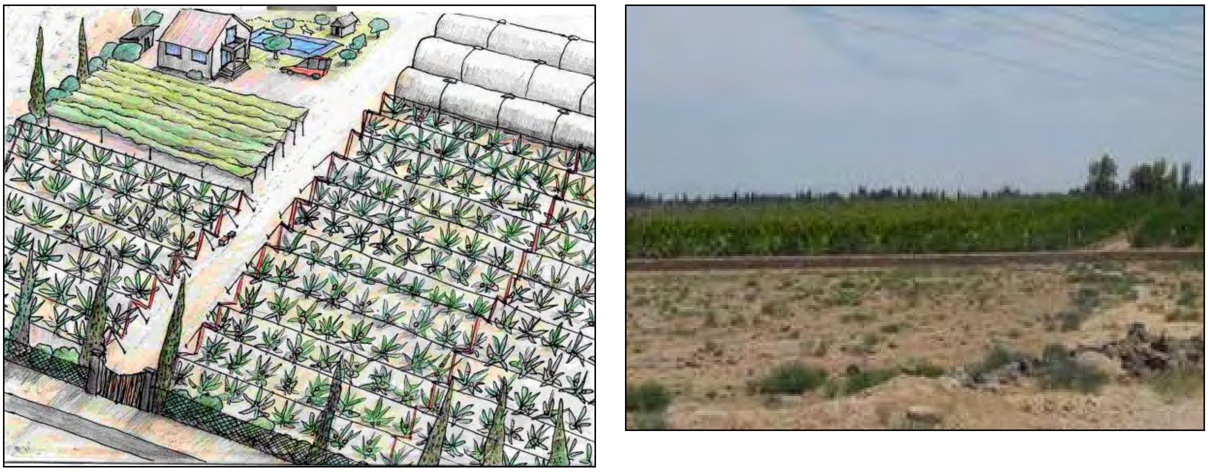
When profitability of vegetable farming decreased during the 1980s and the beginning of the 1990s (chapter 4.1), some Bedouins (owners) shifted to fruit-tree plantations, if they had the investment capacity to do so. They now manage an orchard of 10 to 20 hectares on average and have kept their olive plots (more rarely a small area planted with vegetables).

This shift is still observed today and vegetables are disappearing to the benefit of fruit trees. The household still has a small herd. Farmers essentially have peach and nectarine trees. Initial investment is high (nearly US$29,000/ha), but the net benefit reaches about US$6,900/ha/yr.

*Stone-Fruit Tree Entrepreneurs*

Stone-fruit production is still an expanding profitable activity in the highlands, despite difficult regional economic conditions. Large entrepreneurs continue to invest in orchards: they rent or purchase wells and land often abandoned by vegetable farmers during the last 10 years and engage in high/long-term investments to grow intensively managed and profitable orchards (Figure 5-15).

*Figure 5-15. Stone fruit-tree entrepreneurial farm (Remy Courcier, 2004)*



The owner's family is generally in charge of the management of the farm, the owner being referred to as a *Muzarein*. In most cases, the family is of Palestinian descent and owns between 20 and 300 hectares. The owner of the farm is highly involved in commercialization and marketing of the product, while a caretaker (who often belongs to the owner's family) manages qualified permanent employees and takes care of day-to-day operations. Two main management types can be identified:

- *Very intensively managed farming systems with high-tech irrigation techniques*. The owner is very closely involved in farm activities, initial investments are very high (US$ 600,000 to 700,000 for the area served by one well: 20 to 40 ha), and a large part of the production is exported, often through a family-based network.

- *Investor's farm owned by absentee owners not involved in farm management*. Investment is very high: US$ 900,000 to 1 million for a farm of about 40 to 80 hectares with two wells. Half of the area is planted with low-benefit olive trees.[67]

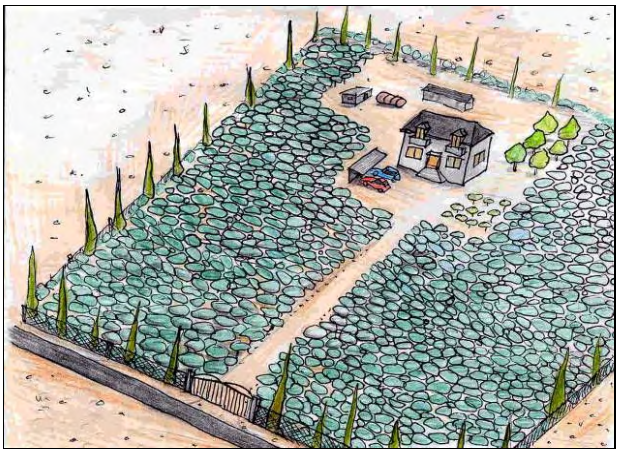
As in family fruit-tree systems (settled Bedouins), peaches and nectarines are the main trees planted. However, entrepreneurs also grow plum, apricot and apple trees that are more expensive, need closer management and more labor but allow better returns. Yields and prices observed in these entrepreneurial farms are higher than in family farms: they have better-quality products and about half of the product is exported to the Gulf countries, Syria and Lebanon (against 30% in family farms). These entrepreneurial farms are very profitable and the per hectare net benefit averages US$16,000 and US$14,850 in intensively managed farms and absentee investor's farms, respectively. Differences in profitability are related to differences in management.

*Absentee Owners: "Prestige" Olive Trees or Extensive Vegetables*

Olive orchards are often developed in parallel to other activities (vegetables, stone-fruit orchards), mainly by settled Bedouins. However, a large share of the total irrigated olive-tree area in the highlands (7,000 to 7,500 ha) corresponds to what can be called "prestige farms."

[67] Olive trees are grown as farmers would not have enough water to irrigate their entire farm if this was fully planted to stone-fruit trees. Moreover, owners are sentimentally tied to this traditional crop and it is a way to appropriate land in these desert areas. Olive orchards have a low profitability: US$60/ha/yr when trees are young and US$550/ha/yr when they are mature (production is exported through the owners' own export channels).

*Figure 5-16.Prestige Olive Farms*



These farms have a high social and prestige and, sometimes, recreational value (with a large house in the middle of the orchard; Figure 5-16), but their conventional economic profitability is very low, sometimes even nil (Lavergne 1996; Fitch 2001; Venot 2004a). They may also include long-term strategies of land occupation and the planted area is maximized based on the well capacity; hence the low depths of water application and frequent deficit irrigation (also observed by Hanson, 2000).

Farms have an average area of 10 to 40 hectares. The owner rarely comes to the farm and when he does, it is only to supervise the harvest period. All the work is done by permanent employees (either Egyptian or low-income Jordanian workers). The orchard is—with very few exceptions— irrigated by drippers. Trees begin to produce after 4 years; maturity is reached between 15 and 20 years and average yields of 4,500 kg/ha/yr can be maintained for 50 years. Profitability is negative for young trees (at -200 US$/ha/yr) but reaches the (still low) level of US$300/ha/yr when trees are mature (at current olive-oil and water prices).

*Poor Sharecroppers*

Sharecroppers farm 1 to 5 ha in the vicinity of villages and cities. Due to high water costs ($0.145/m$^3$; Al-Hadidi, 2002; chapters 5.13 and VI); *sharecropping costs* are high for the farmer: the contract is less beneficial than in the Jordan Valley.

*Figure 5-17. Sharecropping farm in the Eastern Deserts (J.-P. Venot, 2003)*

Absentee owners (see above) lend land, water and irrigation systems for 15% of the gross output[68] and share the remaining 85% (minus refunds for expenses advanced by the owner) on a 1 for 1 basis. Farming yields low benefits for the sharecropper ($500/ha/yr) and slightly higher for the absentee owner ($600/ha/yr)[69].

*Box 5-5: The Olive Sector in Jordan*

At maturity, rain fed olive tree orchards have a production of 3 to 4 tons per hectare and per year and yield 600 to 800 kg of oil per ha and per year (ASAL, 1994). Generally, rainfed orchards are 3 to 5 ha large with two family workers and generate between $190/ha/yr (young trees) and $610/ha/yr (mature trees). Rainfed orchards are already and will remain more profitable than most irrigated olive tree farms in the Lower Jordan River Basin. In Jordan, about 80% of all olive orchards are rainfed, mostly located in the uplands and can meet local demand. However, during the 1990s, governmental policies supporting olive oil production induced the multiplication of irrigated olive orchards, notably in the Amman-Zarqa basin (between 1994 and 1999, the area of irrigated olive orchards in Jordan doubled). In 2002, on the 77,000 ha of olive trees in the LJRB (92% of all areas in Jordan); 10,200 ha were irrigated (50% of all irrigated olive orchards in Jordan) and dramatically contributed to the depletion of the Jordanian aquifers (chapter 5.3 and VI).

The Jordanian production of olives reached 103,000 tons in 2005 (DoS, 2005) and is expected to further increase as young orchards comes to maturity. On the other hand, the local market seems to have reached its maximum absorptive capacity: exportations of fruits and oil have been continuously increasing since the late 1990s (they reached 15% of the local production in 2005; Demilecamps, 2005) and local consumption closely responded to fluctuations in production.[70] This is due to the cultural meaning and the structure of olive oil production in Jordan: each family has a small orchard and harvest is a family gathering; oil is mostly transformed in local mills for self consumption and the production is commonly commercialized within kinship networks. There are real risks of overproduction and drop in local prices. Exportations of olive oil have been increasing (large entrepreneurs in the desert developed profitable exports channels) but are unlikely to provide long term and large scale solutions to the problems of the olive sector in Jordan since 1) water and oil prices are likely to increase and 2) most farmers are unlikely to make the investments needed without support. Promoting high value production for export in the Mediterranean uplands could help in attenuating the future crisis but still faces numerous problems (low quality of the current production, lack of technical skills to use modern transformation machines, lack of an adapted legislative framework, etc. [Demilecamps, 2006].

[68] This share increases to 50% in the suburban area where competition for water is higher (chapter 5.4)

[69] Absentee owners with sharecropping contracts in the suburban region enjoy much higher revenues ($3,000/ha/yr)

[70] Olive trees have an alternative bearing: production is high one year and low the following year (inter-annual differences are lower when trees are irrigated)

Irrigated olive orchards in the eastern desert are currently threatening the viability of rainfed orchards in the mountains; they deplete some of the best-quality aquifers of Jordan and their low profitability is likely to further decrease. Olive trees in the deserts are anomalies from a water-saving perspective: their expansion should be halted and strong measures should be enforced to reduce olive orchards areas in the desert Highlands of Jordan (chapter 6).

#### 5.1.3.2 When Cities Strongly Shape Agriculture: Irrigation in the Upper Yarmouk, Transition and Suburban areas

Cereals and rainfed olive trees dominate the landscape of the Upper Yarmouk and Transition areas (chapter 2) but vegetables in open field or under greenhouses are also common features of these regions, as it is the case in the Suburban area. The extent of irrigated agriculture in these three sub-regions is not well captured through satellite imagery analysis: irrigated areas are larger than evaluated in Appendix 7.[71]

Growing urban pressure, notably since the early 1990s (chapter 2 and III), and growing competition for water are significantly impacting irrigated agriculture in these regions. Many entrepreneurs have moved to the eastern deserts (see above) and family farmers are dramatically affected by increasing water prices. Water from agricultural wells is indeed also sold by tankers for domestic purposes in Amman. To limit these private transactions competing with the public supply network of Amman (chapter 5.4), the government implemented a tax of \$0.35 for each cubic meter of domestic water pumped from private wells. This induced an increase of agricultural water prices by such as much: most farmers in the area do not own their wells and are charged \$0.7/m$^3$ (against \$0.145/m$^3$ in the eastern desert and \$0.02/m$^3$ in the Jordan Valley; chapters 5.12, 5.13 and VI).

*Figure 5-18. Diversity of Landscapes in the Upper Yarmouk, Transition and Suburban Areas*

Upper Yarmouk Area

Suburban Area

[71] Some farmers take up agriculture for the urban market. Such farming systems are not described here.

Transition Area

Surveys led to the identification of both entrepreneurs and family farms. Entrepreneurs own or rent the well and the land they use. They manage 5 to 20 ha partly cultivated with open field vegetables (carrots, potatoes, zucchini, cauliflower, beans, etc.) and partly with cucumber under greenhouses (on a quarter of the area generally). Daily work is done by permanent employees and farms yield average revenues higher than in the Eastern deserts: 1,500 and $2,500/ha/yr for vegetables in open field and under greenhouses, respectively. Family farmers generally rent the land they cultivate and **purchase** water at a fixed rate per cubic meter ($0.7 $m^3$): they crop 3 to 6 ha, have similar cropping patterns than entrepreneurs but their farm only yields an average $1,600 per ha not allowing the household to live above the poverty line. They rely on other sources of revenue and most of them will be driven out of agriculture as competition for water is likely to become acuter.

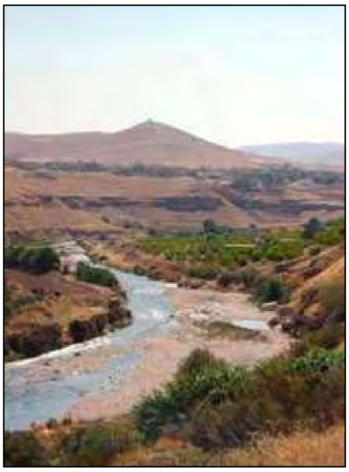
#### 5.1.3.3 Uplands and Side Wadis: A Traditional Mediterranean Agriculture

Rainfed agriculture (olive orchards, grapes, cereals, etc.) dominates the landscape of the Uplands of the LJRB (chapter 2). But, irrigated agriculture has a long history (chapter 3); developed thanks to hand main techniques (diversion weirs, earth ditches and earth canals; Figure 5-19) and remains located along the temporary streams incising the mountains and at the outskirts of the many small size cities of the region that are so many consumption centres. Shallow tube wells, springs and direct pumping in the small rivers are the three main type of water supply.[72] The decreasing profitability of the agriculture sector led to the shrinkage of irrigated areas in a densely populated region where other opportunities of work exist, notably in urban areas. Olive orchards remain the most commonly spread cultivation, followed by vegetables and fodder (Appendix 7). Horticulture is concentrated at the outskirts of cities and is not described here. High-value stone fruit trees orchards (peach, nectarines) are common along the Zarqa River; orchards are smaller and more diverse along secondary streams (figs, almonds, apricots, pomegranates, etc.).

Along the side wadis incising the Uplands, irrigated agriculture participates to the multiple economy of this Mediterranean region (Taminian, 1990). Farms are generally familial farms managed by former Bedouins who settled down in the region, partially abandoned their breeding activity (they generally kept a few dozens of sheeps and goats freely grazing the region) and partially rely on both permanent and temporary labourers for day-to-day work. They partly own and rent the land.

[72] Along the Zarqa river, the water quality is low (chapter 4.4): only fodder is irrigated by direct pumping. This is not the case along other side wadis.

*Figure 5-19. Diversity of Farms in the Uplands Regions, along the Zarqa River and along smaller Side Wadis (Source. J.-P. Venot)*



Farms are highly diversified and their area range from 2 to 20 hectares.

A typical 20 ha-farm is divided in a rainfed olive orchard (5 ha); an extensively managed and diversified irrigated fruit tree orchard (5 ha of peaches, nectarines, apricots, plums, cherries, etc); 3 ha of vegetables in open field (two crops: April-July and August-December of beans, tomato, zucchini, cauliflower, cabbage, potatoes, etc.); 2 ha of greenhouses (Cucumber in March and December or Eggplant in May-December); [73] and finally 5 ha or rainfed cereals. Rainfed plots and each of the irrigated 'units' described above can also be taken in isolation and constitute disconnected farming systems managed by smaller farmers.

Generally, trees and cereals are owned by the family. The irrigated fruit tree orchard is a low-input system; it needs less attention and less time than vegetables but fetch high and relatively stable prices (revenue averages $8,150/ha/yr). Vegetable plots are either own or rented: due to high land pressure, renting costs are high ($2,250/ha/yr) and significantly affect farms profitability. Renting land induce a decrease of revenues from $3,150 to $2,800/ha/yr and from $6,250 to $3,900/ha/yr in open field and greenhouse systems, respectively.

[73] Surface irrigation is still common to irrigate open field vegetables but farmers increasingly shift to micro-irrigation. Cultivation under greenhouse can only be achieved thanks to a pressurized irrigation system: the farmer owns a farm pond and a pumping and filtration system. Generally farmers rent the land preparation material but own a small truck to transport the production to nearby consumption centres.

Along the Zarqa River, agriculture is less embedded in this context of pluri-activity: farming is the main activity of many people. Some large entrepreneurs from Amman have invested in modern and costly techniques for stone fruit trees cultivation. They are enjoying high returns on investment ($12,500/ha/year) on about 10 to 20 hectares they own or rent. Smaller vegetable farms (1 to 2.5 ha) are usually managed by tenants and sharecroppers who share a shallow well belonging to a large landowner who decided to 'outsource' his agricultural revenues and invest more in other, more profitable, avenues. Some farmers from Palestinian origin crop high value herbs on small areas (mint, parsley, sage, etc.): this yields average revenues ($3,000/ha/yr). Finally, along the Wadi Dulheil, treated wastewater is directly pumped downstream of the As-Samra treatment plant to irrigate fodder sold to neighbouring livestock farmers by large absentee managers employing permanent and daily workers (for harvest): the revenue is marginal ($750/ha/yr for farms of 1 to 5 ha).

## *5.2 Agricultural Water Management in the Jordan Valley*

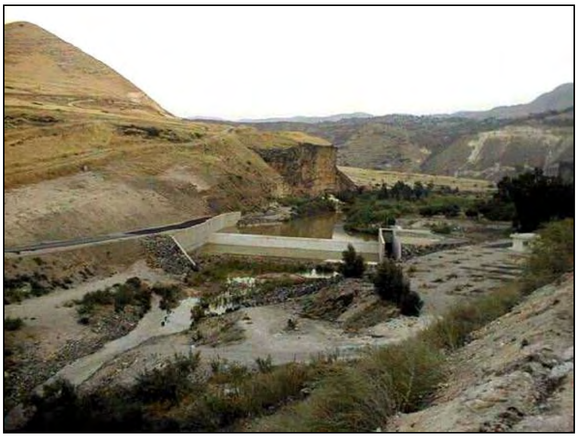
### 5.2.1 Technical Aspects of Water Management in the Jordan Valley

#### 5.2.1.1 The Construction of Large Surface Irrigation Systems

*The Construction of the King Abdullah Canal (KAC)*

The construction of the King Abdullah Canal began in 1957. The canal diverted water from the Yarmouk River in the north of the country to irrigate the Jordan Valley (Figure 5-20).

*Figure 5-20. KAC intake on the Yarmouk River (Courcier 2002)*



The King Abdullah Canal is the core feature of the Jordan Valley development project: it is a 100 km-long concrete open-canal that links the Yarmouk River in the north to the Dead Sea in the south. It was constructed in three phases from North to South (67 km completed in 1967; 18 km in 1978 and finally 14.5 km in 1988 [Table 5-3]). The KAC progressively received additional water supplies from dams built on side wadis during the last fifty years (Ziglab, Kafrein, Shueib, Wadi Al-Arab and King Talal Dam for the major ones). Table 5-3 summarizes the main stages of infrastructure development in the Jordan Valley.

*Table 5-3. Main stages of infrastructure development in the Jordan Valley*

| Infrastructure | Completion date | Storage capacity/designed irrigated area | Construction Costs ($ of 2000) | Location |
|---|---|---|---|---|
| KAC-North Ghor, Phase 1-67 km | 1962 | 12,000 ha | 30.7 | North valley |
| KAC-North Ghor, Phase 2-67 km | 1966 | | 6.9 | |
| Ziglab dam | 1967 | 3.9 $Mm^3$/ 1,250 ha | 6.8 | Southern wadi |
| Kafrein dam | 1967 (raised in 1997) | 8.4 $Mm^3$/ 125 ha | 18.5 | Southern wadi |
| Shueib dam | 1968 | 1. 4 $Mm^3$/ 250 ha | 3.5 | Southern wadis |
| King Talal Dam | 1977 (raised in 1987) | 75 $Mm^3$/ 8,200 ha | 107 | Zarqa River |
| KAC-second phase-18 km | 1978 | 3,691 ha | 23 | Middle Valley |
| North East-Ghor irrigated perimeter | 1978 | 2.700 ha | 20.6 | |
| Zarqa Triangle irrigated perimeter | 1978 | 1,421 | 13.1 | Middle valley |
| Hisban-Kafrein irrigated perimeter | 1978 | 1,659 | 8.6 | South valley |
| Wadi Arab Dam | 1986 | 16.9 $Mm^3$/ 4,286 ha | 14.9 | Northern wadis |
| KAC-Third phase-14.5 km | 1988 | 5,900 ha | 30.9 | South Valley |
| Modernisation-Pressurisation Middle Valley | 1992 | 6,454 ha | 24.4 | North Valley |
| Modernisation-Pressurisation North Valley | 1996 | 7,300 ha | 33.3 | North Valley |
| Karamah Dam | 1997 | 55 $Mm^3$/ 4,000 ha | 81.8 | South Jordan Valley |
| Hisban diversion weir | 2004? | 1 $Mm^3$ | ? | Southern wadi |
| Wehdah dam | 2006 | 110 $Mm^3$ | 95 | Yarmouk River |

The system was initially designed for gravity irrigation with canals supplying water from the KAC to large irrigated perimeters. Since the beginning, the Jordan Valley Authority (JVA) is in charge of the management of this system and of the distribution of water from the main canal to about 8,000 Farm Units of 3.5 hectare (Grawitz, 1998b) each. JVA has a pyramidal organization (see Appendix 5) with a central office in Amman and a control and water management directorate in the middle of the valley (Dirar office and Deir Allah control center) in charge of centralizing information on resources and demand and supervising the management of the KAC. Operation and maintenance of the irrigation network is under the responsibility of three O&M directorates (North, Middle and Karamah directorates). Each of these directorates supervises a geographical area composed of administrative units called development areas (Das, that cover, on average, 200 ha) and pooled in 10 Stage Offices where water distribution among farmers is effectively managed (organization of the water turns among the farmers, opening and closing of the farm gates according to the water turn, and following up of billing and accounting operations). Another directorate is dedicated to heavy maintenance operations.

Until the 1980s, the canal was a main axis with a single aim: providing water to irrigated farms. The management of this water carrier was simple, with an operator from JVA going along the canal to manipulate gates and balance the total outflow to the secondary canals with the inflow into the KAC.

*Changing Needs at the Farm Level*

Until the networks were pressurized in close pipes systems in the 1980s, large flows (about 25 l/s) were distributed at the farm gate according to a rotation schedule based on time (chapter 4.3 and 5.12.2). Water reached the gate of the farms through the gravity channels and a ditch-rider from JVA was opening and closing the gates according to the schedule. Each farm unit was receiving water once a week. Until the 1970s, all farms were irrigated with traditional surface irrigation systems. The farmers were conveying the total flow through earth channels in the farm. The number of weekly hours was generally not sufficient to repeat this operation on the whole area of the farm. The farmers were therefore irrigating only part of it every week moving to another plot the week after. Thus, each plot was receiving large amounts of water but only every 3 to 4 weeks (at least for Citrus farms; MREA and JVA, 2006).

From the 1970s onwards, new micro-irrigation techniques and cropping techniques (greenhouses), mostly developed earlier in Israel, began to spread on the other side of the Jordan River. Due to their great economic return, on-farm drip irrigation techniques associated with plastic mulch for vegetable cropping were widely adopted by the agri-businessmen of the middle of the Valley. Indeed, these techniques drastically reduce the need for labour (especially weeding) and allow a better distribution of fertilizers directly through the irrigation system (this is known as the fertigation technique). Lower production costs and increased were quickly taken advantage of by vegetable growers in the valley (see notably Nachbaur [2004] for a comparison of yields between the early 1970s and the late 1990s).

*Figure 5-21. Example of traditional surface irrigation techniques (Source. Venot 2003)*

The gravity distribution system in the secondary canals, however, did not match the technical requirements of on-farm drip irrigation which required reduced flow, higher pressure and higher frequency of water application. Agri-businessmen started to dig their own farm ponds to store the water they received by gravity through the JVA distribution network and purchased diesel pumps to pressurize this water inside an on-farm network of polyethylene pipes: entrepreneurial farmers thus largely freed themselves from the constraints of JVA's water distribution.

On the other hand, and while supply was sufficient, shifting to pressurized irrigation techniques in citrus orchards did not have the same economic advantages as in vegetable farms. Most citrus farmers thus remained with their surface irrigation systems and were dependent on JVA water turns and flows which were, at that time, reliable.

#### 5.2.1.2 From an Irrigation Canal to a Multifunctional Axis

*The Development of New Infrastructures and Management Tools*

In 1985, a set of pipes and pumping stations was inaugurated and allowed the pumping of freshwater from the KAC in the Jordan Valley to Amman in the Highlands (chapter 5.4). This transfer was made possible by the early completion (1977) and upgrade (1987) of the King Talal Reservoir on the Zarqa

River. Treated wastewater from Amman municipality and its surroundings is first collected in this large reservoir before being further diverted to the southern section of the KAC where it is used for irrigation purposes (chapter 3). From the mid 1980s onwards, the northern section of the KAC has primarily been a conveyor of freshwater for Amman and secondarily an irrigation canal. The southern section of the KAC received a mix of freshwater and treated wastewater.

Saving water, especially in the northern Jordan Valley, to guarantee (and gradually increase) the supply of water to Amman became the priority. JVA was therefore led to redesign its infrastructures, reconsider its management practices and its relations with farmers. Figure 5-22 illustrates the complexification of the hydraulic scheme of the Jordan Valley that has been necessary to meet increasing and competing water demands. During the 1980s and the 1990s, the gravity irrigation system was progressively modernized (Table 5-3) and open channels were replaced with pressurized buried pipes. Most of these pressurized networks are connected to the KAC through main intakes and irrigate an average of 400 to 500 ha: they are called after the position of the intake on the main canal (e.g. TO2 is a turnout located 2 kilometres from the intake of the KAC on the Yarmouk River). Some pressurized irrigation networks are not connected to KAC.[74]

Water is filtered or not before being injected inside the secondary network. The pressurization is made either through a pumping station, or using the differences of elevation between the two main levels of the valley: the Ghor and the Zor (for irrigated perimeters located in the latter and usually located 30 to 60 meters lower).

[74] North East Ghor and Wadi arab irrigation projects directly receive water from Wadi arab and Wadi Ziglab dams, respectively. Water from the King Talal reservoir is diverted into the Zarqa carriers I and II for irrigation in the Middle Ghor irrigation project or to the southern part of the KAC. Shueib dam is mainly used for groundwater recharge and for irrigation on 250 ha. Kafrein dam collects water from wadi Kafrein and from wadi Hisban via a diversion weir and a pipe. The reservoir directly provides water to the Hisban/Kafrein irrigation project (Grawitz, 1998b).

*Figure 5-22. Hydraulic Scheme of the Jordan Valley (Grawitz, 1998b)*

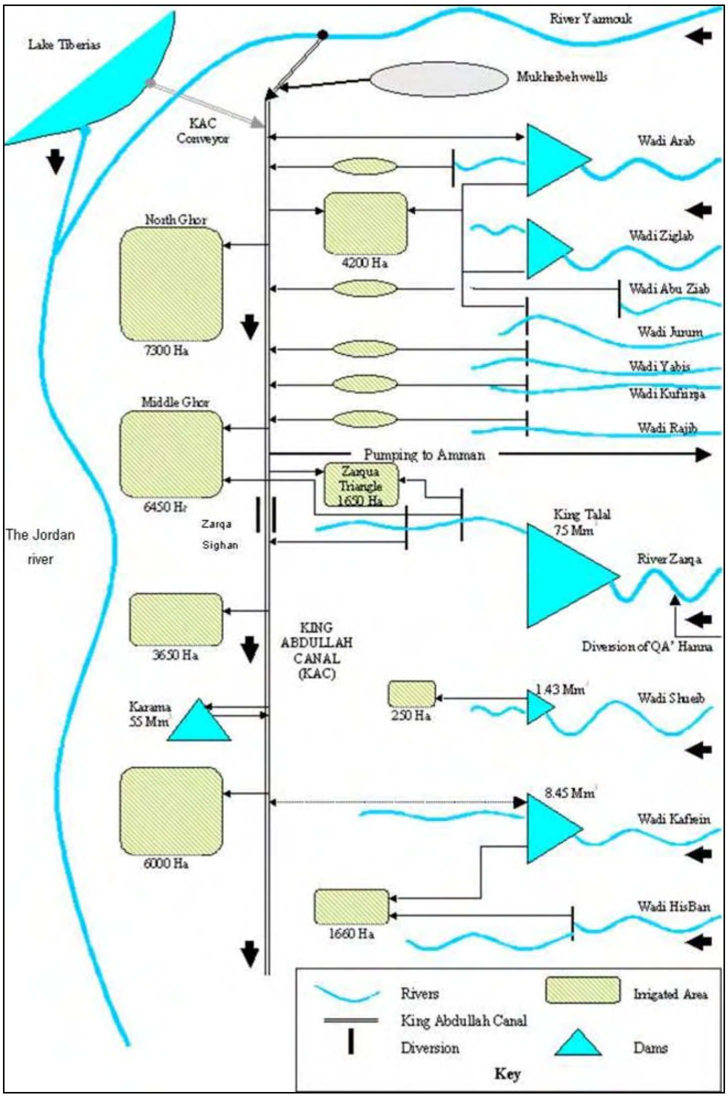
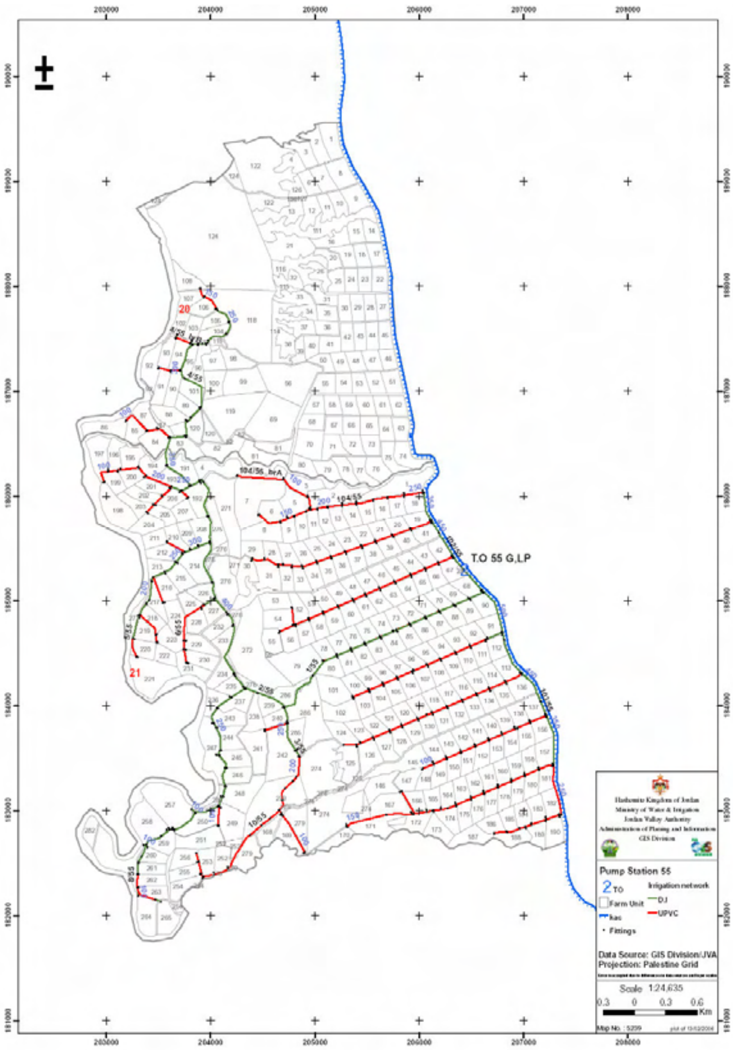



*Figure 5-23. Pumping Station in TO41, Wadi Ryan.*

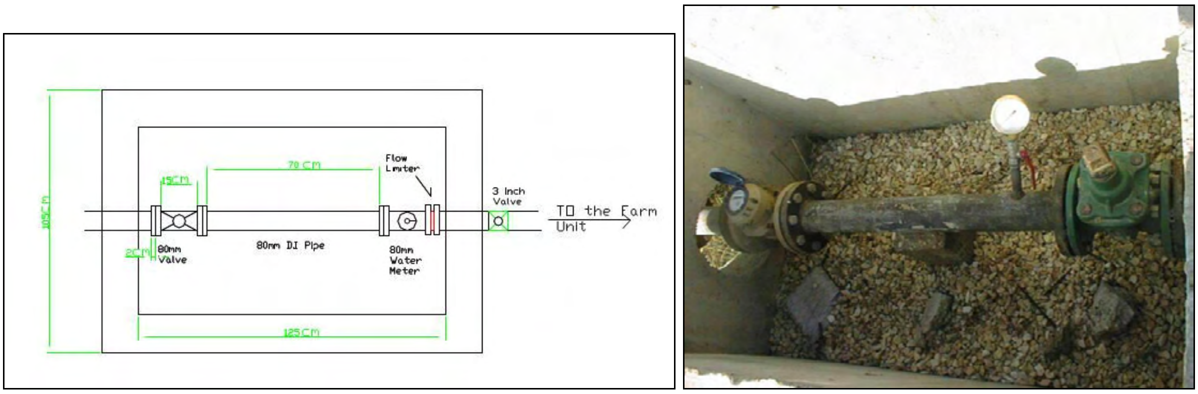
*Figure 5-24. Modelling of a pressurized network (TO55) in the Jordan Valley (Kreymeh, Middle directorate) (Source: JVA-GIS division)*




For each Farm Unit (FU), a FTA (Farm Turn-Out Assembly) replaced the former gate through which farmers received water from the open channels (Figure 5-25). This FTA is made of a concrete box, with a metallic cover and contains at least a gate-valve, a water-meter and a flow-limiter. In most TOs, those FTAs are closed with padlocks and only JVA staff is supposed/allowed to manipulate them.[75]

[75] In some TOs, farmers have fenced the FTA into their farm, leaving no free access to JVA staff.

*Figure 5-25. Schematic diagram and picture of the inner part of a FTA (Source. MREA, 2007)*[76]




The modernization of the irrigation network in the Jordan Valley required very high investments (Table 5-3) but water losses in the conveyance system have been drastically reduced: conveyance efficiency in the JVA networks ranges between 75 to 85% (Hagan, 1998).

*Management Tools to Match Supply and Demand*

As the hydraulic system of the Jordan Valley became increasingly complex and the stress on water resources increased, the traditional management of the canal with a single operator manipulating gate-valves was not adapted anymore. JVA faced growing difficulties to properly manage its infrastructures. For instance, the last 14.5 km of the KAC and the related irrigation networks and pumping stations never received water. Infrastructures were completed but JVA could not provide the necessary water to this area although the resources were supposed to be sufficient at that time. The development of new management tools for canal and networks operations in order to optimize the use of the water resources and to match competing demands started in 1994. The main features of these new management tools are listed below:

- Telemetry System and Automation of the KAC

Thanks to the support of the German cooperation (KfW) and with the assistance of SCP (Société du Canal de Provence), a telemetry and remote control system has been installed on the main hydraulic infrastructures of the Jordan Valley. It measures the following elements:

- All KAC inflows, either through level sensors, or through flow-meters;
- All KAC outflows (through flow-meters), and the status of the pumps (on/off; alarms) within the pumping stations;
- Upstream and downstream water levels for each of the 37 cross-check gates located along the canal;
- Water levels and releases from the main reservoirs supplying the KAC;
- Water flows in the main water carriers (notably Zarqa Carrier 1 and 2)

Measured data is transferred through a cable to the JVA Control Center, located in the middle of the valley in Deir Allah, where it is displayed by a SCADA software (Supervisory Control and Data

[76] FTA scheme for the North Conversion Project in the Northern part of the valley. FTAs slightly differ from one irrigated area to the other.

Acquisition software). From the Control Center, an operator can assess at a glance the global status of the King Abdullah Canal and can remotely control the KAC tunnel entrance gate (on the Yarmouk River; see Figure 5-20), the pumping and releasing gates from and towards the side reservoirs, the pumping from the KAC to Amman, and balance the flow in the canal through 37 measured cross-check gates (Grawitz, 1998). This telemetry system and the automation of the KAC functioning was completed in 1998; it allows a very precise monitoring and control of the main hydraulic infrastructures of the Jordan Valley.

Control is done at several levels: 45 control points in the network; 37 cross-check gates on the KAC and 8,000 individual farm turnouts. Therefore, the operation of the system is rather complex and management decisions at different places of the network are strongly interconnected. Therefore, in order to properly operate the control system, a computerized decision-support has been developed. KFW funded the development by SCP of the Water Management Information System.

- The Water Management Information System (WMIS)

WMIS provides JVA with information to operate the control structures in a proper way. It allows forecasting of resources and demands to set seasonal strategy and consist of two main types of activities:

- The management of water resources or water supplies, which consists in the management of all infrastructures related to the delivery of bulk water to a group of users (i.e. irrigation head infrastructures as pumping stations).
- Water distribution related to the distribution of water to single users (i.e. farm turnouts): collection of demand, organization of rotation schedules, control of illegal uses, billing and accounting.

WMIS is a computerized integrated system regrouping information at the different levels of JVA (Stage Offices, Directorates and finally in the Control Centre in Deir Allah). It is composed of:

- A database (ORACLE), including all data concerning farms cropping pattern; water distribution (to farms); inflows (KAC, dams, main carriers), and water resources availability (Yarmouk River, side wadis, etc.).
- A number of application modules, dedicated to water distribution to farms (including accounting), daily water supply (to irrigation networks), and seasonal planning of water supply and demand.

With the implementation of the WMIS and the computerisation of the system, new management skills are needed and the collection and the transfer of information has become a central, yet not easy, feature of irrigation in the Jordan Valley. This is not happening without raising certain problems (see below and chapter 5.2.2).

#### 5.2.1.3 Water Allocation

From the beginning of large-scale irrigation in the Jordan Valley, in the 1960s, water has been allocated through a system of crop-based water quotas. Volumetric pricing was also initiated in 1961, with a cost of 1 fils/m$^3$ ($0.0014; Hussein, 2002). The official quota system has undergone several changes since the 1960s and has been mainly used as a guideline, with adaptations according to circumstances and national priorities (THKJ and JVA, 1988 and 2001). Between the 1960s and the

1980s, quotas were based on crop water requirements as calculated by Baker and Harza in 1955 and summarized in Appendix 6.

Jordan Valley Development law No.19 of 1988 defined new quotas (THKJ and JVA, 1988): until the end of the 1990s, each plot of vegetable grown between mid-April and mid-December received 2 mm of water per day (during the rest of the year water was allocated on demand). Citrus and bananas were supplied with 4 and 8 mm per day, respectively, from the beginning of May to the end of October (and on demand during the rest of the year, when demand is low).

Bananas and citrus are highly water-consuming crops and were traditionally cultivated in the northern part of the Jordan Valley (Khouri, 1981; Elmusa, 1994; Jridi, 2002; Suleiman 2004; chapter 5.1). In the early 1990s, orchards areas eligible to larger irrigation quotas have been fixed: the government decided to 'freeze' cropping patterns in the valley and to grant "vegetable allowances" to all areas not covered by orchards at that time, with the intent of limiting the expansion of bananas and citrus. This has institutionalized some inequity in the access to water in the Jordan Valley. Historical large landowners (mainly citrus owners) as well as entrepreneurial farmers (with highly profitable banana plantations, although profitability is partly enhanced by import tariffs) are the main beneficiaries of these larger quotas. Bananas orchards planted before 1991 are the only areas to be entitled a "banana allowance": any area planted with bananas after this date is “illegal”—even if no sanctions have been taken—and does not receive the corresponding quota. In 2004, however, in contradiction to its policy to reduce demand, the JVA legalized citrus orchards planted between 1991 and 2001; granting them citrus allowance instead of the vegetable allowance they were receiving earlier. All other areas receive the vegetable allowance *if* the farmer declares to the JVA that he is cultivating his plot.[77]

The 1997-1999 period was marked by a severe drought which strained the resources of the Kingdom and made ad-hoc reductions in farms allowances necessary. In 1999, vegetables and citrus were allocated 75 percent of their allocation while bananas received 85 percent of their quotas. Allocations were reduced by 25 percent in 2000 and 2003, and by 50 and 40 percent during the summer 2001 and 2002, respectively (MREA and JVA, 2006). Some areas were left fallow and yields were significantly impacted, notably in citrus and banana plantations. Lower quotas have been maintained ever since (except in the south of the valley, where treated wastewater is used).

In 2004, the JVA established new quotas to better match supply and crop water requirements (THKJ and JVA 2004; see Table 5-4). Their annual values are close to the reduced quotas of 1999. This is roughly equivalent to 20% of the pre-1999 average amount of water delivered to the middle and northern directorates. The saved water has been reallocated to domestic use in Amman. Before 1999, official allowances between April and November totaled 4,800, 9,500 and 17,200 $m^3$/ha for vegetables, citrus and bananas, respectively. The new quotas correspond to 3,600, 7,650 and 12,550

[77] It is not rare to see some farmers “hiding” some trees (either bananas for their high profitability or citrus for their relatively easy management) on a small share of their farm although they are only eligible to the vegetable allocation. This kind of adjustment reveals that the farmer prefers to cultivate a smaller area of high water-consuming crops than its entire farm with vegetables, especially when other economic activities are available (daily wage labor in other farms or in the construction sector) (Bourdin, 2001; Petitguyot, 2003). The farmer is running only a limited risk since there are very few controls of cropping patterns by the Ministry of Agriculture, and even fewer sanctions taken by the JVA.

m$^3$/ha for vegetables, citrus and bananas, respectively, i.e., a cut by about 20 to 25 percent, already observed since 1999.[78]

*Table 5-4. Current quota system*

<table>
<tr><th rowspan="2">Period of the year</th><th colspan="3">Quotas (m$^3$/ha/day)</th></tr>
<tr><th>Vegetables</th><th>Citrus</th><th>Bananas</th></tr>
<tr><td>March, 16th to March, 31st</td><td>15</td><td colspan="2">On-demand but ≤20</td></tr>
<tr><td>April, 1st to April 15th</td><td>15</td><td rowspan="2">20</td><td rowspan="2">30</td></tr>
<tr><td>April, 16th to April, 30th</td><td rowspan="2">20</td></tr>
<tr><td>May, 1st to June, 15th</td><td>30</td><td>50</td></tr>
<tr><td>June, 16th to August, 15th</td><td>On-demand but ≤10</td><td rowspan="2">40</td><td rowspan="2">70</td></tr>
<tr><td>August, 16th to September, 15th</td><td>10</td></tr>
<tr><td>September, 16th to October, 15th</td><td>15</td><td rowspan="2">30</td><td rowspan="2">50</td></tr>
<tr><td>October, 16th to October, 31st</td><td rowspan="2">20</td></tr>
<tr><td>November, 1st to December, 15th</td><td colspan="2" rowspan="2">On-demand but ≤20</td></tr>
<tr><td>December, 16th to March, 15th</td><td>10</td></tr>
</table>

On a regional scale, changing from the previous quota system (2, 4, 8 mm/day) to the new one generated total freshwater savings in the northern and middle directorates (where the rules apply) of about 20.2 Mm$^3$/yr (between April and November)[79], which were reallocated to domestic use in Amman.

*Box 5-6. Difficulties to evaluate irrigation efficiency at the farm level in the Jordan Valley*

Because of the high diversity of situations, it is extremely difficult to evaluate water use efficiency in the Jordan Valley. Available data are indeed rather inconsistent (World Bank, 2002; Al-Zabet, 2002; Petitguyot, 2003, etc.) and evaluations highly variable since they depend on the features that are considered, among which:

- The volume of water supplied in the valley: aggregated JVA's evaluations at the pumping station, the Development Area (an administrative sub-unit); or the directorate levels often differ from

[78] In this section, economic calculations are based on theoretical volumes supplied to farmers (we tried to collect bills from farmers in order to assess individual and effective consumption but this proved to be unviable because most of them did not have bills for one year on hand –bills are issued every month- and most had paid the full quota because water meters were broken or consumption lower than 75% of their allocation). Because of conveyance losses the effective quantity of water supplied to the crops is lower than these theoretical volumes. On the other hand, many farmers also use water coming from side-wadis and, sometimes, wells (Refer to THKJ et al., 2001; Guérin and Courcier, 2004 for further information on irrigation efficiency and potential improvement in the Jordan Valley).

Extra hours are not considered in this allocation. Extra hours are requested by farmers for exceptional needs and, subject to decision by the JVA, granted in the same amounts to every farmer of a network at specific periods (for example, at the time of land preparation, or "solarization," or during exceptionally hot periods). This system is the main source of flexibility in a quite rigid allocation system. Petitguyot (2003) has shown, for one pumping station in the middle of the Jordan Valley that, on a yearly basis (in 2003), extra hours average 23% of the allocation.

[79] This 8-month period is particularly crucial since water availability is low and water requirements are high. Trees need high supply during the entire period. Vegetables do not require water during the entire period (very few vegetables are grown between May and July) but requirements are high in April (harvest) and in September/October (for solarization, soil preparation and plantation) (Petitguyot, 2003).

centralized data obtained in Deir Allah (where the control centre of the Jordan Valley network is located) or in Amman; the degree of consideration of other sources of water: uncontrolled side-wadis, groundwater, etc;

- The values of ET and of Kc coefficients (uncertainties are high, notably when crops face water stress and for vegetables under greenhouses);
- The evaluation of rainfall and the degree of consideration of effective rainfall;
- The 'unit of study': a farm, an irrigation network, a pumping station, a Development Area, a directorate, the whole valley, etc.;
- The evaluation of cultivated areas (different sets of data are available from the Ministry of Agriculture; the JVA: at the farm, the pumping station, the directorate and the valley levels; and satellite imagery analysis);
- The period of time considered: before or after 1999 (when quota reductions have been first implemented); the whole year (lumping together periods when demand exceeds supply with periods when supply exceeds demand); the period when water abstraction is effectively ceiled (see quotas in Table 5-4); the cropping season, etc.;
- The type of farm and the degree of intensification of farming;
- The type of crop cultivated and of irrigation technology used (surface irrigation or microirrigation with microsprinklers, drippers or open tubes) by the farmers;
- The degree of consideration of special water requirements for specific operations such as land preparation and "solarization" and of occasional periods of deficit irrigation (Petitguyot, 2003);

All these factors combined preclude a clear idea of what the actual irrigation efficiency is. USAID (2006) cites studies which indicate that only 50% of the water received is effectively applied and that "overall irrigation efficiencies might be as low as 40%." A World Bank report (2002) cites "evidence that over-irrigation takes place and water application practices are out-dated," while another report (World Bank, 2001a) specifies that "irrigation conveyance and distribution efficiency in the pressurized network in the Jordan Valley is high" and sees "a considerable range to improve on-farm irrigation efficiency." Other estimates at the country level put irrigation efficiency at approximately 75% in areas irrigated with sprinklers and 85% in areas using drip irrigation techniques (Ghezawi and Dajani, 1995). Further, Shatanawi et al. (2005) found that overall efficiency in the Jordan Valley was 65%.

Our macro-level calculations based on land-use statistics (chapter 5.1), rainfall data (THKJ and Meteorological Department, 2002), assumption of a full ET, and volumes of water diverted by the JVA to irrigated areas in the northern and middle directorates (according to the new quotas which are consistent with volumes supplied as presented by the JVA-water resources department in Amman) give the following annual efficiencies (defined as the ratio of crop water requirements to water supply): 64, 62 and 82% for vegetables, citrus and bananas, respectively. If the April-November period is considered, efficiencies rise to 88, 75 and 84% for the same crops. Overall efficiency in the Jordan Valley is included between 69% (if the whole year is considered) and 81% (if figures are only computed for the April-November period).

5.2.1.4 A Pressurized System Functioning almost like a Gravity System

Policy makers and international community are still seeking more freshwater savings in agriculture and the development of unconventional water resources to meet the demand of the sector. Although management tools were developed, many constraints remain and this can explain why the modernisation of the JVA network has not been accompanied by a large scale adoption of optimized water saving techniques at the farm level (most farmers have shifted to drip irrigation techniques, yet those systems function well below their optimum). We can mention in particular:

*Rejection of the Technical Propositions of the JVA by Most Farmers*

The new pressurized systems were designed to deliver reduced flows of 6l/s (against 25 l/s previously) at the farm gate, with a target pressure of 3 bars that would allow direct connection between on-farm modern irrigation networks and the collective infrastructure. In order to benefit from the modernization programs of the primary and secondary networks, vegetables farmers (and, to a lesser extent, citrus farmers) invested in on-farm pressurized system (micro-sprinklers or drippers on citrus and drippers with mulch on vegetables [Bourdin, 2001]). But very little support (credit, subsidies, etc.) or technical assistance was provided to farmers in order to adapt their on-farm systems to the new conditions (in 70% of the cases, micro-irrigation systems have been installed without technical guidance: irrigation blocks and rotation are poorly designed and farmers face problems of filtration and clogging, etc. [Wolf et al.m 1996; Courcier and Guérin, 2004; Shatanawi et al., 2005]. The majority of farmers using surface irrigation systems in orchards continued using their traditional methods and only few adaptations appeared such as the shift from flooding irrigation to furrows and basin irrigation around the trees.

Therefore, these farmers strongly opposed a drastic reduction of the flow as this would have hindered their system to function: the smaller the flow, the less water stands a chance to reach the tail-end of the farms due to high percolation losses along the channels. Even farmers who already had pressurized systems with pools and pumps rejected the idea of a very low flow, believing that they would receive a smaller allocation. Farmers' mobilization was strong enough to push the JVA to change its plan: flow limiters of 9 to 12 l/s were eventually installed instead of design flows of 4 to 6 l/s (Hermiteau, 2000). This early change in the design of the network impeded the JVA distribution system to function at its optimum. When high flows enter under-designed pipes and pumps, head-losses[80] are high and conditions of flow and pressure are poor: the number of units that can be opened at the same time is smaller with 9 than with 6 l/s. In other words, in the present system, if too many people open their gate at the same time; the total demanded flow is too high relatively to pipe and pump capacities and the pressure delivered dramatically decreases: the on-farm micro-irrigation systems function well below their optimum. The importance of stable pressure is illustrated by farmers in the extreme north of the Valley, most of whom shifted to micro-irrigation systems after pressurization of the network by the JVA in 1996. Yet, most farmers quickly reverted to their previous system as the delivery service did not match their expectations (Bourdin, 2001).

*Lack of Capacity Building for JVA Staff*

Furthermore, most JVA operational staff, who was used to open-channels system, did not receive sufficient training to acquire the necessary skills to be able to properly manage the new and more

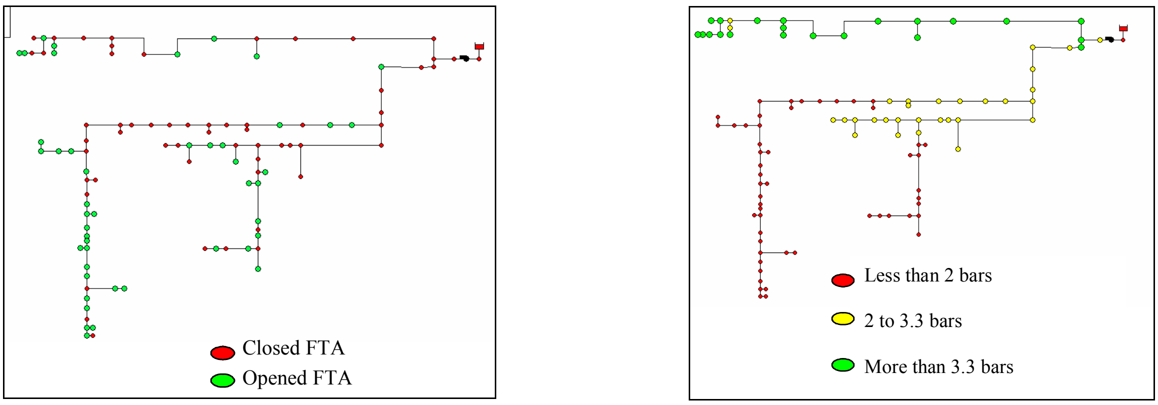
[80] Head-losses need to be minimized to ensure that tail end farm units receive sufficient pressure.

complex system implemented in the Valley (see also chapter 5.2.2). Most JVA employees continue to operate the pressurized system as a gravity network and misuses are common: the preparation and implementation of the rotation schedule is a good illustration of the problems faced during this modernization of the Jordan Valley irrigation network. According to the pump (or intake) capacity, only a certain flow can be demanded at once and the number of opened FTAs cannot exceed some limits. The water turn determines the time for opening and closing the FTA of each Farm Unit and opened FTA should be scattered all along the irrigation lines to limit head-losses. Therefore the principle for designing a rotation schedule in pressurized system is the exact contrary of the organization of a water turn in an open channel system, where flows must be concentrated with high velocity.

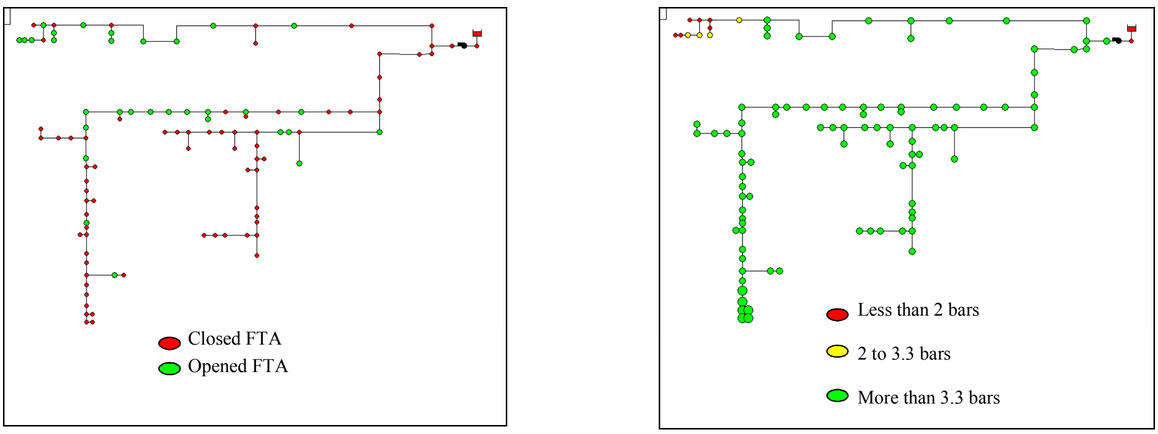
When the system changed, JVA ditch-riders remained in charge of opening and closing farm gate-valves, it was impossible for this limited staff to be in many disseminated spots at the same time. JVA staff therefore kept the habit of designing rotation schedules by pooling neighbouring farms together: this concentrates water flows and has dramatic effect on the pressure delivered to the FTA. Figure 5-26 simulates a JVA rotation schedule and the effect it has on the pressure delivered at the farm gate (not homogeneous and low: the target pressure to allow direct connection between on-farm modern irrigation networks and the collective infrastructure is about 3 bars). For comparison, an optimized rotation with scattered opened FTA and 6 l/s flow limiters is presented: more units are opened at the same time (limiting the risk of illegal openings) and a homogeneous high pressure is ensured to all farms.

*Figure 5-26. Non-optimized and optimized rotation schedule in the Jordan Valley irrigation network*

JVA rotation schedule (Non-optimized)




Optimized irrigation schedule



*A Vicious Circle*

Because of the incapacity to control illegal use, JVA tends to reduce the flow from the pumping station to the farms and deliver a bulk of water to farmers, creating inequities (Figure 5-27). The lack of pressure resulting from this practice, compounded by the non optimized use of the network, quickly leads to malfunctioning: when the pressure is low, the flow limiters (especially if the farm is equipped with a pressure demanding network) will not deliver the expected flow. Some farmers then do not receive their allocation during their water turn. Consequently, the modern farm units, directly connected to the JVA network, and which need higher pressure do not receive their nominal flow anymore while those not using the JVA pressurized network (they can have farm ponds to re-pressurized the water or may be using surface on-farm irrigation techniques) receive more.

Therefore, even before the reduction of water allocation in the late 1990s, farmers started tampering with the system: breaking watermeters, making illegal connections to JVA buried pipes, damaging the opening of their flow limiters to get more flow, illegally opening the FTA out of turn, etc. Farmers not relying on the secondary network pressure because they have on farm pools or because they use surface irrigation systems do not care about the effects of their illegal behaviour. On the other hand, those who invested in pressurized on-farm systems directly connected to the JVA network experience growing difficulties because of deficiencies in the collective networks. Therefore, they adapted their new on-farm installations to this low pressure and to continuous erratic frequency and reliability. The following coping strategies are common:

- Digging pools and purchasing pumps to re-pressurize the water and increase the flexibility of water supply at the farm level (more than half of the farmers have on-farm reservoirs [Shatanawi et al., 2005]). This induces higher operational costs and the poorest can not afford them (see Petitguyot, 2003 and Venot et al., 2007). Vegetables farmers have been the first to dig farm ponds recently followed by citrus and banana farmers;
- Mobilizing other sources of water: from side-wadis and, wherever possible, groundwater that is partly replenished by "losses" from the surface irrigation networks (21.7 $Mm^3$ are presently pumped for agricultural purposes, mostly in the south of the valley [MWI-records for the year 2004]);
- Requesting exceptional supplies (locally called extra-hours) according to crop requirements (land preparation, solarisation, etc…);
- Removing filtering units and any pressure consuming devices;
- Removing emitters for citrus irrigation and using what is locally called open-tubes.

#### 5.2.1.5 <u>Other Limits of the Modernization Programs</u>

- Seasonal planning and forecasting of availability of water resources is not optimized and hinders the reliability of water supply to farmers (Courcier and Guerin, 2004). Indeed, the uncontrolled nature of the inflow from the Yarmouk River impedes an accurate assessment of water resources availability. Furthermore, the seasonal planning modules of WMIS –although functional- are only partially used although some information is crucial for decision-makers. At last, coordination of the different services involved is lacking. As a result, JVA announces the reduction of allocation late in the season, making it hard for farmers to adapt their cropping strategy to the level of scarcity.

- o Rotations are difficult to establish and not respected; and water theft and tampering of equipment are pervasive (GTZ, 2004; MREA and JVA, 2006). Farmers relying on the same pumping stations are extremely heterogeneous in terms of socioeconomic status, and low social cohesion hinders collective management (Van Aken, 2004).

- o Gains in efficiency were not sufficient to provide the necessary water to operate the Southern part of the canal (the last 14.5 km). In this last section, water is occasionally released in the canal whenever available and used by the farmers who have the right to install pumps and pipes directly on the canal to irrigate nearby farms (Vallentin and Srouji, 2001)

- o In the northern and middle directorates, reductions in water allocation have been made necessary during droughts (see above) and summer crops are frequently banned. Reductions are less drastic in the Southern part of the valley, but mixing ratio between TWW and freshwater is higher in summer and this strongly affects water quality.

- o Water quality issues have not really been addressed even though the quality of the treated wastewater collected in the King Talal Reservoir and used for irrigation in the southern part of the valley has been declining with time (chapter 4.4). Moreover, farmers were not informed about the nutrient content of the reclaimed water and did not change their fertilisation and leaching practices accordingly. This leads to soil degradation (Hamoudeh, 2003) and these issues are given increasing attention (McCornick et al., 2001 and 2002; ARD and USAID, 2001a; KfW, 2006).

#### 5.2.1.6 IOJoV Project: from a Vicious to a Virtuous Circle?

Intensification and technological improvements at the farm level can limit the effects of reduced water allocations (Venot et al., 2007), but JVA conditions of water delivery must match the new technical requirements of those systems: pressure and frequency of irrigation should be decided accordingly and be guaranteed. In this context, the MREA (Regional Mission for Water and Agriculture, French Embassy in Jordan), has been working since 2000 with JVA to raise irrigation efficiency from the pumping stations to the plants and to raise transparency between service provider and users. The IOJoV project (Irrigation Optimization in the Jordan Valley) acted at two different levels:

- At the JVA distribution network level, on both technical rehabilitations and the setting of new management procedures in order to create the adequate conditions for water distribution from the pumping stations to farm gate.

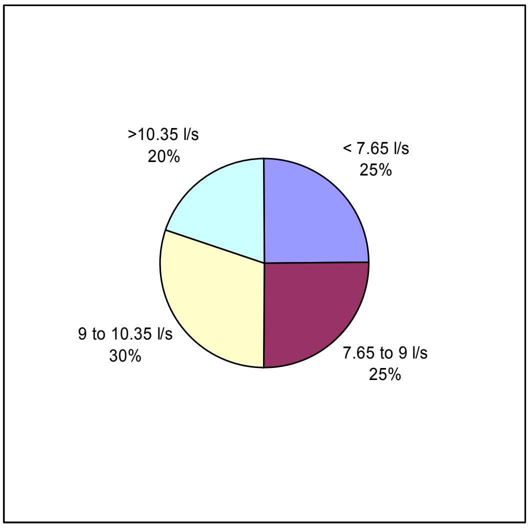
- At the farm level, to support farmers to invest in modernized irrigation techniques.

Thanks to a close follow-up and hands-on training with both JVA and farmers, this project allowed the rehabilitation of the networks and their good functioning in three pilot areas in the Northern Jordan Valley (1,600 ha in total). Watermeters were rehabilitated and protected from physical clogging (new filtration procedures) or tampering from farmers (physical protection) but remained visible by all through a grid on the top of the FTA (to facilitate their regular checking by both JVA staff and users). New flow limiters with the design flow of 6 l/s were installed. New operation, maintenance and control procedures were defined and followed:

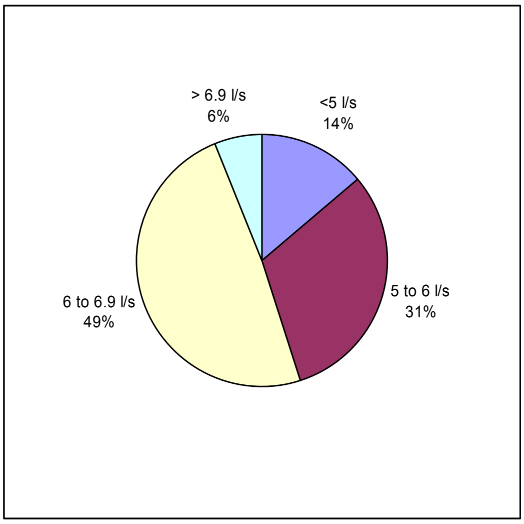
- Transfer of opening and closing responsibility of the FTA to the users to be able to set hydraulically optimized rotation schedule (see above);
- Hydraulic design of rotation schedule using EPANET software;
- Regular watermeters readings to control water use and illegal openings and hourly monitoring of the network by JVA operators;
- In case of illegal uses, the development of on farm intervention (ditch rider patrol) rather than an intervention at the pumping station level through a manipulation of the gate valve ( a common procedure observed earlier and cause of high pressure drop)

As a result, the pressure remains constantly high and stable (Figure 5-27) and farmers, even those who invested in modern pressure demanding systems, can be connected to JVA network and receive their allocation: Figure 5-27 shows that most farmers after the planned flow of 6 l/s after the project implementation).

*Figure 5-27. Difference in flow received from one farm to another in To2 in before and after the project IoJov*




Situation before project




Situation after project

Equity in water distribution and transparency thanks to watermeters facilitated the building of trust between the JVA and the users who invested (supported by subsidies and technical assistance of the project) in new and optimized on-farm irrigation systems. Observed improvements convinced the JVA to extend these recommendations to larger areas: activities will be expanded to the north conversion project (1,100 FU / 3,400 ha) from 2007 onwards (through an AFD funding) and this requires a high participation of the users, especially since water availability for agriculture is expected to further decrease in the future (chapter 6).

#### 5.2.1.7 Operation and Maintenance Costs Recovery

JVA's revenues from irrigation water have gradually increased with time, as water charges established at 0.14 cent/m$^3$ in 1961 later increased to 0.42 cent/m$^3$, then to 0.84 cent/m$^3$ in 1989, and to an average of 2.1 cent/m$^3$ in 1996 (GTZ, 1993; FORWARD, 1998; the planned increase up to 3.5 cent/m$^3$ has been delayed). Water is currently priced on the basis of a block-tariff system (Table 5-5). Assuming that farmers use their full (new) quotas (which they do), we can calculate crop-wise water costs. Total water costs are higher in banana plantations ($350/ha/yr) than in citrus orchards ($138/ha/yr). They are lowest on vegetable farms, which consume less water ($67/ha/yr) (see details in Venot *et al.*, 2007). Differences in water charges for each crop are lower than they were in the past since uses have been capped: the main beneficiaries of this evolution are banana farmers whose consumption reaches expensive tariff blocks less frequently than before.

*Table 5-5. Current and proposed irrigation water tariff structure in the Jordan Valley (FORWARD 2000)*

| Water quality | Usage block ($m^3$/month/3.5 ha maximum) | Irrigation tariff (per 1,000 $m^3$) | |
|---|---|---|---|
| | | Current | Proposed |
| Freshwater | 0-2,500 | $11.5 (JD8) | $21.6 (JD15) |
| | 2,501-3,500 | $17.3 (JD12) | $43.2 (JD30) |
| | 3,501-4,500 | $28.8 (JD20) | $64.8 (JD45) |
| | Over 4,500 | $50.4 (JD35) | $79.2 (JD55) |
| Low-quality water (freshwater mixed with treated effluents or highly saline water) | 0-2,500 | $11.5 (JD8) | It is proposed to maintain the current tariff structure |
| | 2,501-3,500 | $17.3 (JD12) | |
| | 3,501-4,500 | $28.8 (JD20) | |
| | Over 4,500 | $50.4 (JD35) | |

Revenues from water charges covered one-sixth of operation and maintenance (O&M) costs during 1988-1992 (GTZ, 1993; Hussein, 2002), implying an average annual subsidy of $3.4 million. In 1995, revenue accounted for less than 25% of O&M costs. Water charges were increased more than twofold in 1996. In 1997, with a rate of non-payment of 20%, average revenues amounted to 1.7 cent/$m^3$, against 2.5 cent/$m^3$ of O&M costs (i.e., a recovery rate of 68%) (FORWARD, 1998; World Bank, 2001). But, implementing the new quotas led to lower water use and consequently to a lower overall recovery of O&M costs (fees are volumetric, fixed costs such as salaries do not vary with effective supply; and maintenance costs –canals, pumping stations- do not decrease proportionally to volumes of water). Water is now charged at an average of 1.8 cent/$m^3$ (against 2.1 cent/$m^3$ in 1997; see above).[81]

Finally, calculations for 1988-1992 show that fixed asset depreciation and financing costs were twice as large as O&M costs (total costs were thus three times higher than O&M costs) (GTZ, 1993). Likewise, the ratio of average capital costs to O&M costs was 2.07 during the 1997-2002 period (THJK, 2004).

### 5.2.2 Social Aspects of Water Management

We dwell here on social and cultural dynamics in the Jordan Valley in relation to water management: the impact of water technologies and public administration has been strong in the valley and so were, therefore, the local adaptations, forms of opposition or manipulations of the water distribution. This

[81] The JVA's revenue has decreased in line with declining allowances from 1999 onwards. This may have prompted the proposal to establish a monthly flat charge of 2 JD (US$2.8) on each water bill. However, since 2005, the O&M costs of the JVA are totally covered by the sale of water from the Mujib Southern Carrier to the Dead Sea industries. This recent change does not concern agricultural water use.

process took place in the most multiethnic context in Jordan, which gave way to strong competition and social tensions in the access to irrigation, but also to new ideas of community in relation to water and to new patterns of cooperation in a context where the concepts of water, of agriculture, and of management of resources have radically changed.

#### 5.2.2.1 The Interethnic Context and Social Identity

In the Jordan Valley, the mixing of different social groups, increased by the high presence of immigrants in the agriculture sector, has been stronger than in other contexts of the LJRB. In fact, "the tribes' people of the Jordan Valley define themselves in an environment full of others' definitions" (Lane, 1994) and this is at the root of the lack of confidence between many communities in this region, a lack of trust which becomes problematic in the management of common resources.

Different perceptions of identity can be found in the valley and patterns of cooperation are intimately linked to these different ideas of community. In fact, "a sense of trust developed in the Jordan Valley by finding places and peoples in common outside the "area" (Hazelton, 1978:265): in daily life, local inhabitants refer to multiple spatial references due to the ramified network of refugees and due to their family dispersal. The kinship relations often spread in different areas and the impact of migration and mobility is high. A general lack of rootedness and attachment to the Ghor has always been pervasive. Indeed, Bedouins maintain patterns of historical relation to the Ghor as part of their ancient *dirah* (tribal territory), manifested also through new investments in banana or citrus plantation, but recognize that they have lost part of the control on this land to the state.

Mobility is very high since both work relations and solidarity networks often bring men and women out of the villages and out of the valley. Farmers of the valley think of themselves as related to a wider network often spread out in Jordan. Further, the scattered social network is often a main economic resource and, in some cases, a source of employment. Villages in the valley do not constitute homogeneous entities and units; they constitute a political entity for local administration and at the time of elections, but they represent just one term of belonging and people often mobilize not according to their common village.

In some cases, the unit of the village is identified locally with kin-group terminology, which is more important in daily interaction, although every village is often heterogeneous. The problematic of identity is related to the ways in which displaced and migrant groups mobilise different terms of solidarity in a new and changing context: 'Palestinian', 'refugee', 'Jordanian', 'Gharwarneh', 'fellah', 'Bedouin', muzar'e are all terms of identification that have traditional or administrative meanings but have also acquired new interpretations. These terms refer to several 'idioms' of identity, whether the kinship idiom, ethnic definitions, or status connotations. Identities in the valley carry a constitutive and 'built-in' ambiguity (Geertz, 1979): a flexibility in representation and practice that indeed makes possible a contextual use and manipulation of multiple levels of belonging in legitimizing action and, in particular, in the management of resources. Traditional belonging oscillates between continuity and discontinuity with the past. The emphasis on identity ties is reinforced in the valley: for Palestinian refugees, identity has in fact become a substitute for territory (Bocco, 1997) and thus an important part of social capital, linked to an important network through which goods, services, and internal assistance can be mobilised.

As we have seen earlier (chapter 3), Gharwarneh is today a contested and censured term. In fact, Ghawarneh have also been renamed 'Ghorani', 'the people living in the Ghor', an offensive and deprecatory term identified with the low-status black community.[82] What is important here is the reinterpretation of these past terms of belonging in present everyday interaction in an ongoing dynamic of inclusion and exclusion. Thus, 'Ghawarneh' is perceived as the 'native' population in the Jordan Valley who was living more or less permanently in the Ghor before Palestinian displacement. On the other hand, 'fellah' differs markedly from the new developmental category of farmer (muzar'e; chapter 4.3) and refers more to traditional peasant life and to customs linked to an attachment to the village of origin.

*Figure 5-28. A Bedu man opening the front of a greenhouse (Van Aken 2003)*

Bedu is an indigenous category to which people identify themselves and the opposition between fellah and Bedu in history, although presented as a polarity, has been one of interrelation with shifting boundaries. Bedu identity today in the Jordan Valley is not coincident with a pastoral way of life (nor was it in the past) and refers to a moral community linked to ancient roots and to the control of land.

Jordanian tribes in the valley, compared to other situations, lived in a very heterogeneous context characterized by a large refugee population. They witnessed the irruption of aid devoted to Palestinians in the 1950s and the radical transformation, focused on water management, of the entire region. Transjordanian tribes often express the arrival of "foreigners" (*barranya*) as the refugees, as a process of displacement of themselves, even more following the land redistribution in the 1960s. In fact, they use a rhetoric of entitlement to claim property right to water, as they were the people who sacrificed their lands for the purpose of development of the Jordan Valley (Nims, 2003): The ancient and traditional use of land and the extension of their dirah in the valley support these claims of autonomous control on water, in contrast to the control of the JVA.

In a context of numerous layers of belonging and of political censure of these identities, what is relevant in daily life is the continuous interpretation of the 'closeness'(*qaraba*) of the relations by choosing shifting levels of solidarity. Closeness is expressed in terms of kinship ties but in daily practice the language of closeness is also ambivalent: the definitions of who is 'black', who is 'Ghawarneh', and even sometimes who is 'Palestinian' are ambiguous, contested, and dependent on the perspective taken. In some aspects of daily life an opposition between Jordanians and Palestinians may be emphasized, or a racial stigma may be amplified, while in others, economic segmentation will be the base of alliances or exclusion. Palestinians versus Jordanians is a major dichotomy often

[82] Certain lineages that were previously deemed part of the Mashalkha tribe, present themselves today as a separate tribe in order also to avoid the social stigma attached to Ghawarneh, in the process of fusion and fission of lineages often observed in segmentary dynamic.

mobilised: it refers to the problematic belonging of displaced Palestinians that lie between the status of refugee, linked to an internationally recognised right of return and assistance, and the citizenship that Jordan has granted to them: this constitutes a double allegiance between loyalty to the King and loyalty to the Palestinian struggle on the opposite side of the valley.

Since the 1950s, every lineage of Palestinian origin in the Jordan Valley referred to his *mukhtār*, as traditional representative: he mediated conflicts, including water disputes, problems with authorities, with public administration and even development offices, although, following the setting up of municipal councils, he is not officially recognised anymore within the state bureaucracy and most of his roles have been taken over by elected representatives. Besides, the fragmentation of larger tribes has indeed decreased the power and political authority of shuyukhs and mukhtārs as local representatives. Palestinian identity is generally not legitimised in public, Palestinian associations have been forbidden, and talking about Palestinian issues is inevitably relegated to intimate social contexts. The encounter with state representative is often characterized by a distinction between a Jordanian of Palestinian origin and one from Transjordan: the army is mainly composed of Jordanian tribes, and it is often necessary to be Jordanian to gain access in the administration and state bureaucracies through *wasta* relations.

The disruption of wider tribal solidarity and the displacement of Palestinians have transformed the units of belonging. Development institutions took in charge functions and responsibilities that were previously exercised by the tribe, such as management of land and water. Besides, the linkage between land and a definite lineage or tribe has often been lost, due first to the new settlement of land but also as a consequence of the new value attributed to land following the introduction of technology and bureaucratic management. Last but not least, traditional agricultural knowledge has been displaced from the extended family and is today in the hands of the expert, the engineer, the agronomic consultant, or the chemical supplier, and agronomic knowledge has overlapped with the local knowledge that was transmitted across family relations and generations.

*Pakistanis: Encapsulated Communities*

Besides refugees, Egyptians, Bedouins, this valley 'full of others' has absorbed also a smaller but important groups of Pakistani that indeed have contributed to the transformation of the valley since the first groups arrived in the 1970s. After three generations in Jordan, they remain in a marginal position, since they have to renew they visa every year. They are mainly engaged in agriculture, women often as wage labourers, but generally the families work as sharecropper, or lately, lessees mainly in the south of the Jordan Valley. Notwithstanding a relative isolation from Jordanian society, Pakistanis are a highly fragmented community, divided along ethnic and tribal lines. The Sindh and Baluchi compose the two main groups and they are neither on the way towards integration into Jordanian society, nor do they have evolved into a distinctive ethnic group. Their Pakistani culture after 30 years remains the predominant feature that distinguishes them from the other main groups.

Pakistani families arrived in search of a new existence escaping from ethnic violence with the desire to perform the pilgrimage to the Mecca from Baluchistan and from Sindh, often through Iraq, and have turned into temporary migrant labourers. They were admitted freely into Jordan in the 1970s but later their presence was tolerated within national labour policies. They first remained in Amman and were later pushed by their government landlord sponsors (the *kafīl*, the national who guaranteed legally for their presence in Jordan) to settle in the Jordan Valley where agricultural work was increasing. Their settlement pattern in the Jordan Valley reflects the regional and tribal divisions of their places of origin. The Sindhis tend to live in the northern areas of this part of the valley particularly around the towns of Deir Alla and Dhirar as well as in the Ghor al-Kibit. The Baluchi are concentrated further south around South Shunah (Figure 0.2 in chapter 5.1), although within these areas they are further clustered in tribal terms (Franselow, 1991).

Today, they are structurally dependent on the relations to the *kafil* for their work and permanence in Jordan. They remain therefore in a precarious position, defined by the state as temporary labour migrants: they are not legally allowed to own propriety or operate business on their own. One of their main strategies has been to rent units of land turning from sharecroppers to tenants with the help of Jordanian frontmen or to purchase a pick-up or a van and diversify into transport or marketing (chapter 4.3 and 5.11).

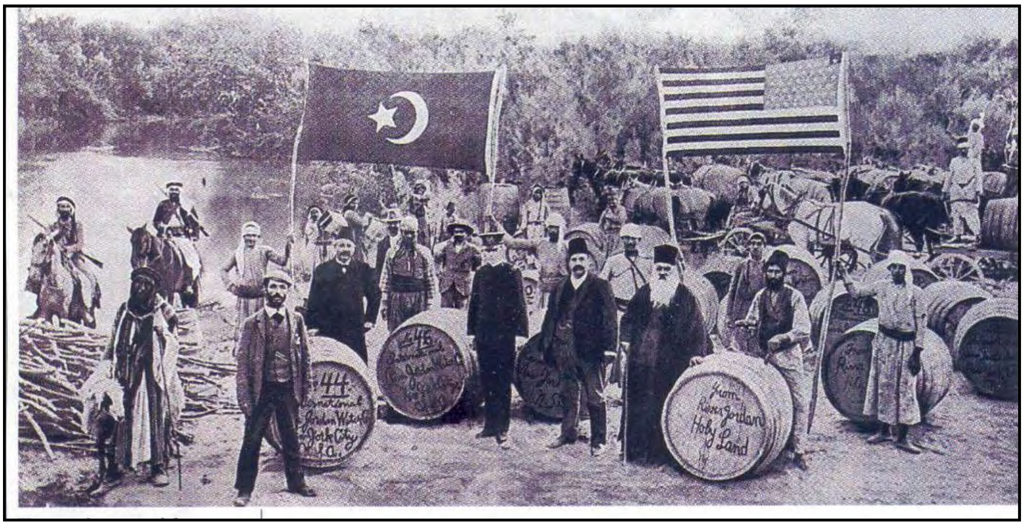
They have a strong tendency towards endogamy and exchange marriage resulting in patterns of extremely close marriage circles. Kinship links have also become crucial in recruitment and in bringing close relatives from Pakistan. Many households move in the hot summer months to the eastern hills around Irbid and Madaba to work as labourers in tobacco cultivation. The households are dispersed and isolate themselves by maintaining self-sufficiency as much as possible. They rely on family labour in agricultural production and in consumption they try to reduce to minimum their dependence to the market. They keep goats, sheep, and chickens, species brought from Pakistan. They show a pattern of avoidance not only of local Jordanian society but also of Pakistani from other tribes, and “Jordanians know virtually nothing about the Pakistani, since they are encapsulated and dislocated within Jordanian society” (Franselow, 1991).

*Symbolic Meanings of the Jordan Valley*

The Jordan Valley is traditionally perceived as a sacred landscape and the Jordan a sacred river. For Muslims, the Jordan River is sacred and its water were reputed as purifying, although today it has become less and less accessible both for Palestinians and Jordanians since it has become a strategic and inaccessible border. For the other two monotheistic religions the Jordan River carries also strong religious values through the numerous Biblical events that took place along the river and near Jericho. For Jewish pilgrims, crossing the river held a symbolical meaning, although this is not considered sacred in itself. For Christianity, the river represents a mythical place, where pilgrims bath themselves, in a replication of Jesus baptism, and represented for pilgrims the entrance to paradise. Special prayers of Middle Eastern pilgrims are connected to the Jordan River and an intense market of sacred water has long developed (Figure 5-29).

The sacredness of the Jordan Valley is reinforced by the presence of many tombs of the companions of the Prophet all over the valley; this is locally linked to the avoidance of selling alcohol or setting up cinemas in the Valley, as immoral and offensive to religion. In local perceptions, a main spatial demarcation in the Jordan Valley is expressed between the villages and settlements in the “upper” side, ‘*foq’*, and those ‘*taht’, ‘lower’*. The first lies near the slope of the mountain far away from the River flow, and close to the main road that crosses the Jordan Valley from north to south. Here lie most of the villages that were planned in the 1970s and 1980s, which also enjoy a higher social status linked to the urbanisation process.

*Figure 5-29. Market of holy water of the Jordan River (TCI, Israel,1997, p. 408).*



This region is held to be distinct from '*taht'*, the 'lower' area close to the river, traditionally called the al-ghor, which comprises most of the agricultural area in the valley. Next is the forbidden area under military control close to the Jordan River, the *zor* (chapter 2). In the ghor villages are stigmatised by their lower status, a demarcation that has been reinforced by their difficult living conditions since the climate is hotter, the large fields have in some cases a high salt concentration, and the villages are distant from market centres and services, since marginal population often do not dispose of vehicles. Inhabited mostly by lineages of the Mashalkha tribe, the area is considered to be of low status because of their poverty and their supposed unwillingness to work. These main stereotypes reinforce social borders. Besides, the agricultural area is socially divided into three main spaces: the greenhouse farms, the open-field farms (makhshuf), and the orchards (bayyāra). The latter are often distinguished by their privacy, as they are bordered by wire or palm tree fences.

#### 5.2.2.2 Irrigation and Social Transformation

The social relations around water refer directly to a wider power structure and distribution of roles, where the state, the distributional apparatus of the JVA, and the farmer are the main actors. In the last half century the communities living in the Jordan Valley have faced tremendous change, not only in their wider life context, but also in their conception and use of water. We summarize here the main changes specific to the Jordan Valley to show the political and social implications of technical inputs. Far from mere technical transformation, new values and cultural ideas of water have encountered and overlapped with local patterns of water management.

*From time (dor) of water to quantity/pressure*

As seen earlier (chapter 4.3), water was divided in time-shares and the "turn" (*dor*) of water was both the definition of the water amount distributed as much as the term for community distribution. The flow received from a canal was inevitably changing and thus it was not guaranteed. What was guaranteed was only the time and therefore farmers had to adjust cropping practices to this variable flow. The following is a typical description of the relation between time, water and ideas of community:

> "We had 80 fasl divided for 4 fukhd (lineages) present in Rama: Dhib, Sa'id, Ayub, Othman. So every fakh received 20 fasl. If one had to get 5 hours, if two, 10 hours. The maintenance of the canals was made by a rotation of labourers from every household."

*Fasl* was a temporal definition of water "of 18 hours in winter, and 9 in summer, two times a week was the turn": the time of water was directly connected to the lineage system, where every part of the larger community received its "time" (share) of water. Thus, time was intimately related to tribal relations. With the introduction of a central bureaucracy, of pressurized pipes and micro-irrigation, a new characterization of water in terms of quantity (cubic meters) and pressure flow was introduced, in contrast to the mere duration of delivery. Pressure represents an intermediate variable that influences the flow. If the volume distributed is the goal, one should adapt the flow and the time accordingly; if the time does not change, the pressure has to be sufficient to ensure the flow and then the volume supplied. Ideally, the system works if everywhere in the network the pressure is close to (or higher than) the design value that ensures a nominal flow (9 or 6 l/s). If the pressure is higher, it is controlled by flow limiters.

In the Jordan Valley, farmers still express widespread opposition to think of water only in terms of cubic meters and the lack of transparency of JVA delivery entails that few farmers are reluctant to talk in terms of measurable volumes. Most of the time, farmers speak in terms of inches (according to the diameter of the pipes) to evaluate the pressure they have. Pressure, as a determinant of the quality and quantity of water, has become crucial in micro-irrigation but is also the main object of conflicts between planners, JVA employees and farmers. It also contributes to a gap between those farmers who can afford on-farm pools, pumps and individual pressurized systems, and those who cannot afford them (for example, lessees who move every five years and cannot invest in a temporary plot of land) and who have to rely on the erratic collective pressurized network (chapter 5.1 and 5.2.1).

The shift from a temporal definition to a pressure-quantity definition is a far-reaching transition between different languages of water, and not only technical managements of water: from a connection between time and tribe to one between pressure/network and bureaucracy. On the other hand, this encounter of idioms around water reveals also a strong adaptation, and manipulation by farmers of the technical language: local terminology of technical input often differs from the agronomic original names, and is sometimes invented (one example is the drip-irrigation tubes, called locally *barbish*). The local terminology is perceived often as sign of ignorance by engineers and planners, while it is one of the many forms of appropriation that a development project entails.

*The Changing Types of Waters*

> "The water here is of good quality; imagine that until the 1980s we could drink directly from the canal!"(farmer in TO 41)

Farmer are well aware that the quality of water has changed and recognize the presence today of different types of water used in the valley, which request a shift in cropping patterns and farming methods (chapter 4.4 and 5.1). In the past, water was distinguished according to the sources (rain, wells, underground) and within these, different words were used to define the types of water (Lancaster, 1999) (chapter 4.3 and 5.5). In the last decades, new types of water have been introduced, as waste-water, treated waste-water, brackish water, desalinized water, treated drinking water, brine from desalinating plants, irrigation return flows, drainage water, which have new characteristics, new relations to land and crops, and also new relations to the bureaucracy. In this new multiple notion of water, new ideas of purity and impurity of water have been produced, according to previous frameworks. In fact, farmers look for pure water in a farm for the ritual cleaning before daily prayers avoiding, for example, the wastewater of the farm: a fact that reveals how these are not perceived locally as ritually pure.

Besides, the range of waters available has increased the problem of water quality, which has become relevant in micro-irrigation (due to clogging of emitters, damage to water meters [chapter 4.4 and 5.11]): often, new types of water have been introduced in the valley without the knowledge attached to it and farmers have been left alone in experiencing, by themselves, season after season, the various effects and consequences of using different waters in their fields. Further, the new types of water introduced in different regions and in different periods of the year in the valley have engendered also several strategies on the part of farmers, as already described in chapter 5.1. Within the sub-regions of the Jordan Valley, there is a large variability in the types of agricultural waters and a mixing of different kinds of waters. This leads to slightly different patterns in water delivery, where for example, treated wastewater is supplied in more quantity even in summer: it is subject to less limitation even during dry years (when freshwater deliveries are generally cut short), and getting extra hours is more easy (chapter 5.1 and 5.12.1). This water of multiple origins is linked also to the complex infrastructure in the valley (chapter 5.2.1): in the south, for example, water delivered from the Shueib reservoir flows in open channels, is allocated free of charge and every farmer owns a share of the water. Farmers in the south of the Jordan Valley also often dispose of kilometres of irrigation pipes in order to transfer water from a surface or a groundwater source to distant fields (chapter 5.1). What may also be unpredictable is not just the quantity but also the quality of water which, with the decrease of fresh water irrigation and its replacement by brackish or wastewater, has become an important aspect in farming (muddy water during winter or water polluted with plastics, pieces of vegetables or algae with the consequent clogging of drip lines are some of the problems farmers face today). Further, the issue of salinity of water raises the need for new cropping patterns and salt tolerant crops, a new reality of waters that requests also new adaptations of local knowledge.

A main local concern is the fact that JVA does not distinguish, in its delivery and prices, between different types of water, or between open or greenhouse cultivation (and the system is, thus, far from functioning on-demand, as it was designed):

> "The JVA does not make any difference between the need of water of a unit of greenhouses and a unit open field! One green house can take as much as water as one dunum open field, but it covers half of the land; besides, it is closed in winter so it does not receive water from the rain"(farmer in TO 41)

Besides, the technical and bureaucratic presence has led to a wider process of secularization, materialization and disenchantment of water (Hamlin, 2000): detached from tribal community, water has become a technical affair, separated also from its social dimension. Not being anymore a public institution in social terms, the issue of transparency and predictability of water is crucial here: water has always been unpredictable in the valley due to weather conditions but at present time, human factors (and also technical problems, water stealing, insufficient maintenance of the networks, etc.), political relations, the competition between urban and agricultural uses are new factors, which increase its irregularity.

The idea of "efficiency" is quite new in local irrigation, since it is linked to variables like evapotranspiration, percolation losses, humidity control, water volumes, all indicators that were already present in traditional irrigation patterns but were not so determinant. Besides, farmers were used to "measure" physically by touching the ground in case of humidity or by a visible judgement of flow and pressure, variables that were not so relevant as they are today in the functioning of water delivery. The introduction of pressure meter, water meters, tensiometers, technical measurement of soil humidity, are not just technical devices, but entail also a new knowledge of water.

In short, two main elements have become today more important and crucial than before in thinking and managing water: the information and the knowledge around water. By knowledge, we refer to the knowledge systems that are attached to the water distribution and the irrigation network. By information, we mean knowing who controls, who has or does not have access to information on the amounts of water delivered among the entire irrigation system, who steals and does not steal.

*Irrigation Network as a New Concept*

The new hydraulic system is a pressurized network and a given number of farm turnouts pipes should be used at the same time, defining a high hydraulic interdependence of the FTAs (chapter 5.2.1). This new hydraulic interconnectedness of water users should be viewed also as a new social interdependence of farmers. The wider the network in function, the better and more equitable is the pressure delivered. Thus, the pressurized system can allow simultaneous distribution of water to very distant units of land but this makes control of illegal openings, preventing an equitable distribution, more difficult to detect.

The new idea of irrigation network has caused another main shift: the turn of water is organized at the stage office but it is traditionally set up around the needs and work of the ditch rider, and not around the farmer, in order to allow the JVA's employee to reach less distant FTAs to open, close, or check them. Therefore, water delivery is generally delivered to the same branch, rather than to FTAs located in different parts of the network (chapter 5.2.1).

The *ganawati* (ditch rider) played, and still plays, a central role in water distribution since he stands at the interface between the bureaucratic schedule and the local distribution. Due to this mediatory role, he is often accused of bribery, manipulations and favouritism: indeed, the *ganawati* holds some power since he is the one in charge of opening the FTA and closing it. Many cases of *ganawati* manipulating the distribution of water for personal and family interest are reported and pose a problem of equity. At the same time, he has always represented a leading figure: "I have been walking, as *ganawati*, from Abu Abeidah to Kreimeh [distant of about 10 km], every day, every place I know!": the *ganawati* walks in order to open and close FTAs, or before the pressurized system, the open canals' gates (manual gate valves were put in operation in 1969 when the KAC was built). Further, the *ganawati* has a deep experience of past irrigation network and water allocation since, before, canals where manipulated based on a knowledge of water flow, in relation to the opening of the valves on the main and secondary channels. This role has inevitably highly changed in present time with the technological transformations and the new regime of water distribution but still refers to an important and recognized perception of local control by the community on part of the water distribution.

In striking contrast with all other previous experiences of water distribution, the pressurized network functions better when water is delivered all over the network and not to a single irrigation branch, since if the flow is in the pipes, then the head losses are also less. At the same time, the higher the pressure in the network, the more difficult it is to control, although the water management by the JVA has often overlooked the main concept of network interdependence due to lack of hydraulic knowledge.

On the contrary, traditional irrigation was conceived as a localized, visible process along a secondary canal or, now, along one of the branches of the pressurized pipes of a pumping station. From a localized activity, it has been de-localized and fragmented at the scale of a wider network: this gap is one of the main contested issues between an efficient system of delivery and the bureaucratic needs. Besides, this idea of network is indeed very far from the practical experience even of skilled farmers and has radically transformed their perceptions of water management in relation to place. Thus, water is today, even more than before, related to a concept of "network": farmers are more functionally interrelated than before in irrigation not just due to the scarcity of water but due to a new system that makes the wider and even distant hydraulic connections more important. In this situation that would request a stronger interconnection of water users, we face on the contrary a long process of erosion of local communities and chronic mistrust towards water institutions, and a slow transition towards other and new forms of cooperation. This indeed makes the whole process of common resources management today so difficult.

Further, the introduction of new technology, the use of PCs and adapted software has led to the computerization of the control and the allocation of water. This is a major issue, since a new instrument has substituted tribal rotation of water-time and now substitutes the pen and hand-made calculations and manipulations of the stage office. Before the computer schedule, this task was performed by the *katib idhara* who used to organize the amount of water to distribute, although today many question the basis of this measurement and calculations. But PCs and softwares have become important tools in water management, making knowledge transfer necessary for any possible local participation.

Water network distribution is now controlled at distance at Deir Alla through a software program that defines and monitors the pressure and the volume delivered at any pump stations in the valley. Far from the sheikh's and community control of water delivery and illegal openings, a central administration controls remotely but this means also that this distant control, along its hierarchy, can be manipulated, changed and circumvented, even more in the context of lack of staff in both quantity and adequate skill.

As water is not visible anymore, buried in pressurized pipes, stealing is not directly evident nor visible, but appears through a pressure drop at the pumping station level. Pressure has become the crucial indicator of quantity of water, of network balance, of fair distribution; but if the pressure decreases, a vicious circle of more stealing and of decreasing pressure takes place in the entire network, which constitutes the main daily problem in the valley. Pressure thus has become the added value in the control of water at the different levels of the hierarchy of the JVA management: in order to hide the stealing at pumping station, pumps are made to function less (for example two pumps instead of three), the pumping station is stopped before time, or gate-valve are partially closed. These actions do solve the problem temporary –the problem of total delivered volume, not of stealing- but just skip the conflict, in a process of manipulation, which is complex just because of the complex hierarchy and multiple interests and interest groups that are built around water.

Finally the concept of network has brought in the idea of on farm design of network, a new way of conceptualizing the irrigation branches in the farm and a new expertise that has become relevant in terms of efficiency of the network, since malfunctioning due to the poor design, but also due to poor operations, leads to water clogging, excessive head losses and water leakage. This raises new problems for farmers and the need for a new knowledge. If micro irrigation is less labour intensive and allows saving hours of work that were spent before in long surface irrigation turns, at the same time, irrigation has become indeed highly ‘knowledge intensive’.

*Water and the New Concepts of Place*

Historically, the new irrigation layout has introduced new ideas and organization of place. The valley landscape has been completely re-organized following planning intervention around water: while the ‘Project Area’ in the Jordan Valley has delimited the boundaries of planners’ intervention, local communities’ strategies and life-worlds extend often beyond this region and outside Jordan, mobilising social networks in multiple locations. Thus, while planners and development agents define the Project Area as their spatial reference of action, as a bounded region, in practice it corresponds neither with actual practices, economic ties, and mobility of the valley inhabitants, nor with the multiple and wider locations of the kin groups and local perceptions.

Besides, other conceptions of place are relevant here: the management of water has divided the valley around three main Directorates, each sub-divided into areas linked to pumping stations, and each of these organized in branches and sub-branches of the irrigation network. New terms as DA (Development Area, sub-directorate) 2, TO 41 (Turn Out Office), branch 16 as one of the branches of a Turn Out, local names of sub-branches, or FTA n.178 (Farm Turn Out Assembly that delivers water to a numbered farm unit) have become new definitions of place for farmers in the new setting of the valley.

These are all new divisions of space, and also of communities, which overlap with previous names given to specific areas, often linked to tribal or lineages names. But the irrigation branch today does constitute a community, since different communities are dispersed and work land even far away from their homes, a fact amplified in case of tenants who may move very far in the search for new and better land. While the new system has introduced new ideas of locality, in which water has been re-organized and distributed, relations of solidarity have often been consequently transformed and delocalized in the management of water. In some cases, there is a social homogeneity of the farmers around the main branches, while in other cases it is highly heterogeneous: a new community and new relationships of solidarity are under construction, but they take more time than building up the water infrastructure itself. In this reality, the constitution of Water User Associations (WUA) could make some steps forward but only if farmers are not passive recipient of external project and turn the WUA into their own project, with their own adaptations and patterns. Another issue linked to the definition of locality is the following:

> “Many farmers are renting land: and if one changes farm as often happens and goes to another pump station, what happens? Or the problem of different owners in one unit, who is the representative in the association?” (farmer in TO 41)

This highlights the complexity of framing a community based on water in a context of different terms of belonging, of multiple spatial attachments and of the mobility of agriculture investment.

*The Resource Management Regime*

> “Making progress with improved JVA service has proved to be more difficult than persuading the farmers to work together” (Regner, 2002:23)

This statement well highlights the dependence of farmers on the water management regime in the Jordan Valley (see also chapter 6) and the fact that, in order to solve the numerous conflicts around water, all the different actors in the context of the Jordan Valley should realign themselves in a change of attitudes and power relationships.

The expert system introduced has indeed a specific culture of organization and is linked to a resource management regime. By the latter, we refer to the discourses and practices of water management that have become dominant today in the valley: it includes an authority system, a regime of justifications of its action, ideas and values connected to water, ideas of equity and efficiency, a hierarchy of control and access to information and knowledge. Many actors intervene and interfere in water management in the Jordan Valley: from donors and technical agencies to Water User Association; from the central administration of the JVA (in Amman or in the control centre in Deir Allah) to the three Directorates; from the stage office, to the pumping stations; from the ditch riders to the farmers. This constitutes a "hydro-political constellation", where political status is built around the management of a scarce resource: the most contested site is represented by the FTA where different policies, water cuttings but also illegal openings take place. We will take into account the water regime in order to highlight the fact that what is often at stake is not just the contested quantity of water but also the power relationships between the different actors in the "water relationship".

*Contested Knowledge on Water*

> "The foreigners think we are primitive, they do not treat us on an equal basis!" (Farmer in TO 41)

This farmer raises the main concern of the devaluated perspective in which farmers have been often conceived by engineers, experts and researchers. Indeed, this is at the core of the scepticism between farmer and planners and their mutual non-recognition and mistrust of the past. Notwithstanding numerous surveys and continuous interactions, mistrust, mutual stereotypes and lack of knowledge define today their relationships. This dynamic is historically linked to the asymmetric relationship in which farmers have been caught up and to the lack of attention to the social and cultural frame of technical innovations. This aspect is yet more relevant from the moment that water has become an interface of contested knowledge. Secondly, the access to and control of information on water have become strategic in water management. In fact, drip irrigation introduced with it a wider technological apparatus, as specialized skills, soil sterilization, humidity control, pesticide schedule, fertilizers distributions, new seeds and varieties, new operations and a new broad and intensive knowledge of water, all elements not practiced previously.

The elite system of the water management regime holds the expertise and the control on resources through infrastructures, information and knowledge. That is why any change in water management should tackle the crucial issue of access of information on water by farmers. As noted by Waller, "water managers use their expertise to portray them (i.e. the changes) as technical rather than political decisions" (Waller, 1994:20). This is a major issue in the Jordan Valley, where water management is often portrayed as an expert endeavour, too complex for any farmer to handle it. This technical priority has depoliticized both the actual political decisions, which are made in relation to water, as much as it has neutralized a public debate on water issues in Jordan, leaving them to the expert system, consultants and decision makers. In this way, water management reflects a hierarchy of power and had difficulties in becoming a public debate in Jordan.

Another important consequence of the present delivery system is that political loyalties and favours are distributed around water management. In fact, "the political objective of securing the loyalty of influential constituencies collides with the objective of providing efficient irrigation services by the JVA" (GTZ, 1999:59). Political asymmetry is at the core of the critics of many farmers, who complain about the lack of equity, transparency and the bias in water delivery.

Further, some characteristics of the JVA are here relevant in understanding the relationships linked to water management. First, "JVA lacks autonomy and has a conflict of interest and unfair reciprocity relationships with several of the government's institutions, creating confusion with respect to its mission's statement" (Suleiman, 2004:29). The multiplicity of political actors and management responsibilities in the past has caused a lack of coordination, an issue that the recent centralization of water policies in the Ministry of Water and Irrigation (MWI) has tried to solve (chapter 4.5). Besides, as GTZ has argued, "JVA is a standard government agency lacking key aspect of autonomy. It lacks the power to hire and fire staff (..) it also lacks financial autonomy and has no freedom to set its own budget and to retain its revenues." (GTZ, 1999:20). Lastly, expert staff is nearing retirement and there is "the danger that valuable knowledge about the system management is lost because it cannot be passed onto successors" (Regner, 2002:10).

*Information as a New Strategic Resource*

Information on water has thus become a crucial variable at all the different levels of water delivery, from the directorates down to the FTA: water delivery is the consequence of a wide network where different actors influence and manipulate the water distribution through the management of information on water. It is not just balancing water which is at stake here, but balancing the information on water. The lack of information on water is at the core of the lack of trust perceived by farmers vis-à-vis state agencies, since they recognize that they are excluded from decisions that directly concern them.

The complexity and hierarchy of the irrigation network is today one of the main impediments for a potential transfer of part of the responsibilities to farmers and WUAs; it is not enough to call upon farmers' participation in water management if organization of the whole network is not re-adapted and transformed in practice. The information of water follows on one side a hierarchy, which is linked to the organization of the water institutions; but at the same time, lines of authority can be overruled by informal processes, by external and transversal manipulations. We will present here some major aspects of the hierarchy line of this top-down flow of information.

A first aspect that influences the water delivery is the pressure of external aid and consultancies on irrigation issues, a reality that is linked to the political economy and dependence on aid of Jordan. A second element that impedes a transparency in water management is the unpredictability of water at the macro level. Some main data are strategic here: the winter rains and the Yarmouk River flow (including some extra transfers from Israel when requested, if accepted, during summer according to the 1994 Peace Treaty [chapter 4.2]), the amount of water going to Amman from the KAC and the yearly-diversion from Tiberius lake-Israel to the KAC: these quantities of water are crucial in determining the water available for irrigation in the Jordan Valley but are often unpredictable or non transparent and, above all, non directly publicly available. The water system is composed of dams, main conveyance system, secondary systems, on-farm systems, and drainage systems, and all these include variables in the acquisition as much as in the delivery of water that engender unpredictability of the amount of water delivered. This makes, for example, very difficult to balance out "water distribution between O&M Directorates in the valley and the municipality of Amman" (GTZ, 1999:28). Amman having the priority, the amount of water delivered then to the valley is often unreliable and its information comes late to Jordan Valley users, notably in the southern part.

It is important to add here that the information, and consequently the lack of information, concerns both the quantity as much as the quality of water: the past case of pollution of the KAC itself is one example on how water quality has become a crucial variable in the performance of irrigated agriculture (chapter 5.1). The last years of water scarcity have highlighted the gap of information but also the disputes between the Central Directorate and the three Operation and Maintenance Directorates in the Jordan Valley (GTZ, 1999). It seems indeed very difficult at present for the central Directorate to define the precise amounts of water it will allocate to the O&M directorates since those are often unpredictable until the very last moment. Only the central Directorate has a late knowledge of the supply to be expected (which can be variable) and of the short term requirements of Amman. Therefore, GTZ argues that "O&M and central Directorate can estimate 80% of their demand "while the rest of the data (20%) cannot be obtained in a reliable manner".

The priority of delivering water to farmers in the Jordan Valley encounters so other priorities in a distribution of water scarcity in the entire network. Furthermore, the water provided by the central Directorate is even more unpredictable due to the illegal connections of farmers.

The O&M Directorates should calculate their respective demands of water on the basis of information on the cropping patterns and the cultivated areas that are collected for the forty pumping stations and the 8000 FTA in the valley, by the ditch riders. However this data remains "theoretical" and often do not correspond to the field reality.[83] In fact, "farmers' demand is not based on actual crop water requirements but on what they think they (i.e. farmers) can use" (GTZ, 1999:39). Therefore the data collected is a virtual information, corresponding neither to the effective needs nor to the use of water by farmers in relation to the land cropping. This engenders inevitable asymmetries of information that impede a reliable knowledge of the water delivery and "the customer cannot be informed and so cannot control everything the provider does" (GTZ, 1999:40). What seems to happen is the conveyance of hidden information within this network, such as overestimations of water requirements by the Directorates, where the information on water is "manipulated for opportunistic reasons" (GTZ, 1999:40). In short, the difficult balance is made between the water availability, the expected water demand and the water quality control, all elements that reveal levels of unpredictability.

The lack of flexibility in the rotation schedule and in the adaptability to farmers' needs have been one of causes of stress for the plants and for the farmers too. Linked to that, the lack of on-time knowledge about cuts in water, as in the last 4 years, has definitely increased mistrust, since farmers came to know of changes in water delivery only after they had already planted and invested on their fields[84].

*Box 5-7: Water "stolen by the JVA": a case of contested water reallocation*

In Deir Alla region, a source of hot water near the village of Abu Zighan was very popular among local inhabitants, and it was also used by highland 'tourists'. This water source was constituted of two little natural pools where old or sick people used to go to have some relieving bath in the hot and salted water, young boys and girls used to go play in the only open swimming pool available, adults used to go in the evening to have a barbecue, eat and gather near the flow of water. Indeed, it was an important gathering site, where people of the valley encountered those coming from the Highland. It

[83] In 2004, the only cropping pattern maps that were available dated back to surveys done in 2000.

[84] These conflicts are also exacerbated in case of other operational problems such as electricity cuts, maintenance of pumps or other devices, or personal difficulties.

was therefore autonomously organized and managed: some cement works were done to make the entrance into the water easier; women could bath, while men had to wait at some distance waiting for their turn. It represented so both a popular health centre as much as one of the few places of enjoyment in the valley. All of a sudden, as part of the new nation-wide effort to capture all water resources available, the site was fenced and water conveyed to a desalination plant, before being pumped to Amman to cover its increasing demand. Local population of nearby villages (Deir Alla, Sawalha, Abu Zighan, Dirar, Er Ruweiha) were neither informed nor consulted and one of the few and important places of gatherings suddenly disappeared from the public sphere and was "taken by the Sulta (the JVA) as local inhabitants say. This form of re-allocation of a source of water was perceived as one of the many forms of coercion and lack of participation by the JVA that did not take into account local inhabitants and local use and values of water: from entertainment and health cure, water was directed to urban purpose The symbolic effects of this relationship just reaffirmed, at the local level, the asymmetry in decision making regarding water issues.

When farmers cannot know if they actually receive their precise allocation, they feel legitimized in taking out of their turn what they think they owe. In order to do that, they adopt multiple creative coping strategies: illegal openings, request of extra-hours, construction of farm ponds in order to store (sometime stolen) water, renting land; transfer of water from an uncultivated plot (declared as cultivated) to another. Besides they also manipulate the information on water by breaking water meters, hiding water stealing, hiding illicit cropping patterns, declaring false cropping patterns or hiding bribery and cancelled fines. Indeed, farmers are often highly reluctant to reveal actual information on their farm, while the JVA itself tries to avoid legal causes because they are too long and get the institution caught up in tribal matters and dispute solving. All these informal adjustments are tied to an imposed water planning, to a lack of transparency, and to an unequal access to resources. This should not legitimize these "illegal" acts but should help in understanding the context that has led to their diffusion in the valley. This gap of confidence has led to the lack of interest by farmers in the maintenance and repair of their FTA and of the water meters.

The lack of transparency is also engendered by the poorly maintained network, where reparations are also often linked to preferential priorities. This is also caused by an organizational problem, where there is no flow of information between those responsible for detecting the problem and those who should repair it. Besides, JVA employees often do not have the knowledge, the equipment or any incentive to check the service and the pressure along the lines.

#### 5.2.2.3 Water as Public Institution?

> "Jordan is full of water underground, the problem is who decides and its distribution" (farmer in TO 41)

Although this farmer is rather optimistic concerning the amount of groundwater resources in Jordan (chapter 2, 4.12 and 5.13), it explicitly refers to water as a political issue. Mosse, in his interesting study on water tanks systems in South India, argues that irrigation systems are "symbolic resources, [they] are public institutions, expression of social relations, status, prestige and honour" (Mosse, 1997: 472); in other words, they are public contexts and signs of a public activity (not in legal terms), where community is in action and expresses its values and contradictions.

In the Jordan Valley, irrigation has ceased to be a "public activity" and a public domain. Water has been nationalized and put into the hands of a centralized bureaucracy, new ways of thinking of water have been introduced with few or bad extension services, and applied with little attention to local ways of adapting to this radical change. More generally, water management has been often conceived as if water was given to the crop rather than to people who planted that crop: de-linking irrigation from its wider social context through a technical perspective did certainly not help in facing the political and cultural issues that are at stake today in this process.

On the other hand, local population were well used to react to changeable situations, they have re-adapted to the new context but not in the way prospected by planners: often the secondary consequences of technical projects are much more relevant and pervasive in practice than the official targets. Water management today is the consequence of many forms of manipulation and informal adjustments of bureaucratic rules at all the different levels of the hierarchy of water management; this is not just a perverse consequence of "traditional attitudes", but a main adaptation of local needs and power structure to a new management system and authority regime.

*Participatory management and Water User Groups*

In the last ten years, policies have pushed to a radical change in water management and Participatory Irrigation Management (PIM) has become an icon of this change in a context of non-cooperative behaviours, increasing conflicts between farmers and JVA, and among farmers themselves on water issues. In this frame, "self-seeking, non-cooperative behaviour has become a quite rational response to the institutional structure of the hydrological and agricultural conditions" (Trawick, 2003:986): the evasive actions in stealing water and all other creative patterns to evade formal rules are not here to be legitimised, but should be understood as a consequence of the asymmetrical relationships that have characterised state and farmer relationship on water, as part of the broader state-citizen relationship. They are the consequences of both the present legal pluralism and multiple regime of justification as much as they are amplified by the effective competition on water. These patterns "enable a rigid system to persist by simultaneously creating and disguising operation flexibility" (Lees, 1986:610). The context of the Jordan Valley should be understood not as a conflict between a traditional and a modern system, but as the interaction of different systems of authority and relationships that are "water-linked". Traditional community management and local villages have been in the valley "a corollary of the extension of state power, not its inverse" (Mosse, 1997:471). But this process of mutual interdependence of local communities and state formation in relation to water is further amplified by the conflict situation of the valley and by the presence of dislocated and migrant communities.

The fear of any change that may modify the actual *status quo* in water management is apparent: now farmers at least know how to manipulate and circumvent the system through personal relations in the hierarchic system, according to their status and social network. As a farmer in Wady Rayan mentioned:

> "Many farmers are afraid of the WUA because they fear the power of the largest tribes and so they prefer to keep the relation with the government, which at least they are used to and know how to manipulate in case."

The setting of WUAs, the new water policies, and the future decrease of fresh water availability for agriculture are some of the main concerns of farmers. The possibility that the most influential families and lineages could reproduce their power within the WUA is the main misgiving: since the strongest families are often the most educated, the more able to deal with JVA and to talk of water management, low-income group fear of being even more marginalized in this process:

> "People in the valley are used to follow the *tarik al aila* (the patterns of the family), they are not used to an association! There are farmers who have enough good relations, they know people in the Ministries, and they phone directly to solve some water problems."

The realities of water distribution and of local manipulations, which are based on the social network, are not static but the result of the encounter between the state and local heterogeneous population. The tribe has readapted to the presence of the state in water management in a hybrid system that reveals its inequalities. The present revival of local traditions follows often an idealized image of community with a strong rhetoric on local participation and democracy. In contrast, farmers express a widespread scepticism towards the possibility that WUAs could work as an efficient means to get partial control of water management. First of all, Water User Associations in the valley remind farmers of the bad experience of the few past cooperatives, which collapsed after personal mismanagement or cases of stealing. Secondly, WUAs are inevitably new political institutions that may reproduce old social pressure of main interest groups within the WUA, amplifying an already present state of inequity at the local level. WUAs inevitably become a new disputed resource not just linked to water affairs but more broadly to political influence.

The new paradigm of PIM has been, even worldwide, often based on a false dichotomy, where the community stands as a polarity vis-à-vis the state: an opposition that often does not help in understanding local dynamics and the interrelation between the construction of the state and the change of local communities. In Jordan, we cannot understand the recent state construction as a mere opposition to local communities, since both have been intermingled in a dynamic of cooptation and mediation in daily practice. This simplistic notion of "community", de-contextualized from its historical and political frame, tends to remove issues of social and economic differentiation in water management, of political tensions, and it obscures the power relations that are built around water, both at the community level and in the hierarchical organization of water. This leads to a desirable goal – participation- but without the proper tools and effective change of political and social relationships around water.

In order to transform what is perceived as a state affair regarding water management into a public domain with more transparent rules in the access to this resource, a change of the present relationships between farmers and the state and their asymmetries has to take place. The irrigation management regime has to make adjustments in its own structure and functions, and not only the farmers.

The state-driven ideologies of community development can in fact do more harm than good if they are not paralleled by a critical analysis of the complexity of the local context. The ongoing process of constitution and spread of WUAs in the Jordan Valley, a process led in the last years by several GTZ projects in the Jordan Valley, is definitely an attempt to build a new frame of community. Indeed, in some areas the social homogeneity of one tribe or one common lineage may help in constituting a common group of interest around water use (transparency and participation in defining water turns and extra hours delivery; delegating the opening/closing of FTAs to users; maintenance of water meters; avoiding stealing water in a frame of a collective responsibility undertaking, as main examples), but in many other regions water users belong to different families or social groups, and this makes common organization more difficult. Facing this new process, one of the fears of many farmers is that the JVA and state administrations will retain their power and privileges, and that the WUA promotion will just be another state-driven process to co-opt, in some cases control, farmers and intervene in their affairs. It is also perceived as a tool to delegate and pass tense issues over to farmers, like water stealing or tribal affairs.

Some instances show that a delegation of responsibility could be possible, if responsibilities are truly delegated. In Grega, Wadi Araba, for example, two cooperatives, representing two main tribes, manage potable and agricultural water on their own. They cultivate 200 units of land that are redistributed on a rotation schedule every year, in a clear similarity to the old pattern of musha' system (chapter 3). They are responsible for maintenance and control of the network and the cooperatives are sustainable in economic terms. In Wadi Rayan area, too, farmers joined together in 2002 when facing severe drought and water cuts by JVA during the summer period. In order to capture the unused water from a little stream flowing through part of TO 41, the farmers cooperated in an autonomous way, setting up a pump on the stream, and conveying the water through pipes to the 16 farmers of this informal cooperative, irrigating around 40 units of land through a system of self-managed turns of water. Interestingly, this informal association was not based on a common social belonging or linked by family ties; on the contrary, it gathered farmers of different social belongings on the basis of a common need, territorial contiguity, and of their own expertise, pumps, and tubes.

This process of state-driven participation has to be looked at in the wider context of the construction of civil society in Jordan, which has always been highly dependent upon the will of the regime, with its priority on stability and internal security, due to the Jordanian dependence on external politics. Thus, the state-citizen relationship has been shaped by strong external factors, through patterns of cooptation, control and censorship. This has constituted a security state, where the presence of a large population of refugees has certainly played a major role. Notwithstanding the process of political liberalization after the 1990s, professional organizations have been strictly controlled, labour unions have been co-opted and associations often censured (Brand, 1995). WUAs develop in the context of these past experiences and of past mistrust and vulnerability of local forms of official participation.

*Stealing Water*

As many farmers stated, "bil haram, bil halal, we have been stealing!", haram and halal being the two most important concepts in defining what should be forbidden and what is allowed, connected to sacred and normative significance. "Bil ghor ma fish dor!"("in the Jordan Valley there is no turn") is another common expression that shows the custom of stealing as a common practice. Cheating and stealing have become part of irrigating in many local perceptions, although it is acknowledged that the counterpart is not only JVA but that neighbouring farmers also lose water when someone else steals (chapter 5.2.1). But the rigid and hierarchic structure of water management is seen as the main cause that obliges farmers to steal, if they want to irrigate their crop:

> "Often I need some water, outside the turn, but just some hours that are necessary in some periods in greenhouses. I ask the engineers of the Jordan Valley Authority but they tell me that it is not possible. Water is a problem because engineers of the JVA always stay in their office and they do not know what happens outside in the fields. If I have a problem that cannot be solved here, I even have to go to the central office in Amman!"

Thus, the issue of water is perceived as out of farmers control, centralized in the hands of the JVA and therefore stealing of water has often lost the moral condemnation attached to stealing other resources. "Here everybody was stealing before, if one did not, he could die with his farm!": this other quotation shows the feeling of passivity and the vicious circle of water stealing. Rules are seen as something that farmer can manage to circumvent and stealing has become a daily, collective and necessary custom in order to get the farm productive: "*mn shabba al-shi, shabba ale*" ("Who grows with one pattern, goes along with it"). Furthermore, as a farmer in TO 41 stated, "in water issues the *qu'a* (power) is above the *qanun* (the law)!": the local hierarchy of power circumvents in practice the rules and the water schedule, since who has political and economic influence can manage to get access to better or higher water distribution. Notwithstanding the fact that water does not constitute the main expense in the farm (chapter 5.1 and Viand that water has become a major concern due to the scarcity in the last years, water represents locally a political, more than an economic problem, as this quotation shows:

> "With tellim and dullab (i.e. traditional furrow irrigation) there was much more work but more water was available. The main expense in the farm is labour: I spend on this unit around 3000JD ($4,200) for labour. (…) Water does not cost much, I pay much more in Ajloun, here I spend only between 8 to 12 JD a month ($11 to 17)" (farmer in TO 41)

The struggle between, on the one hand, the extensive bureaucratic and computerised distribution system and on the other hand, the so-called illegal methods daily reinvented by farmers to get access to water, which contribute to a decrease in efficiency of the system, expresses different and contrasting 'projects' within water management.

Farmers steal water by adapting new methods of opening the pressurised pipes, by breaking gate valves, by breaking or modifying the diameter of the flow limiter in the irrigation outlet (or FTA); they can also pump directly from the main canal; open the valve along the network (chapter 5.2.1) while controlling the roads when they steal in order to avoid fines. This continuous reinvention of stealing promotes an increasing emphasis on efficient management by donors and pressure for stricter control by the JVA, without ever touching upon, or explicitly hiding, the general causes of these practices and frictions.

Water and irrigation are related to wider and multiple economic strategies chosen by the family, linked to the off-farm economy in a context that extends beyond the valley. What is at stake here is both the meaning of community and of the eroded sense of solidarity, but also the relationship with JVA, as state counterpart:

> "Many farmers today are poor, agriculture should be stronger in Jordan. On water issues, they think we are underdeveloped and that in two years we have to become as in Europe. The main issue is one of equality of water distribution because there are tribes that are strong and have strong linkage with government and they receive what they want."

As this representative of trade unions states, water is a political affair, and the ethnocentric and evolutionary prejudice of experts in the past has played an important role.

*Water, Conflict and Cooperation*

> "In the entire world, the water flows from the top to the bottom. Here is the opposite: water goes bottom-up, from the valley to the city, it then goes to the toilet flush, and comes back here!"(Farmer in TO 41)

In the Jordan Valley, farmers are well aware both of the radical changes that the valley has undergone, as much as of the political implications that water management entails. Especially in recent years, the belief has spread that "next year there won't be any agriculture here", as the continuous market crises persist and signs of the lack of sustainability of irrigated agriculture multiply, with the concomitant fears of water privatization and JVA restructuring.

The word of Mehta that refer to an Indian case, can be helpful here: "in such situations it is impossible to speak of water as a common good because there is no common or collective community. People see water as an issue over which they compete and are divided." (Mehta, 2000:4). Even in the Jordan Valley, water is something connecting to the state: the state is perceived as the provider, communities are fragmented over disputes and steal water from one another in a general lack of trust and cooperation. State control has indeed brought about contradictory results and the main friction has been the opposition or disruption of local patterns of cooperation. In the many disputes that arise around water, local cooperative patterns in managing a common resource seem to have eroded, and the mistrust between institutions and farmers is at the base of opportunistic and conflict-prone behaviours.

What is certainly relevant here, is that farmers have to make an effort to reinvent forms of cooperation that can lead to a better and more sustainable resource management (chapter 6), as much as the state agencies and employees, at various degrees of the hierarchy, have to reshape their traditional attitudes and roles: in the past, local institutions and patterns of management have often been censured in the valley and this has had a strong impact on confidence building.

The conflicts and stealing of water are linked to the coexistence of several overlapping principles in managing and distributing the benefits of water. These are connected to a multiple regime of justification, through a discursive frame that validates and gives legitimacy to specific actions although they come into conflict since they belong to different frames in understanding reality. Therefore, they engender crises in the distribution of water and in farming performance, as stealing, circumventing laws, using wasta or personal relations to get access to a benefits or resources. These frames of actions are also linked to different ideas of "common interests" around water, since multiple interests coexist that do not always collide. We could synthesis some main regimes of justification in managing water that are mobilized in the Jordan Valley in order to explicitly legitimate specific actions.

- "the right of thirst", which refer to a moral and religious frame;
- The *qanun*, or the State law represented here by the JVA, which should be enforced for efficiency and equity in distribution;
- The family solidarity, related to a moral regime of autonomy and honour of the family and linked to wasta, as pattern of mediation in getting access to a resource.

These three main patterns are linked to different actors involved in water management, to hierarchies and different ideas of equity. It is interesting to refer here to the work of Sherl and Assaf (GTZ 2003) on the farmers' perception of water stealing in the Jordan Valley. Often farmers feel justified to steal and forced to steal by their need of water and stealing becomes a vicious circle. Although stealing is generally considered by farmers *haram*, 'forbidden' in a religious idiom, it is justified in the case of water since it represents the icon of state delivery and of a patron-client relationships between state and the citizens. Therefore, the right of thirst is called back as a universal principle of equity of the needy. In the frame of an asymmetrical relationship, stealing water has become often a widespread sport, where farmers compete in exhibiting more smartness than others in circumventing rules that they perceive as imposed. Being smarter than others coincides with being proud of manipulating the system, of acquiring a space for autonomy in the lack of transparency and the perceived lack of respect by JVA.

There is an explicit critic to water policies, which in local perceptions privilege Amman at the expense of the Ghor and favour influential families instead of the general community. Further, the water crisis is highly politicised and is perceived as linked to the Gulf war, to water policies, to the increase of conflicts on land, to the decay of family and tribal structure. Besides, water access is definitely linked to the unequal access to land and to the presence of unequal size of holding in the valley that have "strong impact on the functioning of the system of water allocation and delivery in the valley" (GTZ, 1999:24). This widespread conflict situation is expressed locally by the erosion of tribal solidarity and of the patterns of cooperation within the lineage; this is locally linked also to spying, to the evil eye and jealousy that increase the tension between farmers, in a place where farmers are no longer neighbouring their relatives or their own clan. It is indeed this history of socio-environmental conflict in the context of change that has undermined local patterns of cooperation (Nims, 2003).

*Water Mediation and Family Solidarity*

Farmers use and emphasize personal ties and family relationships through wasta within the JVA to obtain keys to open the farm turnout assembly or to adapt irrigation timings to personal needs through illicit and personal exchange of favours. The forms of mediations in the access to water make the rigid system more adapted to the daily situations but also reflect the different political hierarchy in being able to get access to a smaller or bigger wasta, as a form of cooperation and solidarity within the extended kin group. Water is the main term of the encounter with the administrative practice and stealing water is a normal practice to cope promptly with the need for it. The ganawati (ditch rider) well represents the encounter of different perspectives in his difficult mediating role. As a JVA water employee, himself a part-time farmer on a unit of land, reported:

> "With the open canal system it was easier to steal water, with the pressurised system it is more difficult, but farmers in any case find different methods to obtain water. When you are thirsty, you find the way. If they steal the water, it's because there is a reason. They could leave the keys of the valve with the farmers and there won't be any problem. But in the actual situation we cannot go straight."

At the stage office the only term of flexibility in a quite rigid allocation system is the selective delivery of extra-hours (Petitguyot, 2003 and chapter 5.2.1). The lack of transparency on extra-hours allotted is another form of hidden information, where water can be distributed on the basis of preference. This is related to the fact that stage offices act often not just in an operational context, but have become, as many other offices, large diwan, where hospitality is performed and social networks are activated. The diwan has definitely entered in the stage office of the JVA (*madakha*): which is indeed organized as a diwan in its dispositions, hospitality rhetoric, time devoted to relationships, reciprocity of honour and respectability and exercise of power. This has become a crucial place of exchange and diffusion of information on water and therefore the stage office is often full of visitors and farmers with different requests such as extra-hours, maintenance problem of the FTA, change of turns of water; they may also just hang out because they can sit, sip a tea or coffee and get access to information. Indeed, "sitting" in these contexts is an intensive dynamic, where the hierarchy of the position, of word and of authority follow that of reputation and status. It constitutes therefore the place where water management, in the actual conditions, is made effective and more flexible; but the problem is who has the authority to make requests and who has not, who has the political influence to manipulate the information and get access, for example, to more water, and who has not. As any other diwan, this place of hospitality, assimilated within the water bureaucracy, reflects the hierarchy of status of the guests and their capacity to have a "voice" (*sot*) that has to be taken into account in public.

## *5.3 Agricultural Water Management in the Highlands*

### 5.3.1 Technical Aspects of Water Management in the Highlands

#### 5.3.1.1 Historical Perspective of Groundwater Exploitation in the Lower Jordan Basin

This section complements the overview on groundwater resources given in chapters II and 4.12 In Jordan, the first wells were drilled during the 1930s in the Azraq oasis and water was pumped for both local agriculture and domestic uses in Amman (chapter 3). Some wells also existed along side wadis and tapped shallow neighbouring aquifers. In the highlands and notably in the eastern desert region, the shift from animal husbandry to agricultural activities based on exploitation of groundwater resources was a state policy as far back as the 1960s when diesel motor pump were largely introduced. Groundwater exploitation was further developed in the 1970s and 1980s with the introduction of new drilling techniques and electric pumps powered by the newly established electric network. Groundwater development also allowed Jordan to meet its domestic and industrial water needs. Some governmental well fields were developed near cities (notably near Amman-Zarqa: the number of large-scale deep wells used for domestic purpose in Amman doubled from 6 to 12 between 1975 and 2000 and the total quantity of drinking water abstracted increased due to growing urban pressure) while other cities were supplied through interbasin transfers (chapter 2, 3.12 and 5.14).

A water accounting exercise done for the lower Jordan River basin yielded estimations of the average annual abstracted volume in the 1950s, the 1975s and 2000s for each of the four groundwater basins of the LJRB (chapter 5.6). Groundwater exploitation was almost nil in the 1950s. In 1975, only the Amman-Zarqa basin was significantly exploited (85% of the annual recharge: most wells where then located in the region of Wadi Dulheil and were part of Bedouin settlement projects) while groundwater abstracted in other sub-basins was lower than half their annual recharge.

During the last 25 years, private agricultural wells have mushroomed in the eastern desert area (notably in the vicinity of the city of Mafraq) in both the Yarmouk and the Amman-Zarqa Basin. Groundwater abstraction for agricultural purposes amount to 43 and 59% of all water and all freshwater used for irrigation in the LJRB, respectively. Measures adopted to limit agricultural groundwater abstraction will have strong impacts on the Jordanian agriculture sector but are highly needed as the current groundwater abstraction amount to 157% of the annual recharge of all aquifers of the LJRB (THKJ, 2004 and chapter 4.2). Due to a high density of wells (Figure 5-32, the Amman-Zarqa and the Jordan Valley basins are the most over-exploited. In 2004, groundwater abstraction reached 215 and 170% of their respective annual recharge. The same year, abstraction in the Yarmouk basin reached 125% of its annual recharge. Only the side wadis basin, rainier, was exploited below its annual recharge (74%).

Figure 5-30 illustrates wells dynamics both in northern Jordan since the 1950s and in the Amman-Zarqa Basin since the mid 1960s. The increase of the number of wells was sharp during the early 1980s when agriculture was particularly profitable and when farmers beneficiated from governmental subsidies (chapter 3 and chapter 4.1). There were 29 wells in northern Jordan in 1950; in 1994-96, this number reached 1,628.

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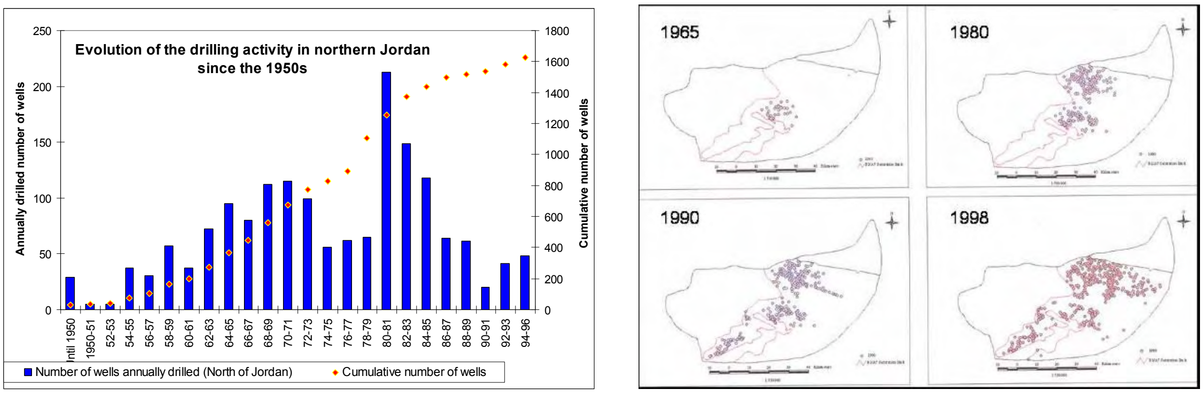
*Figure 5-30: Dynamics of wells in northern Jordan (left panel; BGR-WAJ, n.d) and in the Amman-Zarqa Basin (right panel, ARD and USAID, 2001b)*




### 5.3.1.2 Demand-Management: a Changing Pattern of Groundwater Exploitation?

In the early 1990s, Jordan's officials evaluated the coming water crisis and began shifting their policy focus from supply augmentation towards demand management (Al-Jayyousi, 2001; chapter 4.2). The World Bank and other development agencies were influential in calling for an agenda that would include demand-management instruments to encourage efficient water use, transfer water to nonagricultural higher-value uses, and reduce groundwater overdraft (Pitman, 2004). This section lists some of the measures taken to reduce groundwater abstraction as well as the difficulties met to implement them:

*Well Licensing and Abstraction Limits*

From 1962 to 1992 licenses to drill agricultural wells were granted by the government. Two- thirds of the licenses granted specified the maximum amount of water that each farmer could pump (most commonly 50,000 or 75,000 $m^3$/yr, and sometimes 100,000 after 1990; Fitch, 2001) but these limits were never enforced by the Water Authority of Jordan (WAJ; THKJ and MWI, 1997b, 1998a). Farmers do not feel concerned by these limits, rarely mention them during interviews and often exceed them in the eastern desert area (chapter 4.2, 5.11 and VI). Licenses also specified a licensed area which could be irrigated, in order to limit water transfers between areas but this has never been enforced. Wells which do not have an abstraction license are considered "illegal." After 1992, only few licenses have been delivered and drilling wells was made illegal. This constituted one of the main policies implemented in order to reach a more sustainable use of groundwater in the country. In spite of this interdiction, the number of operating wells controlled by the WAJ has strongly increased since then (see WAJ records of 2004 in the following section).[85]

*Taxes on Industrial and Domestic Groundwater Abstraction*

From 1994 onwards, well owners have been charged 0.25 JD (0.35 $) for each cubic meter pumped and sold/used for industrial or recreation purposes.

Since 2002, well owners are also charged 0.25 JD (0.35 $) for each cubic meter they pump and sell for domestic purposes. This taxation was implemented to limit the parallel private drinking-water supply system in the region of Amman. This private supply actually competed with public services and undermined the measures taken by LEMA to modernize the city's distribution network (chapter 5.4). Large water consumers (hotels, restaurant) preferred buying water from private wells than to be connected to the public network (for which they have to pay some taxes). This measure has been effectively implemented and since 2002, the movement of tankers in the region of Amman has strongly decreased and so did competition with public supply. However it is not sure whether this private water supply has decreased since Amman population has strongly increased during the last 5 years, while the public network is still under rehabilitation (chapter 5.4)

On governmental wells, fees are different: 0.35 $/m$^3$ are paid for beautification purposes (public gardens…) while 0.14 $ are charged for every cubic meter pumped for drinking purposes.

*Well Metering*

Since 1994, the WAJ is developing a policy of groundwater control through the installation of water meters on all wells in the country. In 2001, for example, 90% of the wells located in the Amman-Zarqa Basin were equipped with a water meter. Between 1995 and 2002, the number of wells controlled by the WAJ increased from 1,630 to 1,865 (WAJ-records) while the total water abstracted and evaluated by the WAJ decreased during the same period (see below). These two observations seem to be contradictory and can only be reconciled if the average quantity of water pumped in each well has continuously decreased since 1995. Reasons for this trend could be very diverse (decrease of the irrigated area, decrease of water application per unit of land, pumping limitation in governmental wells, well capacity decrease due to a drop in the water table, misevaluation due to non-working meters, inaccuracy or lack of control…). A detailed study of WAJ database could help in understanding the mechanisms of this groundwater abstraction decrease and in identifying whether this trend is likely to last in the long run.

Since 2004, a USAID-ARD project brings technical support to the WAJ to generalize the use of water meters on deep wells in the Jordanian Highlands: homogenization of meters used, existence of spare parts to maintain the meters in operating conditions, capacity-building of WAJ-employees for water meter reading and repairing are some of the measures implemented

[85] This may be due to the development of well metering and do not necessarily mean than the absolute number of wells increases.

*Groundwater By-Law No.(85) of 2002*

Despite a growing concern about over-abstraction of groundwater since the mid 1990s apparent into several water policies (THKJ and MWI, 1997b and 1998a, chapter 3 and 4.12), the By-law No.(85) of 2002 constitutes the first real attempt to effectively control groundwater abstraction from private agricultural wells in Jordan and notably in the Highlands of the Lower Jordan River Basin.

In 2002, the groundwater bylaw introduced a system of quotas combined with taxation of any use exceeding the quota. This bylaw is officially presented as a conservation tool to preserve the quality of the main Jordanian aquifers (THKJ and MWI, 2002b and 2004a). It introduces effective metering and fee collection. However, instead of endorsing previous license quotas, the bylaw allowed uncontrolled abstraction up to a limit of 150,000 $m^3$ per year and per well, a volume much higher than the limits mentioned in the licenses. Rules for the taxation of the water pumped above this limit are detailed in Table 5-6

*Table 5-6. Water prices according to the volume abstracted in private agricultural wells.*

| Quantity of water pumped | Water prices in wells with former abstraction license -2002 bylaw- | Water prices in wells with former abstraction license -2004 amendment- | Water prices in wells without former abstraction license |
|---|---|---|---|
| 0 to 100,000 $m^3$ | Free | Free | $0.035/$m^3$ (0.025JD) |
| 101,000 to 150,000 $m^3$ | | | $0.042/$m^3$ (0.030 JD) |
| 151,000 to 200,000 $m^3$ | $0.035/$m^3$ (0.025JD) | $0.007/$m^3$ (0.005JD) | $0.050/$m^3$ (0.035JD) |
| More than 200,000 $m^3$ | $0.085/$m^3$ (0.06 JD) | $0.085/$m^3$ (0.06 JD) | 0 $0.098/$m^3$ (0.07 JD) |

*Source:* THKJ and MWI 2002b, 2004a: as mentioned in bylaw No. (85) of 2002

It is reported that farmer interest groups have obtained the canceling of the former limits against the acceptance of the principle of taxing volumes abstracted above a certain limit (Pitman 2004): technical, institutional and political difficulties act as impediments to the effective implementation of the reforms.

Compared with other water fees (notably on industrial and municipal groundwater use charged at US$0.35/$m^3$), the fees summarized in Table 5-6 are very low. Lower quotas and higher tariffs have been designed for unlicensed wells.[86] In April 2004, the first bills, corresponding to water consumption between 01/04/2003 and 31/03/2004, were sent to farmers. Until November 2005, no employee of the MWI had been entrusted with the task of collecting fees. In these conditions farmers have not yet paid these bills. However, fees can be cumulatively determined and could still be collected later.

Between May and August 2004, two amendments have modified the regulation: the first one is a lowering of the already low fees for the volumes abstracted in licensed wells between 150,000 and 200,000 $m^3$/yr. Volumes will be charged at 0.007 $/$m^3$ instead of 0.035 $/$m^3$ (Table 5-6). The second amendment concerns abstraction from brackish aquifers: the higher the water salinity, the lower the

[86] Unlicensed wells in Jordan are mainly located near the Azraq oasis out of the basin limits and in the south of the Jordan Valley where they tap the brackish aquifer.

fee. This will greatly reduce the impact of the bylaw in the south of the Jordan Valley and banana farmers will continue to deplete the valley aquifer (Venot, 2004a; chapter 6). In the highlands, this amendment will not have much impact since the two main aquifers generally have a salinity lower than 1,350 ppm (ARD and USAID 2001b) the limit above which the rules described above apply.

*Problems Faced to Implement the Measures*

The aquifers of the lower Jordan River Basin (notably Amman-Zarqa and Yarmouk basins) are some of the best-quality sources of groundwater of the country. Their present drawdown (0.5 meters a year in the Amman-Zarqa groundwater basin [ARD 2001; Chebaane et al. 2004]) is paralleled with a decline in water quality (due to increasing salinity and use of fertilizers and pesticides; chapter 4.4) and it is feared that both domestic and agricultural uses could be jeopardized and further costly investments in water treatment needed (ARD and USAID, 2001a; Chebaane et al., 2004; JICA, 2004; Venot, 2004a; chapter 6). In addition to these salinity problems, aquifer overdraft incurs growing pumping costs to all users and the abandoning of some wells (Chebaane et al. 2004). In order to avoid (or at least to limit) the related increase in prices, which is likely to be borne by the entire Jordanian society, the over abstraction has to be lowered and that can only be done through a strong decline in agricultural pumping, which will only be obtained through strong governmental action.

Implementing the bylaw is now possible since most of the wells are equipped with water meters (94% according to Al-Hadidi [2002]). However, several problems must be underlined. First of all, in 2001 and in the Amman-Zarqa Basin, only 61 percent of the meters were functioning properly (Fitch, 2001) and, although major replacement campaigns have been conducted, this problem is likely to recur. Moreover, there is an important lack of material and human resources since controls are done by a small number of employees of the WAJ. There are, for example, only three teams to control the entire LJRB and this is not enough to effectively control farmers' abstractions.

According to the head of one of these teams, each team is made up of two engineers in charge of water meter reading, one technician in charge of meter maintenance and two drivers. The team in charge of the surroundings of Amman is supposed to control around 400 wells monthly. This means about 10 wells per working day and per group of readers (the team can be divided into two groups if cars are available). Wells are very scattered and vehicles are not always available. These conditions impede frequent controls. There is a strong need to improve the efficiency of these control-teams by increasing material equipment (cars, water meters spare parts, portable flow measurement devices…) and by training other persons of the WAJ to meters reading. Only such actions should allow an effective implementation of the by-law, based on accurate and frequent readings.

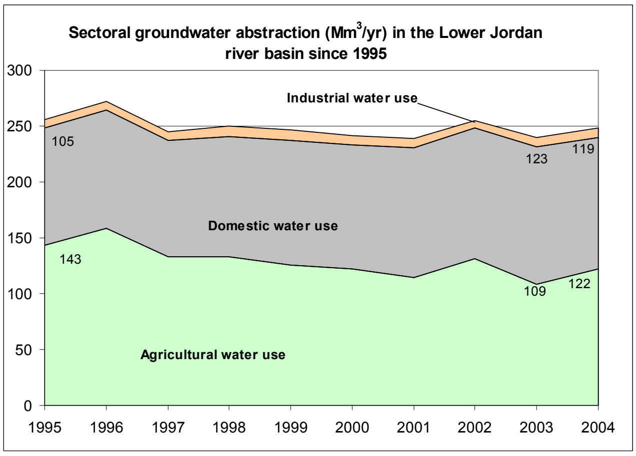
Another problem comes from the fact that meters are still not protected. Experience in the Jordan Valley has shown that if water meters are not protected in a box closed with a padlock, they are likely to be broken or at least fiddled with (Courcier and Guérin, 2004). As the meter is paid for by the farmer, the risks of deterioration are reduced but, on the other hand, tampering is quite easy and could become common.[87]

### 5.3.1.3 Pattern of Groundwater Exploitation and Difficulties to Evaluate Effective Depletion

*Pattern of Groundwater Exploitation*

Figure 5-31 illustrates the recent evolution of sectoral groundwater exploitation during the last 10 years. MWI records show that between 1996 and 2003, agricultural groundwater abstraction has noticeably decreased from 158 to 109 Mm$^3$ despite an increase in irrigated areas, in part due to policies supporting olive oil production and subsidizing planting of olive tree, although rain-fed production was the main target (World Bank, 2003; WTO, 2001). Reasons of this decrease are not yet clear[88].

*Figure 5-31: Sectoral use of groundwater in the Lower Jordan River basin since 1995 (Source: MWI database)*




This tendency to decreasing agricultural groundwater abstraction has been almost completely balanced by the slow but steady increase of domestic groundwater use: 119 Mm$^3$ were pumped in 2004 (against 105 Mm$^3$ in 1995). Industrial groundwater use remained constant at about 8 Mm$^3$ per year. Of the 2,804 wells registered by the WAJ in Jordan, 1,412 wells were located in the LJRB.[89]

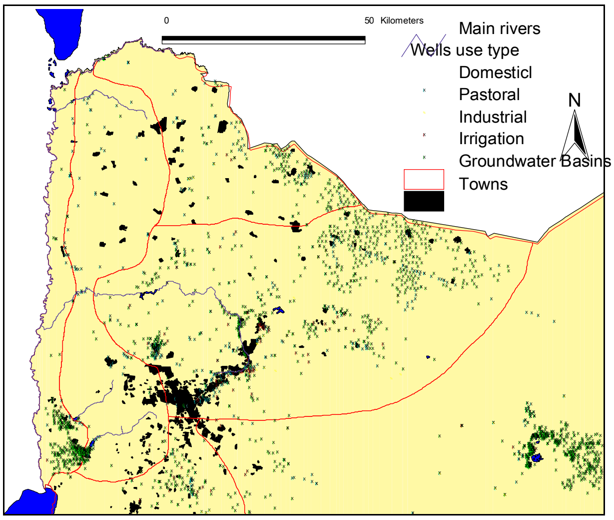
Figure 5-32 maps the different kinds of well of the LJRB and Table 5-7 discriminates groundwater abstraction in the lower Jordan River basin according to both the quantity of water pumped per well and the type of use of this water.

[87] On an anecdotal plan, during one survey in the highlands a farmer told us that he called the WAJ in Amman and managed to have the controller come to his farm to read the meter again, two days after he had received his water bill. The first time, the water bill indicated fees to be paid based on a consumption of 270,000 cubic meters. After this visit and a new reading of the meter, the WAJ employee agreed that the bill was not accurate since the consumption of the well ‘only’ reached 148,000 cubic meters. Thanks to a phone call, the farmer managed to save about $4,200 either because the first evaluation was really inaccurate, or because the farmer tampered with the meter, bribed the government official, etc.

[88] Possible reasons for this trend include: a decreasing pumping capacity of wells as the water table drops; underreporting due to the tampering or destruction of water meters; shifts from vegetables to fruits, from fruits to olive tree (Chebaane et al., 2004), and from furrow to drip irrigation, which may have lessened water abstraction.

[89] Out of these 1,412 wells, most are agricultural wells (1,009). 325 wells are used for domestic purposes while only 78 are used by the industrial sector.

*Figure 5-32: Wells distribution in the Lower Jordan River Basin (Source. MWI-database)*




Generally speaking, agricultural wells have a low production: 80% of the wells have a production lower than 150,000 cubic meters a year and represent 47% of the total agricultural water abstracted in the Lower Jordan Basin. Only 199 wells (20% of all wells in the LJRB) produce more than 150,000 cubic meters and will be concerned by the By-law implementation (see above).

*Table 5-7. Groundwater abstraction according to the capacity of the wells in the LJRB (data for 2004, MWI-database)*

| | Agricultural wells | | Municipal wells | | Industrial wells | |
|---|---|---|---|---|---|---|
| Producion per well (thousands of cubic meters per year) | Number of wells | Abstracted volume (Mm3/yr) | Number of wells | Abstracted volume (Mm3/yr) | Number of wells | Abstracted volume (Mm3/yr) |
| 0-50 | 432 | 11.5 | 69 | 1.2 | 47 | 0.9 |
| 50-100 | 248 | 17.2 | 29 | 2.0 | 17 | 1.3 |
| 100-150 | 130 | 16.2 | 22 | 2.7 | 5 | 0.7 |
| 150-200 | 87 | 15.1 | 19 | 3.3 | 6 | 1.0 |
| 200-300 | 61 | 14.3 | 54 | 13.3 | 4 | 0.9 |
| 300-400 | 25 | 8.7 | 33 | 11.5 | 1 | 0.4 |
| 400-500 | 7 | 3.1 | 25 | 10.9 | 0 | 0.0 |
| >500 | 19 | 9.3 | 74 | 73.6 | 3 | 2.9 |
| Total | 1009 | 95.7 | 325 | 118.5 | 83 | 8.0 |

Most industrial wells have a low capacity: 83% of industrial wells produce less than 150,000 $m^3$. Industrial use of water is mainly located in the AZB and the JV basins (nearby the cities and for potash exploitation on the Dead Sea shore; not shown). The distribution pattern of municipal (domestic) wells is different. Abstraction of groundwater for domestic purposes is mainly done in the AZB and the Yarmouk basins (not shown; see chapter 4.2). Low capacity wells are important in number (118 on 325 wells produce less than 150,000 $m^3$ per year) but produce little amount of water (5.9 $Mm^3$ a year). They may be owned by private owners selling water to tankers. On the other hand high capacity wells are largely spread (there are 132 wells producing more than 300,000 $m^3$ a year) and produce 96 $Mm^3$ on a total of 118 $Mm^3$ abstracted for domestic purposes in 2004). The municipal wells producing more than 500,000 cubic meters a year are generally governmental wells and produce the lion's share of domestic water in Jordan.

For agricultural wells, the structure of groundwater abstraction differs from one basin to another (not shown in Table 5-7). In the Jordan Valley, wells have a particularly low capacity: 60% of the wells produce less than 50,000 $m^3$ and 90% less than 100,000 $m^3$ (this remains much higher than the highest JVA's quota of about 15,000 $m^3$/year for bananas). In terms of volume, wells producing less than 100,000 $m^3$/yr represent 63% of the Jordan Valley agricultural groundwater abstraction. The low capacity of wells is directly linked to the small size of farms in the valley. In the Highlands, farms are larger and wells capacity higher than observed in the Jordan Valley. In the Jordan Valley, the bylaw will only affect 17 wells on the 353 wells that are currently monitored. Out of the 606 agricultural wells located in the Amman-Zarqa and Yarmouk basins, only 182 yield more than 150,000 $m^3$/yr and will be concerned by the bylaw (That is, 38% and 91% of all wells to be concerned by the bylaw in Jordan and in the LJRB, respectively). Discounting wells producing more than 500,000 $m^3$/yr,[90] this figure drops down to 166 wells that represent 62 percent and 7 percent of water abstracted in the Amman-Zarqa and Yarmouk basins, respectively (37 and 3 $Mm^3$/yr). Finally, the By-law could affect 183 wells, most of which yielding less than 200,000 $m^3$/yr. Wells in the side wadis basin have a low capacity and irrigate small farms in an essentially rainfed region. They are mainly located along permanent rivers, tapping shallow aquifers. There are no wells yielding more than 100,000 $m^3$/yr.

Note: The Disi fossil aquifer is different from other aquifers in Jordan. Most wells have a very high capacity. They are owned by very large and influential entrepreneurs (agricultural wells) or by the government (industrial and municipal wells). All wells used for drinking purposes yield more than 500 $Mm^3$/yr. Moreover, 75% and 40% of the wells used for agricultural and industrial purposes pump more than 500 $Mm^3$/yr. In these conditions, implementing the By-law in the Disi aquifer would have strong economic consequences on farmers and could lead to important water savings.

*Difficulties to Evaluate Effective Groundwater Depletion*

In addition to the difficulties linked to an evaluation of groundwater abstraction through well's metering (see above); chapter 5.6 will clearly show that one has to differentiate water use/abstraction and water depletion. This is notably of crucial importance to evaluate the net overdraft of aquifers when return flows from agriculture, domestic and industrial uses drain back to the aquifers and to assess the impacts that different measures aiming at limiting groundwater abstraction would have on the aquifers of the Lower Jordan River Basin (chapter 5.6). Based on estimates of irrigated areas (presented in chapter 5.1) and data on crop water use, we approximated groundwater abstraction and aquifer over-exploitation for the two main groundwater basins of the LJRB: the Amman-Zarqa and the Yarmouk basins. These evaluations are compared with earlier estimates from other sources and summarized in Table 5-8. Annual recharge values are drawn from THKJ (2004).

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[90] These wells are governmental wells. Water is either used locally (Amman-Zarqa basin) or pumped to be transferred and used in the Jordan Valley (*Mucheibeh* wells in the Yarmouk basin). They will not be affected by the bylaw although limiting this water transfer could lead to substantial water savings at the regional scale. Decreasing the production of wells producing more than 500,000 $m^3$/yr to 150,000 $m^3$/yr would allow savings of 3.1 and 27.4 $Mm^3$ in the Amman-Zarqa and the Yarmouk basins (i.e., 70% of the maximum expected water savings in the two groundwater basins) but will have dramatic impacts on Jordan Valley agriculture. These savings would represent 7.3 and 1.1% of the present gross groundwater abstraction in these two basins.

*Table 5-8. Different agricultural water abstraction in the Amman-Zarqa and Yarmouk basins.*[91]

| ***Source of estimates*** | *Amman-Zarqa Basin (Annual recharge: 67.5 Mm$^3$)* | | | *Yarmouk Basin (Annual recharge:37.5 Mm$^3$)* | | |
|---|---|---|---|---|---|---|
| | Total abstraction Volume (Mm$^3$) | Total abstraction % of annual recharge | Agricultural abstraction (Mm$^3$) | Total abstraction Volume (Mm$^3$) | Total abstraction % of annual recharge | Agricultural abstraction (Mm$^3$) |
| **Earlier estimates** | | | | | | |
| MWI- gross abstraction records for the year 2004 | 145 | 216 | 60 | 47 | 100 | 37 |
| Total gross abstraction according to ARD (2001) - prevision for the year 2002- | 155 | 230 | 80 | No Data | | |
| **Our estimate** | | | | | | |
| Gross abstraction | **168** | **249** | **83** | **73** | **195** | **63** |
| Net abstraction | **121** | **179** | **60** | **63** | **168** | **55** |

Table 5-8 indicates that gross agricultural abstraction records of the MWI are 20 percent below other evaluations. The MWI may underestimate present agricultural abstraction, partly due to the difficulties attached to water metering mentioned above. In "our estimate," gross abstraction rates are presently reaching 249 and 195 percent of the annual recharge in the Amman-Zarqa and Yarmouk basins. By computing return flows of irrigation and municipal/industrial uses, exploitation rates decrease to 179 and 168 percent of the annual recharges of the Amman-Zarqa and Yarmouk basins (net abstraction of 121 and 63 Mm$^3$/yr). For the LJRB as a whole, the overall net depletion of the aquifers comes down to 119 percent of their annual recharge.

### 5.3.2 Social Aspects of Water Management in the Highlands

We will deal here with the social context and the dynamics that characterize the Highlands of the LJRB. Two aspects in specific will be highlighted: the multi-resource economy in which agriculture and irrigation are embedded and the demise of pastoralism despite the resilience of pastoral system of values. Two main dynamics that strongly influence water use are the flexibility given by the family adaptations and the legal pluralism in resource management. Further, it is important to take into account the effects of mobility, in the old and new patterns, which link the LJRB with eastern or southern areas.

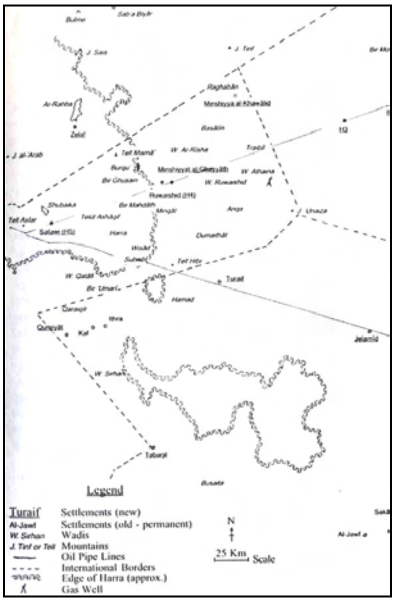
#### 5.3.2.1 <u>Bedouin Settlement and the Multi-Resource Economy</u>

As discussed in chapter 3.1, the Highlands have been characterized in the past by a strong social and ecological adaptation to unpredictable water resources, to continuous concerns for security and to a general lack of central government. The tribe, with its patterns of seasonal mobility and its local political organization, constituted the main political framework for the management of resources. We consider here the Badia region, that makes up most of Jordan: rangeland covers 88.9% of the country, 75% of which is desert rangeland.

[91] We used average gross abstraction rates as follows: 8,500 and 11,400 m$^3$/ha for vegetables and fruit trees, respectively (average between Fitch, 2001 and our surveys whose results are presented in chapter 5.1) and 5,500 m$^3$/ha for olive trees. Crops also receive between 100 and 200 mm of rainfall each year. Municipal and Industrial (M&I) groundwater abstraction has been computed according to MWI records for the year 2004. The net abstraction is based on efficiencies of 70% in vegetables and olive-tree agriculture, 80% for other fruit trees, and 70% in the domestic and industrial sectors. We assumed that all the water not used by crops infiltrates back to the aquifer.

Bedouins have been at the core of early development of irrigated agriculture, notably in the Amman-Zarqa basin (whose area is 60% of all LJRB highlands) but many of them later sold their farms to outside investors. The major tribes represented in the area are Ahl Al-Jabal, Al-Sirhan, Al Masai'd, Al Isa, and As- Sardieh, Al Shurafat, and Idhamat in the north and east part of Badia; Bani Hassen in the area extending from Mafraq to the outskirts of Zarqa; Bani Khaled and Bani Sakher in the Dulayl-Khaldiyya-Hallabat area and Bani Sakhr in the Middle Badia.

*Figure 5-33: The eastern Badia area (from Lancaster and Lancaster, 1999)*




The integration of pastoralism with agriculture in this area and the presence of a multiple pattern of ownership (both individual and collective) are two crucial aspects of the social framework of water management in the LJRB Highlands. If the tribe has become fragmented, in response to the radical transformation of land ownership and to the central government, at the same, time tribal solidarity has reproduced itself into an important political actor of the modern nation state (chapter 4.3).

The extensive development of groundwater use in north Badia led to a reconfiguration of the local social reality: in 2001, only 20% and 46.2% of the farm owners in the Zarqa and Mafraq regions, respectively, were of Bedouins origin, with their own dirah in the Badia (ARD, 2001; Jabarin, 2001). Private investors formed the vast majority (76%) of owners of surveyed farms in Zarqa and 49.1% of those in Mafraq.

This region presents a higher percentage of Bedouins controlling land due to the fact that communities in North Badia are more attached to their lands due to the symbolic value of the dirah. They grow seasonal crop and while some of these farmers have decent revenues, the majority has marginal income and large debts (chapter 5.1). Further, about 50% of the farmers are managed on a day-to-day basis by the owners, 40% are managed by labourers and agricultural engineers (…) and the remaining 10% are leased farms and managed by sharecropper or tenants" (Chebaane et al., 2004). Private investors include professional farmers from other regions of Jordan, especially from the Jordan Valley, but also returnees from Gulf countries after 1990. This last influx was determinant regarding technological investment in irrigated agriculture in the Highlands but also in political terms, since it represented a large frustrated population who often came back to a country which they did not know well.

Most of these exogenous farmers in this area own modern tree farms or seasonal crops/tree farms. As reported by ARD (2001), "these farmers often represent only themselves (…) they may rally behind Bedouin community leaders to protect their interests". Government officials and employees, senior army retirees, and private sector employees have invested in agriculture in the Highlands and mainly developed olive tree orchards (chapter 5.1 The concomitant reduction of profitability of sheep rearing, compounded by the suspension of forage subsidies, has also turned agriculture into a potential alternative strategy.

The irrigated agriculture sector employs a fairly large number of local labourers (67%) and local females form the majority (64%) of the total working force and compose 96% of local labour. The majority (70%) of permanent labourers are foreigners, mostly Egyptians (Chebaane et al., 2004). The higher percentage for Mafraq is due to the fact that local Bedouins own nearly half of the farms in the northern Badia, while the majority of farm owners in Zarqa Governorate live in Amman. This also explains the lower percentage of remotely managed farms in Mafraq: 26.7%, against 51% in Zarqa.

*The Change In Labour Patterns*

Similarly to the Jordan Valley, irrigated agriculture in the Amman-Zarqa basin employs a large number of local female labourers who form the majority of seasonal working force: they make up 54% and 74% of total irrigated farming labour in the Zarqa and Eastern desert regions, respectively (ARD, 2001). Besides, just like in the Jordan Valley (chapter 4.3), female labour wages constitute in many cases a significant part of the family income.

Most of the permanent labourers are male, mainly Egyptian migrants, whereas females constitute the majority of the temporary labour. Egyptian, as well as low-income Jordanian women, circulate between the Jordan Valley and the Highlands according to the availability of agricultural seasonal work. This shows the deep interconnectedness between the Highlands and the Jordan Valley, not only in terms of water resources, but also of manpower.

#### 5.3.2.2 Rangeland: Degradation, Pastoral Resources and Agriculture

Since the mid 1970s, the state has subsidized supplementary feed concentrates (0.5 kg/head/day)[92] in order to assist herders and has pushed towards settlement of Bedouins. This induced a dramatic increase in the number of sheep and goats: sheep have increased fivefold over the past 50 years, while goats have risen by 78% (Dutton, 1999) with a subsequent strain on the environment (chapter 4.4). Over-grazing has become a common phenomenon induced by the historical disruption of transhumance routes by national borders but also by the spread of trucks used by nomads to displace their herds.

The Badia is in fact used to accommodate the flocks in different climatic conditions, rather than representing a primary feed resource, since most of the food is bought and supplied through trucks. As observed by Rowe (1999: 349), “the increased demand of cash as purchased feeds and other commodities have become increasingly important and households rely on non-livestock economy, as pensions, agricultural incomes, remittances and propriety rents”.

[92] Since the removal of the subsidy in 1996, the number of sheep has decreased (Dutton, 1999; chapter 4.4). It has proven to be very effective in reducing overgrazing but dramatically affected the poorest groups: nomadic pastoralists (Pitman, 2004)

*Figure 5-34: Average expenditure per animal in a monetarized pastoral society, 1995-96 (Rowe, 1999)*

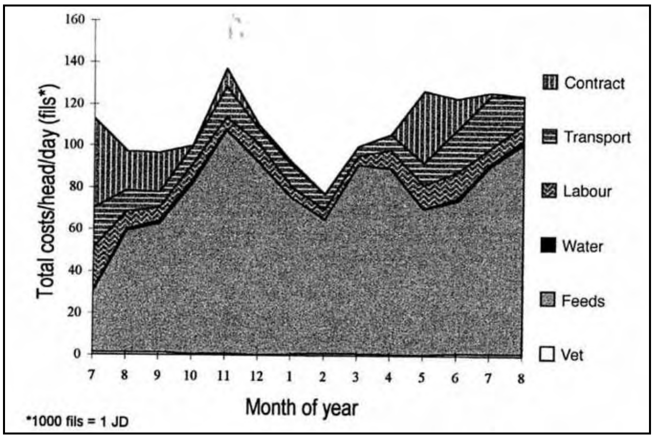



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Figure 5-34 illustrates that in this kind of multiple and pastoral economic pattern, water remains one of the lowest expenditures (below 1%), while feeds or transport constitute the main ones.

Households seek to broaden their livelihoods with numerous sources of income, such as waged employment, occasional barley cultivation or sharecropping. Due to the sharp increase in livestock numbers, intensive cultivation and periodic droughts, rangelands have become extremely degraded in the past 30 years: plants of high fodder value have been eliminated and replaced by less productive plants, less palatable and nutritive; severe soil erosion and gullies have formed especially on steep slopes (USAID, 1993; see also chapter 4.4). Of the 73,033 inhabitants of northern Badia in 1993, only 2,653 were categorized as being transhumant, but livestock pressure has remained high and has put new strain on this fragile ecosystem.

During the last fifty years, the size of flocks has changed, increasing from 60-80 heads per family to 150-200 twenty years ago, to over 250 nowadays. Earlier the size of sheep and goat flocks was smaller because herders also had camels and/or donkeys that provided additional milk for human subsistence and were important medium of transport to carry water for humans and animals, or for other paid services. In the past, the ovicaprid management was dependent upon an adequate supply of standing water, as well as suitable grazing of grasses and legumes (Lancaster and Lancaster, 1999). Due to the unpredictability of rainfall, the crux of the matter was to get the information on where water and grazing land were available, two resources which often do not coincide.

The number of people involved in pastoralism as a main activity has certainly decreased, but it has often remained more of a way of life, a symbol of a moral community rather than an exclusive source of income. Furthermore, it has adapted to the main market-oriented production, to the subsidized feeds and to the availability of veterinary services. Compared to the past, women have increasingly taken up the grazing activities, because of the high employment and the related out-migration of men in the army and service sector. It is important here to stress that according to the Agricultural Law No. 20 (1973) all rangelands are owned by the Government, although practice differs. In fact, more than 90%

of rangelands in the steppe are privately owned and used for erratic cereal production, while the remaining is state owned and characterized by steeper slopes.

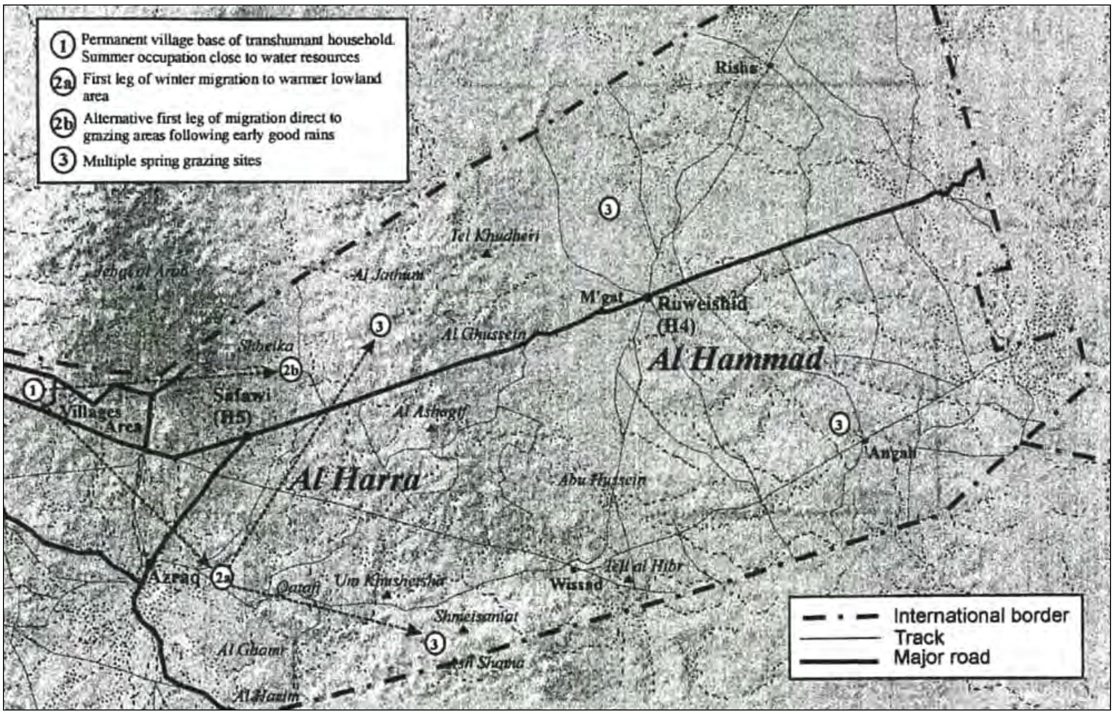
Tribal right of cultivation was recognized in 1945 and then encouraged within settlement schemes. Fencing, water resource development, ploughing and cultivation have become strategic means to claim state land for the future and as a result more tribal and state lands are becoming privately owned. Therefore, agriculture has often been performed as a means to maintain control over a land that often has other important symbolic values outside agriculture: land is connected to tribal values from the moment that tribes have always considered themselves as the real and effective owner of the land. Following the loss of access to the steppe rangeland, nomadism has nearly disappeared; bigger flocks have become less mobile than in the past, triggering a process of land use intensification without compensatory improvements in management and degradation of the remaining rangelands. In such a situation, "rangeland development should be accorded a high priority because rangeland is the most important renewable resource in the country" (USAID, 1993: 38).

*Patterns of Pastoral Life*

It is necessary to give here a social picture of the meaning of pastoralism in relation to water and agriculture. As Lancaster has argued in his extensive study on the Badia resource management, "from the point of view of any population, the key characteristic of the bio-climate [of the badia] is its wide variability and unpredictability. Opportunism is the key to successful use." (Lancaster and Lancaster, 2001:128). Bedouins have developed fine knowledge and social system to cope with these environmental constraints.

In some years, the Badia may offer enough water and grazing, while in other years, the ability to, and experience in, discovering where and how to get access to the resources is paramount (see Figure 5-35). Domestic groups, on which the pastoral economy was based, are indeed extremely fluid and adaptive to the situation and the economy has inevitably been a multi-resource economy, even more in the last decades.

*Figure 5-35: Seasonal migration out of villages in the Badia (from Rowe, 1999)*




*Box 5-8. Hammad and Harra*

Pastoralists draw a sharp distinction between the basalt boulder surfaces of the *harra* and the limestone plains of the *hammad*, being well aware of the distinct grazing possibilities that each landform offers. The harra is relatively mountainous and variably covered with black basalt boulders while the hamad is open, gravely country. The hamad in the recent past has supported camel rather than sheep and goat pastoralism. In the hamad, to the east, the only water sources are seasonal pools on mudflats (*khabra*) or in wadi beds (*ghadir*). Khabra are natural pools but have often been enhanced by man; *mahafir* are more recent artificial pools created at the edge of many khabra or in other suitable place for collecting run-off water.

Pastoral economy has to be put in the context of wider economic change where "present day Badia users see direct relationship between size of flock and several external factors": the size of family has increased; the economic options open to Badia users have augmented with the incorporation into the national economy, and at the same time, urbanization has led to an increased demand for both dairy and meat products. Herds have remained mixed, mainly as an "insurance policy against disastrous climatic extremes as well as an effective way of utilizing available forage resources" (Lancaster and Lancaster, 2001:130). Sheep generally prefer to graze annuals although they will browse, while goats prefer to browse perennials although they do graze. Generally, "the more sheep there are in proportion to goats, the greater the likelihood of a closer relationship with a community that practiced some agriculture", a fact that presupposes inevitably some Badia products to exchange.

As mentioned earlier, fodder has been highly subsidized in the 1970s and 1980s as part of the rentier character of the Jordanian economy. The use of supplementary feeding in present pastoral economy is certainly linked to the loss of traditional grazing areas (due to land appropriation; see above), but it has also developed due to the profitability of sheep dairy products following increased urbanization. Since the flocks tend to be much bigger than before, Bedouins "relate the use of truck and tankers to the need for increased flock numbers: trucks for carrying feed and tankers for carrying water mean that sheep and goats can be kept in the Badia for longer periods and in greater numbers" than before (Lancaster and Lancaster, 2001:132). At the same time, Bedu need to increase their flock in order to maintain the vehicles and their expenses. Large herds in the Badia have thus switched from using rangeland as a source of feed to simply using it to raise animal.

Today, only 22% of the Badia population is dependent on livestock for their livelihood and 60% continue household migrations seasonally (see Figure 5-35). Families are generally settled in one village or city, which have developed in the last 20 years, but patterns of limited transhumance are still active. These take place in multiple tents named *goum*, as livestock collectives which constitute a form of labour pooling, skills, of expertise and capital resources. Rowe has defined this complex system of economic and ecological knowledge as "a highly specialized form of monetarized pastoralism" (Rowe, 1999:352) characterized by a collectivized approach to livestock management. This unit is constructed "around the core of four brothers three of whom are based at the herding encampment while the fourth represents the collective's interests at a distant village. This core owns and manages the majority of the livestock, capital and financial assets of the collective." This collective management pattern, to which other kin-related households are associated "share a common interest in maintaining the economic viability of the *goum* and strengthening the cohesion of the lineage" (Rowe, 1999: 353).

Pastoral migrations out of villages and Highlands summer camps begin with the growth of the first pastures since migration is performed not only to get access to additional grazing and fresh pasture but also to avoid winter cold weather in the lambing season. Thus, herders exploit the climatic variation across the Badia landscape, which has radically changed in a few decades, but where some main patterns of flexibility and of adaptability to vertical and horizontal movement on the map have remain crucial.

Although tribes were included in subsidies schemes, strong prejudices exist against using state-managed wells in rural area. As Rowe argues, Bedouin were discouraged by the requirement of registration with the local agricultural and water department prior to using the well. As a result, most of them purchased water from private agricultural wells; used households supplies of water or Badia natural sources such as pools, springs, and traditional wells (Rowe, 1999:356).

Pastoralists today still fall back on the Badia landscape as an asset in order to minimize undesired transactions with the state and still benefits from occupying remote areas of the Badia. The building of a state-citizen relationship refers to as relation made of mistrust, cooptation and reciprocal manipulation between tribes and central management. Besides, the Badia population has very limited political weight, with a population in 1994 of 16,267 (Dutton, 1999), although it conveys a high symbolic value in terms of Bedouin and ancient 'Arab values' incorporated into the image of the nation.

In these patterns of seasonal migration, "information is vital for pastoralists in the Badia" (Rowe, 1999:356). By information, we refer here to getting access and circulating knowledge on the weather and grazing conditions, on the current livestock and commodity prices, on the future market and the implementation of policies at a number of levels. Information is disseminated orally and the gathering of information accounts for a large part of herders' time, often through hospitality settings. Information nodes exist close to locations where many Bedouins migrate from different tribes. Migrations are thus an opportunity for all members of the household to make new acquaintances and tap new information. In Bedouin popular mythology and poetry, it is also the herding camp where clandestine romances have the opportunity to spring up. Thus, the decision of the spatial coordinates of migration is the product of a wide range of risk management options chosen in a highly opportunistic mode of resources exploitation.

*Tribalism and Agriculture in the Badia*

For lack of a central administered system, kinship has offered a pattern of security and of management of resources. As Wahlin (1993) argues, “tribes fill every economic niche from nomadic herders to settled farmers, forming a complex web of integrative social alliances” (chapter 4.3). The importance of land as the basis of the honour and origin (asil) of the tribe has indeed remain intact, notwithstanding the fact that tracts of land are sold to exogenous investors and farm managers (see chapter 5.1 for a description of these irrigators).

Land remains symbolically the base of the honour and status of a tribe, its claim of control. Notwithstanding continuous selling and buying, Bedouins often continue to talk of tribal space as if it had not changed due to the symbolic meanings attached to land. Even newcomers are represented as living and working in the Badia under their protection (“*sakinin tahit hamayitna*”): “the land has been sold, but the political dimension of ownership-the right and ability to protect that land from others- has not yet been fully transferred” (Shryock, 1997b: 50). If the tribe has often lost the traditional material base (control of land, water or mobility and transport), it remains an instrument of social and political differentiation and of insertion within the administrative apparatus. Thus, “the tribe as actual social structure has declined, while its significance as referent of social identity and loyalty has persisted” (Wahlin, 1993:4). According to Wahlin, who has studied the Balqa region in the Highlands, tribal belonging remains important in connection with landownership and it influences marriage decisions. According to him, “attitudes to land actually have changed more slowly than attitudes to “blood” in connection with marriage” (Wahlin, 1993:2), since land remains an icon of the tribal unity, and therefore, many strategies are adopted to avoid the land being alienated from their tribe’s core territory.

Mobility forms part of the diversification strategy used by rural population to adapt to changing conditions. Tribal cohesion supports this solution by guaranteeing a “home” to return to- whether that home is geographically fixed or not is irrelevant in this context. Today, tribalism at the local level means referring to family relationships to legitimate economic or other actions and to create some room for manoeuvre in the integration into the nation and in the encounter with the bureaucracy. In fact, “tribesmen use genealogical identities to mobilize against planners, to resist the agendas of other tribesmen, to lobby the King and so on. Propriety is part of these identities. (..) Individual ownership is not based on individualism; instead, private ownership is a collective property defined and guaranteed by one’s position in a tribal group” (Shryock, 1997b 49). Old Bedouins recognize the political sovereignty of the Hashemite rule who today control land, resources and the bureaucratic apparatus, but at the same time, they claim a space of autonomy in a context of legal pluralism where different claim overlap in order to legitimize the control of water. In Jordan the nation has been built according to a genealogical popular nationalism where the kinship model has represented the mode of shaping the nation itself: thus even the population of Palestinian origin, for whom tribe had often lost its relevance in favour of class division already in the British Mandate period, have stressed tribal affiliation as a medium of incorporation into the new state of Jordan and as a form of brokerage in accessing resources.

The Jordanian government has focused on controlling and limiting the power of tribes, which could endanger the Hashemite legitimacy, but at the same time, it has imposed tribalism and ‘beduinism’ as a national identity for the whole population. In this framework, the Hashemite are perceived as super-sheikhs with a genealogy tracing back to the Prophet. Therefore, using wasta has become a common language and frame of action also for the non-Bedouin and non-Transjordanian population. Following the insertion into the bureaucracy and the national structure and administrations, tribal solidarity has acquired new meanings and new power too. In particular, bureaucracy has become the main element of social and economic differentiation, due to the high population employment and to privileges and security linked to it.

*The Mobile Frontier of Farming Areas*

The extension of irrigated agriculture has been allowed by the ability to drill deep wells, or by the provision of piped domestic water supply in intra-urban fields. Villages and irrigated agriculture have also expanded thanks to the ability to acquire government abstraction licences to operate wells and then to obtain loans to carry out the work. Besides, the purchase of land at relatively cheap prices has attracted people from outside the area to buy large landholdings (more than 50 hectares). Therefore, the access to market and the urban growth, which have been accompanied by the loss of agricultural land in the western Highlands (notably around Amman), have been crucial in the expansion of irrigated agriculture in the eastern Badia. Many villagers and Bedouins have migrated to villages that control large areas of rangelands or left Jordan. In these areas, the availability of large quantities of land has enabled migrant farmers to build up relationships with the village and to return each year to practice temporary irrigated farming.

Already in the past, there was no sharp division between the Badia and the more fertile areas. Even more today, “the boundary shifts every year and just as there are islands deep in the Badia, there are islands of land in the fertile areas that are useless for agriculture but suited for herding” (Lancaster and Lancaster, 2001:136). Further, “the decision as to whether land is agricultural or pastoral is in part a cultural one, made from perceptions of economics and politics as well as environmental considerations. There may be no essential difference between what are loosely called agriculturalists and pastoralists” (Lancaster and Lancaster, 2001). Of course, irrigated agriculture has intensified and the abstraction of water has exceeded the annual recharge (chapter 4.2 and 5.13.1.).

We observe since the 1960s a gradual eastward expansion of agricultural settlements in northern Jordan. According to Millington, people migrate from areas with relatively high cultivation potential to marginal semi-arid/arid frontiers for three main reasons: social differentiation, political factors and economic and environmental constraints. Two concomitant trends are evident: the area of rainfed cultivation has increased until the mid 1970s -although it declined afterwards- but more importantly, there has been an incremental loss of rainfed to irrigated agriculture that developed due to new techniques allowing groundwater abstraction in these desert areas (Millington, 1999:374; see also chapter 4.2; 5.11 and 5.16). This transition has occurred in parallel with migration, settlement and village expansion (Millington, 1999:365).

A common pattern in the agro-pastoral integrated system is to keep sheep and goats at home, feed them with grain and then graze them on harvested fields. The interrelationship between rainfed, irrigated agriculture- as recent phenomena- and livestock rearing is crucial in understanding the dynamic of new and extending settlements: “permanently irrigated farms may replace land that was formerly under rainfed cultivation, whilst permanently irrigated farms have been established in former rangeland areas. (…) Temporary irrigation fields are cultivated for one summer, reverting to rainfed cultivation the following winter. In the succeeding years, the areas revert to rangeland or are again used for rainfed cereal cultivation” (Millington, 1999:375-76). This flexibility therefore generates difficulties in regional and national accounting of the use of land (see Thus, the extension of the eastward frontier since the 1970s is related to a pressure related to population growth but also to multiple socio-economic factors: three decades of settlement schemes, the availability of cheap land, good quality groundwater resources and, for some, the ability to obtain licenses for groundwater abstraction.

In addition, the Government has directly encouraged the conversion of rangeland to cultivated areas through its water policies and stock feed subsidies over the last three decades. This has led to "a frontier that is moving ever eastward into increasingly ecologically and economically marginal environment" (Millington, 1999: 383).

Figure 5-36).

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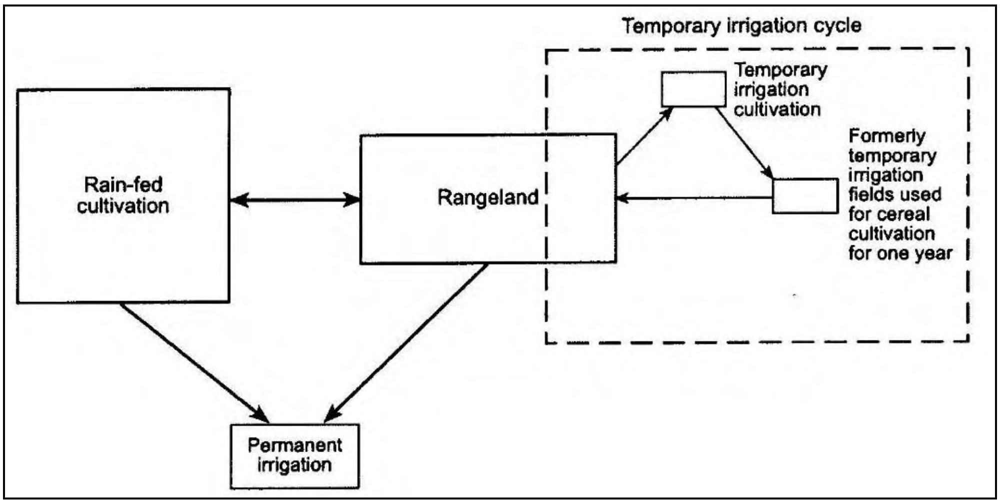
*Figure 5-36: dynamics of rangeland and cultivated areas in northern Jordan (from Millington, 1999)*




*Box 5-9. A case study on family adaptations*

A case study of Wadi Zarqa will help in highlighting the relationship between farming, land and family strategies in the Highland. The case study of ‘Ain village (Taminian, 1991) illustrates the perceptions and contexts of local families facing change and risk in relationship to land and to the wider labour market. The authors show how kinship relations have continued “to be central to the way a family or a household manages its land” (Mundy and Smith, 1990:55), where even rental agreements took place primarily within relatives.

'Ain lies in the north-eastern part of Jordan in the lower Zarqa catchment; the annual rainfall ranges between 200-300 mm and the main farming system combines livestock and annual rainfed crop production of barley and wheat. The population of the village is about 700, most of whom live in cement houses built in the village site. Many of the houses have caves at their back that once were the primary habitations but have now become storage rooms. Caves were abandoned reluctantly in order to build approved licensed houses.

What the authors show through a study of land ownership, occupation and farming strategies is the new role that agriculture has acquired in this frame of the Highlands. In the 1990s, only a minority of men residing in the village had agriculture as their main activity and less than a quarter of the men over the age of 16 were working as full-time farmers. Some main changes have occurred that reveal broader dynamics. First of all, the agro-pastoral system witnessed a transition to settled cultivation, and later to mixed irrigated cultivation of olives and annual crops. This shift was supported by state's settlement policies and agricultural subsidies. This has been paralleled by the "the quiet revolution of farm mechanization", where pumps and water saving techniques have played a major role. Secondly, young men in the village are eager today to spend the first part of their adult life in the army and not in farming, leaving the village and the farm to family elders, retired persons, or lessees in various patterns of part-time farming. Lastly, the modification of lifestyle entailed by the move from caves to cement houses has been a huge change of settlement (Mundy and Smith, 1990:56).

In the late 1970s, the World Food programme (WFP) Highlands Development Project was implemented, supporting tree crop production especially that of olives trees (chapter 3). This process was discontinued by the Zarqa River Basin Project in order to decrease the rapid erosion and filling of the recent dam (King Talal Dam in 1977 –see chapter 3 and 5.12.1) but also due to the non-participatory approach, which was therefore often rejected by farmers. Since then, the "double career" has become a common strategy of villagers who mainly try to enter the army, or any other salaried employment but continue farming in the afternoon or the weekends. Consequently, farming is composed of a set of mixed strategies, which leads to a preference for crops that do not demand continuous and intensive labour, while intensive agriculture has come to depend upon imported labour. More importantly, the study shows how "members of a family or household will adjust their occupations according to what other members are doing" (Mundy and Smith, 1990:161): farming, working in the army, salaried work, out-migration are all choices that depend on the wider family strategy and on the main value of family autonomy. In fact, "43% of the employed work force have worked or are at present working in the army. A further 13% are employed in the civil service" (Tamimian, 1991:23). This data illustrate the diversification of the local economy and the integration in the state apparatus of farmers and fellahin[93].

The village thus witnessed the penetration of capital-intensive farming but the majority of farm units remained much more mixed enterprises: mix of crop types, mix of labour forms, mixed sources of cash income out of the agricultural sector. In this heterogeneous and changing pattern, "the extended family remains the frame of strategies in coping with risk. (…) A father and one of his married sons, or two married brothers, may form a unit with a common budget, what the people of 'Ain call a "kis" (bag) or "jaibah" (pocket) long after the households have become separate" (Mundy and Smith, 1990:21). In the 1980s, the speculation in the land market has led to the selling of small plots of land to non-locals. In 1990, 60% of the plots in the village were owned by 'outsiders'. The development of

[93] Further, 19% work in private business, and only 26% work in agriculture.

"villa farmers" who reinvest the remittances from the work in the Gulf and build summer houses with orchards has been one of the most striking changes (see also chapter 5.1). Water Management in Amman[94]

The development of drinking water facilities for the cities clearly appears as the main priority and one of the main challenges for the Jordanian government. We focus here on Amman water supply (the two joint cities of Amman and Zarqa group more than half the population of Jordan). The Water Authority of Jordan (WAJ) has long been in charge with drinking water facility management in the capital but between 1999 and 2006, the operation and maintenance of the Amman drinking water supply network has been transferred to a private company LEMA. The contract has not been renewed after 2006 (see below)

### 5.3.3 The Explosive Development of a Modern Capital in a Water-Short Area

Amman enjoys several geographical advantages: 1) the Zarqa valley is one of the easiest way from the Jordan Valley to the Highlands and link Mediterranean cities to Arabia and Egypt to Mesopotamia; 2) The neighbouring Balqa plateau is one of the richest rainfed agriculture areas in the LJRB Highlands; 3) Ras El Ain and other neighbouring smaller springs have long provided adequate water to local settlements. In ancient times, Amman became one of the most important cities in the region (one of the 10 "Greek" commercial cities of the Decapole [chapter 3?]) but, like the whole Transjordan, the city passed through many periods of development and decline and only with the British Mandate did it witness a rapid increase of its population due to a chain of events with notably:

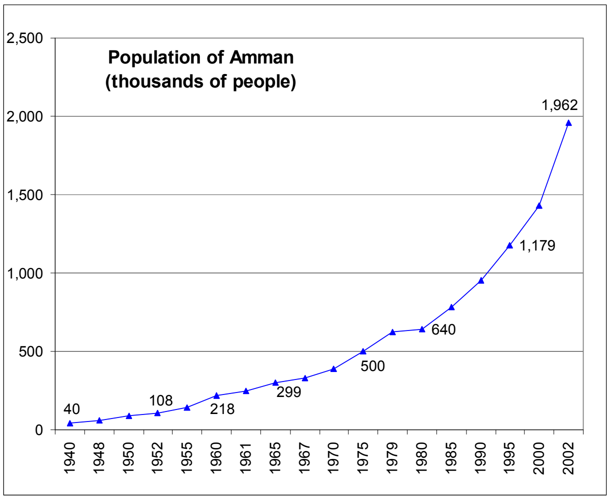
- The development of Amman as the capital of the country;
- The creation of the state of Israel and the invasion of the West Bank which induced transfers of population, of capital and international investments to stabilize these new population;
- The Lebanese war which induced a transfer of financial and insurance businesses from Beirut to Amman;
- The increasing importance of the remittances from the gulf countries where many Jordanian found job opportunities;
- The first Gulf war which induced: 1) the return from Kuwait of a large Jordanian population with its skills, knowledge of markets and capital and 2) a cheap supply of energy from Iraq (in exchange of diverse goods Jordan supplied to its ally);
- The construction of new routes between Iraq and the Red Sea as well as from Egypt to Syria and Iraq became necessary after the creation of the state of Israel and Aqaba became a strategic harbour for trade and commerce;
- The peace signed with Israel transformed Jordan into a regional centre for international activities and attracted many international investments in what became the only stable open country of the region (see chapter 2 and 4.15). Jordan is also attractive for many tourists of the Arabic peninsula who found clement climate and cheap health care.

[94] Most of this section is drawn from Darmane (2004) and (2006)

- Finally, internal migration from rural areas, small cities and the Jordan Valley are a common feature of the LJRB landscape: with its universities, its social and cultural activities, the job opportunities it proposes, Amman is attractive to the Jordanian population.

Although demarcated administratively, it is now strongly connected to the urbanized area of Marqa and then Zarqa (800,000 inhabitants; Figure 5-38), 25 km north-east creating an almost continuous urbanized area. In 2002, almost 2.8 million people were living in the Amman-Zarqa conurbation (52% of the Jordanian population). The population of Amman is likely to have further increased following the massive influx of Iraqis during and after the second Gulf war (chapter 2). The entire urban landscape was modified very quickly as the city expanded from its ancient core (Figure 5-38). Amman is now characterised by a main delimitation between East Amman and West Amman: this vague geographic border coincides with a social and economic border, where the east of Amman is characterized by poverty, squatter areas, where also migrants or Iraqi refugees have found home, side by side the Palestinian refugee camps. On the other hand, West Amman contains high status residential areas, financial and market centre, and it has radically developed following the influx of Palestinian returnees from Kuwait in 1991, who have invested their remittances in construction and commercial activities: rural areas have been progressively encroached and flocks and crops can still be found in urban chinks. The polarisation of Amman in two main and non-communicating parts reflects in reality the polarisation of the rest of the country. The emergence of a metropolitan area represents the wider space where commuting networks, commercial activities and social life take place, but is related to a general lack of regional planning coordination in the past, which has left freedom to spontaneous construction and also disputes on land (see below).

*Figure 5-37. Evolution of the population of Amman between 1930 and 2002*[95]



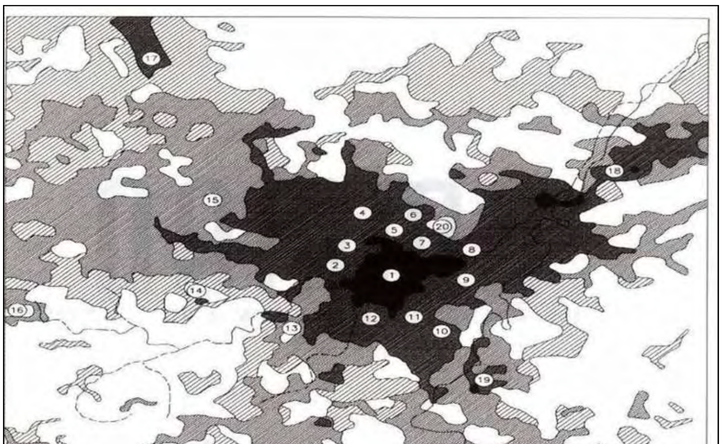

Amman has therefore developed into a "primat city" where one city's dimension is out of all proportion compared to the other cities in the country" (Soffer, 1990; Although demarcated administratively, it is now strongly connected to the urbanized area of Marqa and then Zarqa (800,000 inhabitants; Figure 5-38), 25 km north-east creating an almost continuous urbanized area. In 2002, almost 2.8 million people were living in the Amman-Zarqa conurbation (52% of the Jordanian population). The population of Amman is likely to have further increased following the massive influx of Iraqis during and after the second Gulf war (chapter 2). The entire urban landscape was modified very quickly as the city expanded from its ancient core (Figure 5-38). Amman is now characterised by a main delimitation between East Amman and West Amman: this

[95] Sources: Hacker (1960) ; Bataineh (2002) ; Abu-Shams (2003) ; Population and Housing census (1952, 1961, 1979, 1994 and 2002) and http://books.mongabay.com/population_estimates/1950/Amman-Jordan.html

vague geographic border coincides with a social and economic border, where the east of Amman is characterized by poverty, squatter areas, where also migrants or Iraqi refugees have found home, side by side the Palestinian refugee camps. On the other hand, West Amman contains high status residential areas, financial and market centre, and it has radically developed following the influx of Palestinian returnees from Kuwait in 1991, who have invested their remittances in construction and commercial activities: rural areas have been progressively encroached and flocks and crops can still be found in urban chinks. The polarisation of Amman in two main and non-communicating parts reflects in reality the polarisation of the rest of the country. The emergence of a metropolitan area represents the wider space where commuting networks, commercial activities and social life take place, but is related to a general lack of regional planning coordination in the past, which has left freedom to spontaneous construction and also disputes on land (see below).

Figure 5-37). In 2002, the Great Municipality of Amman totalled 1.96 million (36,8 % of the total population of Jordan).

*Figure 5-38: The different stages of Amman development between 1946 and 1995 (adapted from Darmame, 2004)*




The black area represents the expansion of Amman as in 1946; the dark grey as per 1977; the light grey as per 1981 and the hatched area as per 1995. The figures are localities within Amman city.

### 5.3.4 Historical Evolution and Present Needs of Water Management in Amman

#### 5.3.4.1 History of Water Development

Until 1928, when the first pumping station at Ras El-Ain (south-west of Amman) was set up in order to distribute water through collective fountains to the first neighbourhoods of Amman, families were getting and transporting water from the springs to their homes and were using rivers formed by these springs for laundry. The first Palestinian dislocation in 1948 imposed urgent changes in the drinking water systems. After 1952, the population totalled 108,304 inhabitants (Population and Housing Census, 1952). In 1955, various pumping stations were built in distant regions to divert water from springs like the Saïl Amman spring and other springs in the Al Mahata and Aîn Ghazal localities, now located in front of the Royal Palace (Abderahman, 1969; Amman north-west). Also in 1955, an agreement with Wadi Seir municipality brought an additional 115 $m^3$ per hour from the Fuheis springs (Amman-north).

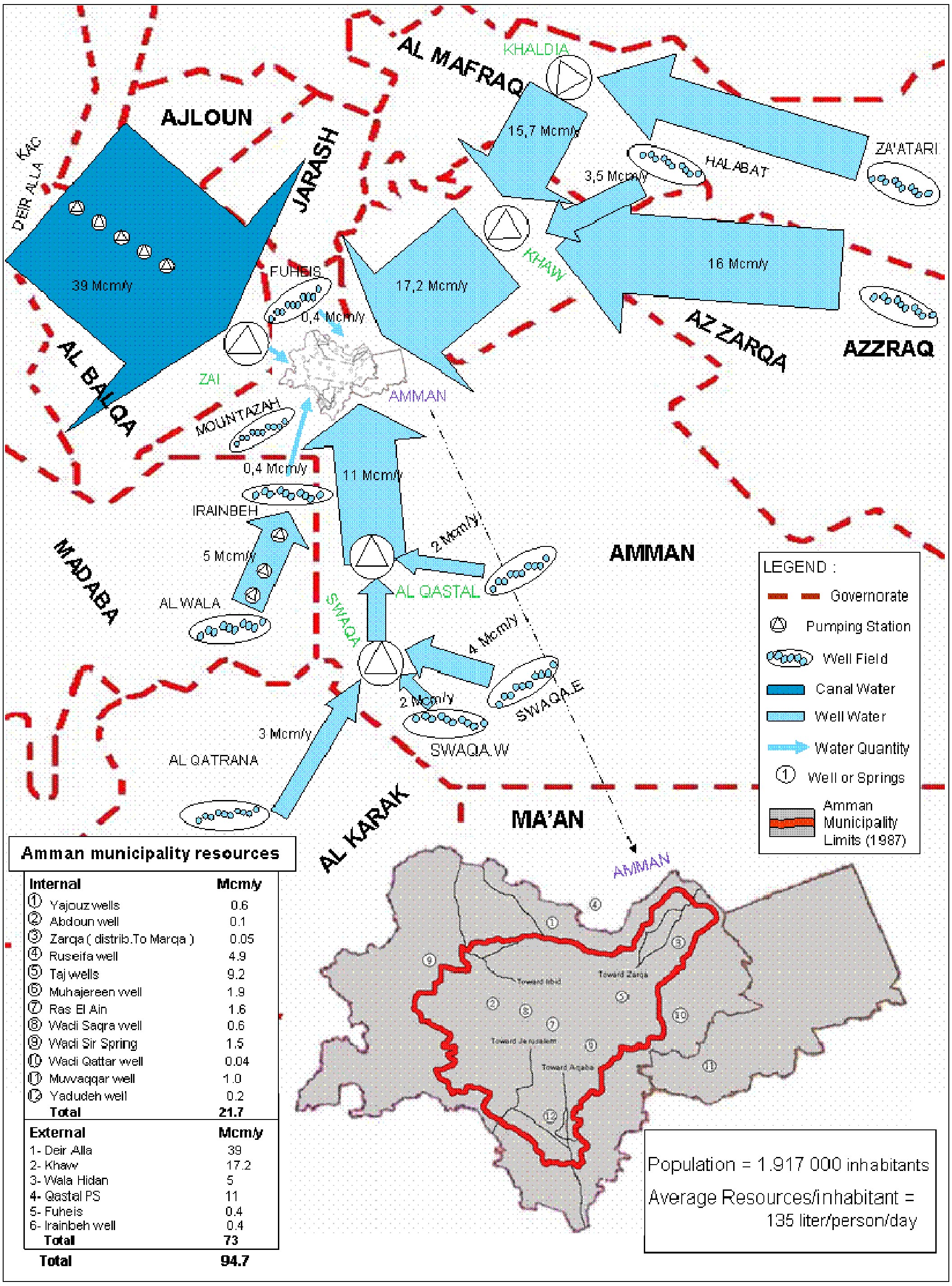
After 1975, with the second demographic shock caused by the transfer of Palestinian refugees, the population of Amman totalled 600,000 inhabitants (THKJ, 1977). Water transfers from distant springs were increased in the 1980s when important quantities began to be pumped from the Azraq oasis (which was already supplying the northern cities of the countries and notably Irbid). The large transfers to Amman and the development of local irrigated agriculture provoked a very severe overexploitation of the aquifer, and the drying up of this desert oasis (chapter 4.4.6). From the beginning of the 1980s, surface water resources (springs and rivers) appeared insufficient to meet the increasing urban demand and deep wells were progressively dug, first inside the city of Amman and later in neighbouring areas. But even this low-cost development of good quality groundwater abstraction had to be complemented, in the early 1990s, by a transfer of water from the Jordan Valley (chapter 4.2).

*Figure 5-39. The pumping station and a basin of the Zai-Dabouq conveyor pumping water from the Jordan Valley to Amman (Papin, 2007)*

This decision had long been planned but seems to have been implemented due to the new needs that appeared with the arrival of Palestinian returnees from Kuwait. This transfer, together with those from the Azraq and the Dead Sea groundwater basins, represent the main inter-basin transfer affecting the LJRB. At present (Figure 5-40), between 40 and 50% of the water supplied to Amman is coming from the Jordan Valley; 20% is coming from the Zarqa and Mafraq regions through the pumping station of

Khaw[96]; another 20% comes from the Dead Sea basin (in Qatrana, Swaqa, Qastal, and Wala/Hidan). The rest is pumped from deep wells near Amman (mainly Taj, Russaifa, Ras El-Ain, Muhajerine, Wadi Sir).

*Figure 5-40. Water supply diagram of the city of Amman in 2000 (adapted from Darmane, 2006)*[97]




[96] Between 2000 and 2007; pumping from the Azraq oasis to supply Amman has been stopped to preserve the remains of this Ramsar site. But some transfers still function and supply the northern cities of Jordan.

[97] Figures have slightly changed since 2000: the transfer of water from the Jordan Valley was reaching 50 $Mm^3$/yr in 2005 and is likely to be even higher now as the capacity of the pumping scheme has been doubled (chapter 6)

Increasing needs are due to both the population growth but also to a general improvement of the standards of living. In Jordan, the average domestic water consumption increased from 64 litres per capita and per day in 1975 (THKJ, 1977) to 94 l/ca/day in 2000 (THKJ, 2004). Darmane (2004) showed that the average consumption in Amman was higher than this national figure with people consuming about 115 to 150 l/ca/day.

The percentage of families who benefited from water distribution systems jumped from 30.3% in 1961 to 69% in 1979 (Nusseir, 1992) and nowadays 98% of Amman's population is served by the public network. Finally, total municipal water consumption in Jordan was estimated at 40 $Mm^3$/year in 1975 (THKJ [1977] and Courcier et al. [2005]; among which 14 $Mm^3$/yr in Amman [Darmane, 2004]). It now reaches 167 $Mm^3$/year (THKJ, 2004), with estimations at 416 $Mm^3$/year for 2020 (THKJ, 2004; chapter 4.2 and VI). After exploiting the cheapest resources (local springs, distant springs, deep wells inside the city, deep wells in neighbouring areas), it was necessary to tap more expensive ones (distant deep wells in the basin or in neighbouring basins, surface water from the Jordan Valley) and future solutions (such as long distance transfers and desalinisation) are requiring ever increasing investments and operation costs (see Table 5-9 and chapter 6).

#### 5.3.4.2 Very High Investments Required and Increasing Operation Costs

With settlements and urbanisation, the population has come to rely on centralized water distribution networks that have soon been one of the priorities (along with investments in education, health, security and roads) of a nation in construction. High public investments have been done and a high level of subsidies kept consumer prices of drinking water at relatively low levels (see below) even though both investments costs and Operation and Maintenance costs (including treatment costs and costs of collecting and treating effluents [see below]) of infrastructures rose tremendously with time as water is transferred on ever increasing distances and generally needs to be elevated from several hundreds of meters (tube wells are generally between 200 and 400 meters deep; water from the Jordan Valley is elevated by 1,100 meters, etc.). The energy costs of supplying water to Amman are very high: water elevation from the Jordan Valley accounts for half the total production costs of domestic water in Amman and, overall, costs of pumping and transferring water account for 18% of all energy costs in the country. Table 5-9 summarizes volumetric water costs for some drinking water supply projects to meet Amman’s growing demand. As presented in chapters 4.15 And VI, most of these projects are supported by foreign cooperation.

*Table 5-9. Volumetric Water Costs for different projects of drinking water supply to Amman (adapted from Nachbaur, 2004; Sources: ∂ GTZ (1998); ♠ THKJ (2004) and * Fitch (2001))*

| Water Source | Cost (US$/m3) |
|---|---|
| Amman network rehabilitation♠ (low hypothesis) | 0.036 |
| Amman network rehabilitation♠ (high hypothesis) | 0.346 |
| From groundwater currently serving farms* (low hypothesis) | 0.086 |
| From groundwater currently serving farms* (high hypothesis) | 0.105 |
| Wehdah dam (on Yarmouk) ♠ | 0.166 |
| Zai-Dabouq conveyor (transfer from the Jordan Valley)♠ | 0.415 |
| Pipe from the Litani river in Lebanon∂ | 0.678 |
| Sea water desalination Mediterranean Sea-Dead Sea∂ | 0.706 |
| Disi fossil aquifer♠ | 0.786 |
| Import by sea in bags∂ | 0.831 |

| | |
|---|---|
| Sea water desalination reverse osmosis plant[∂] | 0.955 |
| Sea water desalination Red-Dead[∂] | 0.998 to 1.3 |
| Import by sea in used tankers[∂] | 1.108 |
| Pipe from Euphrates in Iraq[∂] | 1.108 |
| Import by sea in new tankers[∂] | 1.386 |
| Pipe from Seyhan-Ceyhan in Turkey[∂] | 1.635 |

#### 5.3.4.3 The Need for Water Treatment and Effluent Collection

In addition to mobilisation, transport and distribution costs; treatment costs of both water supply and effluents are high but such treatments are compulsory to ensure safe drinking water to the population and limit environmental degradation. Two kinds of water treatment can be identified. Primary treatment aims at controlling the concentration of suspended solids, of the biological population and of other undesirable elements such as boron, nitrates and heavy metals. This is not technically difficult and relative cheap but as groundwater is increasingly saline and polluted (chapter 4.4); reverse osmosis plants to desalinate water and control its nitrate contents will be increasingly needed and this will increase water treatment costs (chapter 6). Secondary treatment consists in chlorination and limits the development of biological elements (algae, bacteria, worms, etc.) in the water for its safe distribution. In Amman, drinking water from all sources receives a secondary treatment and only surface water from the Jordan Valley requires a primary treatment. However rare cases of water contamination still exist (Box 5-10).

Box 5-10: A severe case of water pollution in Amman

In 1988, a case of poisoning of water took place in Amman. All of a sudden, this attracted public attention on the problems of water quality and scarcity in the city and a general mistrust and scepticism regarding the provision of water quality developed. The water treatment station of Zai, where 40% of the capital's water is treated, was contaminated by algae and the station was not equipped with the proper filters to treat contaminated water. The most affected areas were in West Amman and water distribution was halted for two weeks in the mid of summer. Water from the poorer areas of east Amman was partly diverted to west Amman, causing inevitable problems for poorer communities who could not always afford to buy water on the private market, which in the meantime had increased to $11 (JD8) per cubic meter. Some inhabitants died, many were hospitalized and following this case of pollution the Minister of water had to resign. The quality of the water from the Tiberius Lake was suspected, emphasizing the risk to depending on foreign resources. Contamination of water in roof-top cistern is also widespread.

Finally, as the country is facing low water availability; collecting and treating waste water is a necessity to enhance unconventional water use (agriculture is increasingly supplied with treated wastewater; see chapter 3). Sewage networks and treatment plants require high investments: in 2003, $150 million have been allocated to upgrade the Khirbet As-Samra waste water treatment plant whose capacity was too low to properly treat an increasing volume of effluents coming from Amman-Zarqa. Many wastewater treatment plants still function poorly and this has dramatic impacts on the environment and on agriculture in the south of the Jordan Valley (chapter 4.2; 4.14 and 5.11). There is a clear need for further investments on water treatment plants.

### 5.3.5 Planning Problems in Drinking Water Distribution Systems

Planning of water distribution systems in Amman has been ill-defined from the beginning. Too few reservoirs have been built and generally at a lower elevation that the too large areas they have to supply. The city is located in a hilly area with steep slopes and top-down water distribution is not adapted: most houses receive water from reservoirs located at a lower elevation or pipes frequently go through depressions (former wadis) where pressure increases to such extent that pipes may burst. Induced leakages are very important and this technical problem is the main reason (along with illegal connections) for a discontinuous water distribution in Amman (water is generally supplied 24 to 48 hours per week; [Decker, 1999]). Another crucial problem is the extension of existing networks (Amman network totals abot 4,600 km of pipes [Darmane, 2004]: when the city expands, the main pipes of the existing network are generally not replaced and have to convey much higher flows than initially planned: this induces head-losses, decreasing pressure and a supply heterogeneity that increases the risks of water leakages..

To solve these two problems, a technical solution would be to divide the entire city in many areas that would be supplied by a single reservoir located at a higher elevation and from which water would be distributed by gravity to areas of homogeneous pressure conditions (same elevation and same hydraulic conditions). A separate network of large diameter water pipes could distribute water to each of these reservoirs, potentially allowing continuous distribution (and obviating the need for individual roof reservoirs).

Other technical problems of the Amman supply network include: a) the lack of WAJ planning for a necessary replacement of the pipes, valves, pumps and other secondary equipment (part of the network is 20 to 30 years old), b) a poor control of the operation of the distribution system (with no water meters to control flows in and out of reservoirs, no pressure gauges, etc.); c) the fact that urgent repairs are generally done very slowly; d) the fact that many leakages are not apparent and very difficult to locate and repair without expensive modern techniques (often, the cheapest way is to entirely replace the pipes).

As running water is generally supplied once a week, households need to store water for their daily use: the poorest families have difficulties to cope with the extra storage cost and many sanitary problems occur with the cheapest water tanks generally located on the rooftop (Figure 5-41). Roof cisterns are generally small (70% of the households have cisterns of 1 to 3 cubic meters and only 10% have tanks larger than 4 $m^3$) and no pumping is required to fill them but water is kept under high temperature conditions and pollution is frequent.

*Figure 5-41. Roof top water cisterns in Amman (Venot, 2007)*

Pipes (which used to be in galvanized iron and are now rusted) are not continuously conveying water and water is stored in improper condition in the cisterns: this creates high risks of biological developments (bacteria, fungus, worms…) and frequent health hazards; and the water is often unpalatable and red.

### 5.3.6 Historical Management Difficulties of the Water Distribution System

The difficulties of water supply management in Amman are diverse and affect both the populace and the WAJ:

- Some users consider that they are too poor to pay for water delivery services and that the state has to give them free water (see below a discussion on water costs for the poorest);
- Some, especially settled Bedouins in nearby areas, consider that they are entitled to use the city pressurized water to irrigate their farms and have illegal connections inside the city;
- Some users tamper or destroy water meters, hoping they will avoid paying for the water;
- Some users with political connections and access to *wasta* do not pay their bills and continue using water expecting that the state will face some difficulties in enforcing payment;
- Army installations and other public institutions do not pay their water bills;
- Trials to prosecute faulty users are very difficult to initiate and even more to conclude. It is very difficult for WAJ to close an individual connection, even if bills have not been paid or WAJ properties (water meter) destroyed;
- Too many employees lack expertise. The lack of competence has led to general mistrust between water users and service providers, due to wrong water meters' registration, delays in sending water bills, diffused cases of corruption. The very low salaries of the employees also provide them low incentives and wasta remains a main characteristic of the drinking water sector.

Overall, unaccounted for water (technical losses through leakages and uncollected bills) reached 54% of the total water supplied in Amman in the late 1990s (with illegal connections alone accounting for 25% of the total water used in Amman e.g. 24 $Mm^3$/yr). If WAJ O&M costs were completely recovered, WAJ accounts showed an overall average deficit of $74 million in 1993-2000 (Darmane, 2004 after WAJ records) e.g. about 2% of total state expenditures at $3.7 billion (Jreisat, 2005).

This fragile financial status was worsened by the development of a private informal water supply network: private trucks were purchasing water from neighbouring agricultural wells and selling it back in the city to houses, shops or industries unhappy of the public services. This activity was highly profitable: tankers purchased the water at about $0.35/$m^3$ and could sell it back for 2 to 3 $ per cubic meter (in comparison, total production costs of drinking water in Amman are about 1 to 1.5 $ per cubic meter and average water price for the consumer reaches $0.6/$m^3$: drinking water is subsidized by international aid). It continued expanding even after the transfer of the management of the Amman drinking water supply network to a private company: LEMA (see below).

### 5.3.7 The Partial Transfer of Drinking Water Management to a Private Company (LEMA)

Faced with such problems and after the Water Strategy Policy of 1997, the Jordanian government invited tenders for the management of the Amman drinking water supply network. This transfer was supported by the World Bank and other international donors (KfW, USAID, EIB, etc.) by a loan of $250 million for the rehabilitation of the entire network and the restructuring of services delivery. The French-Jordanian company LEMA (dominated by the ONDEO group) was contracted in 1999 for a 4 year period further extended until 2006. The aim of the contract was to improve the management, the efficiency and the quality of the services for the 350,000 connected clients and to reduce unaccounted for water.

This management transfer to one of the world biggest water management private company appears as a first showcase in the Middle East (with another project in Gaza City attributed to the same group) of a partial privatisation of water (the private company is in charge of treatment and the distribution of the water; of the operation and maintenance of the network and of the planning and building of further investments; the Jordanian government retains the ownerships of infrastructures). It has been strongly supported by all donors and sometimes presented as a further step of the modernization and peace process in the region.

The main improvements have been: a) the decrease in the delay for repairing the network thanks to an efficient call centre and the elaboration of GIS detailed maps of the network facilitating interventions; b) the organization of better trained and equipped technical teams; c) a better and quicker production and distribution of the water bills; d) a better regularity in the water delivery and the decrease of water cuts in summer (notably for big users); e) a higher control of the quality of water; f) the development of awareness campaigns to inform users about the changes in the management; g) staff streamlining (about 25% of the existing staff has been fired or transferred to other sectors with WAJ authorization; and LEMA recruited: the total staffed decreased by 15%); h) the development of water metres repairs and regular water meter readings; i) much stricter procedures for service disconnection and court cases; j)the introduction of the legal responsibility of the operator in front of the clients and finally k) a better bill recovery rate higher than 100% due to the collection of old unpaid bills.

WAJ recognized the improvements obtained by LEMA (notably concerning the management and formation of the employees), although the reduction of leakages remains the main problem. The objective of reducing unaccounted for water from 54 to 24% was clearly unattainable as the rehabilitation project of the Amman drinking water supply network (funded by the World Bank, the German cooperation KFW, the EIB, the Italian government, USAID, the Japanese Cooperation JICA, etc.) was finally initiated in 2003 (instead of 2000). Further, the constraints imposed by WAJ to LEMA (rigidity of management, lack of legal tools to prosecute faulty users; bureaucratic slowness) are further impediments for a company which does not have real management autonomy and is financially dependant on the Jordanian government (through the rehabilitation program) to plan its intervention while it is the sole responsible of any malfunctioning in front of the users. Finally, WAJ complained about the augmentation of LEMA salaries and expenses, which seemed too high in relation to the results obtained.

The survey done by Darmane in 2004 in East Amman areas confirmed the quicker repair of technical problems; the more regular distribution of water, even in summer; the easiest contact with the company and customers services through its call centre and the improvement of water quality. But most households are still complaining about insufficient quantities, irregular delivery, low quality of water and higher costs due to water meter repairs and regular readings. One further success of the management transfer has been the enforcement of laws while the Jordanian state was previously unable to act efficiently due to the general use of wasta system and to the lack of efficient legal procedures. In 2002, LEMA had put forward 4,000 legal procedures against illegal connections, compared to the few hundred of the previous years. The state was thus able to transfer the responsibility for unpopular decisions to the company and this facilitated the management of water facilities. To put it simply, during the first two years, LEMA had convinced almost everybody of its technical skills and management capacity. Then, during the two following years, the economic results have been satisfactory (many consumers were forced to pay their bills and the controls were improved) but the real impact of the project on the "unaccounted for" water had been criticised. The contract extension by two years (notably funded by the French government) was meant to give LEMA enough time to support the implementation of the rehabilitation project and reduce the unaccounted for water. But many critics were made and many options to suspend the management contract have been discussed and prepared with notably the possible creation of a new state company. At the end of 2006, the contract has not been renewed……..

After a period of increasing interest for water facilities privatisation (LEMA in Amman, possible privatisation of the Jordan Valley irrigation system with the support USAID, privatization of the Northern cities water facilities with the support of German cooperation, privatisation of water facilities in Aqaba …) some doubts have developed inside the Jordanian government: the transfer of management of the Jordan Valley infrastructure is, for example, not anymore a burning agenda. The Amman experience shows that real progresses have been made in management procedures to ensure a better service (notably to have a better rate of bill recovery and limit illegal connections). But in the long run, private companies can only be interested in management contracts if profits are sufficient: this would only be the case with a much longer term concession or a lease contract giving more freedom for intervention to the companies. The Jordanian government may not be ready for such alternative which could antagonize supportive segments of the society, while gains would be uncertain. The experience in Amman was made possible only because the costs of the private services have been supported by international donors (the World Bank and later the French Government) but with all the subsidies presently borne by the government and because O&M costs and investments of new projects are likely to further increase; it is difficult for the Jordanian government to bear extra costs for the management of its facilities: the willingness and capacity to pay of the majority of the population allows only a very limited improvement in the financial viability of the system. The prices paid by the majority of the consumers are likely to remain under the production costs. The crux will be how the Jordanian government will continue to subsidize public water distribution while trying to limit these subsidies as much as possible. Both LEMA (low profit, limited freedom) and the Jordanian government had interests in not renewing the contract in 2006: a donor supported technical cooperation and the creation of an autonomous agency to continue the "experience" maybe the solution preferred by the government.

*Box 5-11. LEMA and private tankers in Amman*

The involvement of LEMA in the management of the Amman drinking water supply network led to stronger enforcement of both supply and sanitation bill collection while the public network still retained many constrains (see above). Many big water users (notably hospitals and hotels) increasingly called upon private tankers (some bought their own trucks) for their daily consumption. In 2002, while LEMA used only 26 tankers to supply clients not connected to the public network, around 2,000 to 2,500 private tankers were purchasing water from neighbouring agricultural wells. LEMA was progressively losing its larger clients and its economic viability was under threat: this pushed the company to request an intervention from the government which met with strong support from the World Bank. Despite the lobbying of private investors, the Minister of Water and Irrigation put a halt to this development in implementing a tax of \$0.35/$m^3$ for all water pumped from private wells and used for domestic purposes (see chapter 4.2): the situation came back to normal with a strong decrease in the number of private tankers (according to WAJ data, in 2004, there were 1,267 private trucks among which 289 belonged to industries and hospitals). This shows that the state is able to solve problems of water resources management even if strong private interests have to be confronted, at least when its own interests are directly and immediately threatened (if LEMA would have lost its monopole and appeared to be economically unviable; the investments for the rehabilitation of the Amman network could have been stopped or reduced and the state would have to subsidize WAJ to cover its losses).

### 5.3.8 Expensive Water for the Poorest?

One of the main problems of the current management of the drinking water supply network in Amman is the cost of the services for the poorest families. Despite the implementation of a block tariff system (This is mainly due to the fact that many poor families can not afford the installation of an individual water meter or cannot officially declare that they are living in unregistered buildings. In these conditions, many families share a common water meter and proportionally pay more than their water share as the water meter shows a consumption reaching expensive blocks: 60% of the surveyed families reported illegal connections to a common water meter and average water costs accounted for 11% of the total revenue of an 'average family' (the water bill alone amounts to 7% of the revenue [Darmane, 2004]). This causes huge friction with LEMA and even among users as bills and payments are deemed excessively high. One very important "social" program in favour of the poorest families would be to subsidize individual water-meters even for families in illegal housing situation. Finally, most families complain about the discontinuous delivery, due to the technical characteristics of the network; the bad quality and the low quantity of water they receive. It is clear that investments to improve the network are needed but if those extra costs are made to be bear by the population through water price increase, this would have dramatic impacts on the poorest.

Table 5-10); the survey conducted by Darmane (2004) in five low status neighbourhoods of East Amman shows that the poorest families do not benefit from the low prices of the first block despite their low water consumption. They use 75 l/ca/day in average and 33.5 l/ca/day for the poorest (e.g. a consumption lower than 20 $m^3$ per family for three months) against an average of 135 to 150 l/ca/day for the whole Amman [Figure 5-40]).

This is mainly due to the fact that many poor families can not afford the installation of an individual water meter or cannot officially declare that they are living in unregistered buildings. In these conditions, many families share a common water meter and proportionally pay more than their water share as the water meter shows a consumption reaching expensive blocks: 60% of the surveyed families reported illegal connections to a common water meter and average water costs accounted for 11% of the total revenue of an 'average family' (the water bill alone amounts to 7% of the revenue [Darmane, 2004]).[98] This causes huge friction with LEMA and even among users as bills and payments are deemed excessively high. One very important "social" program in favour of the poorest families would be to subsidize individual water-meters even for families in illegal housing situation. Finally, most families complain about the discontinuous delivery, due to the technical characteristics of the network; the bad quality and the low quantity of water they receive. It is clear that investments to improve the network are needed but if those extra costs are made to be bear by the population through water price increase, this would have dramatic impacts on the poorest.

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[98] Despite this bias, water meters indicating consumption lower than 20 $m^3$/three months compose 30% of the LEMA billing system (LEMA, 2004). It is clear that the real costs of water are only partially linked to the production costs presented by WAJ and LEMA: users incur other costs to secure their access to water (roof top cisterns, pumps, canalisation, purchase of water in the informal sector etc…)

Table 5-10: Domestic water tariffs (Source: LEMA 2003)

| Consumption in m³ per water mater for a three month period | Water Tariff ($/m³) | Water Treatment Tariff ($/m³) | Water bill ($ for 3 months) |
|---|---|---|---|
| 0-20 | - | - | 4.2 |
| 21-40 | 0.169 | 0.550 | 9.4 |
| 41-70 | 0.475 | 0.200 | 47.9 |
| 71-100 | 0.752 | 0.337 | 109.3 |
| 101-120 | 0.936 | 0.429 | 164.3 |
| >121 | 1.058 | 0.553 | >164.3 |

Facing shortages and irregular water distribution, users have adopted multiple strategies that are linked to their socio and economic conditions. Capitalized families can invest in large tanks in order to get a minimum of autonomy and safety to face water cuts or water quality degradation: the economic status becomes then crucial in determining the capacity to free oneself from the unreliability of the network functioning. Another strategy is to adjust domestic activities to the timing of water distribution. Buying additional water from some neighbours or on the private market is also possible but very expensive. Yet 25% of the population occasionally rely on these alternatives supplies. At the same time, within the informal network and solidarity system, water circulates often as a gift or as part of a pattern of exchange, reciprocity and mutual aid as a main coping strategy. What remains a crucial factor is the reality of *wasta* and clientelistic relationship, where who manages to mobilize powerful mediators, according to his political and economic status, manages also to obtain water autonomy and water privileges, and to circumvent legal procedures on illegal connections. The network based on tribal solidarity remains one of the main elements of conflict and of encounter of legal pluralism, although it may play different roles: in case of high status families, it helps in reproducing their power and influence also in the water distribution, in case of low status and poor social groups, solidarity networks based often on kinship of neighbour relationships, become one of the main assets in order to cope with daily domestic needs. Therefore, differentiated access to water becomes a strong social and political marker in Jordan and it plays an important role even in election campaigns, where candidates widely promise a provision of the water with decreased bills.

### 5.3.9 Conclusion

In this changing context, the clientelist and redistribution character of Jordan as a state-provider enters in conflict with the problems of efficiency and of equity. In a frame where water has been one of the subsidized symbols of the state-provider, the new reforms tackle inevitably the state-citizen relationship and the issues of social and economic inequality. The service of water was previously based on a supply logic, where water was part of the resources provided by the state and so the goal was often to increase the water provided instead of limiting the consumption of water…. this is interesting but need to be develop. You say how it was before but not how it has become

*Box 5-12. Urban land and legal pluralism: a case study*

A case study by Razzaz (1994) highlights the intermixture between local effects of global and regional migration, remittances, market integration and urban pressure on land in the Ammanite region and local contestation around the management of a common resource in a context of legal pluralism. The value of land and of water has changed in relation to the rentier character of the Jordanian economy, the demographic growth and the urban pressure on water: between 1972 and 1982, Amman grew from 21 to 54 $km^2$ (Razzaz, 1994). Yajouz has historically been the dirah of the Bani Hassan, one of the largest tribes in Jordan. It was mostly used as herding pasture at the edge of the desert, and was managed in a musha system of tenure among two main branches of the tribe, the Khalaleh and the Zawahreh. Most of this land registered as state land could indeed be claimed by the tribes that managed it as their domain, inhabited it, used it for herding or scant cultivation (even if many groups refused to register their lands for fear of excessive fees and taxation by the State [Razzaz, 1994:15]).

Following growing population pressure in the 1960s and 1970s, the Bani Hassan started to become interested in registering the land in order to obtain titles that could be subdivided into residential plots and sold on the booming land market. The Government increasingly opposed this practice since the Bani Hassan had not cultivated the land for long and had therefore no legitimate claim to ownership. The Bani Hassan started to illegally subdivide small parcels of land and to sell them to new settlers who were seeking new land near Amman and Zarqa, in a wide development of unregistered land market. As Razzaz shows, what started as a routine developed into a self-help action by some members of the Bani Hassan, this action "ranged from the subdivision and sale of what is legally public land to the provision of basic services in the area" (Razzaz, 1994:17). Indeed, water and electricity state agencies did not extend their services to the area due to its ambiguous legal status and its scarce population.

Investors were mostly migrants from the Gulf, coming back in summer to marry and who were interested to buy tracts of land for house building. Since these land sales are judged illegal by the state, no official titles are present, but a document is used as a proof referred to as *hujja* (proof): the tribal sellers guarantee to "protect" the buyer against the invasion of other tribal members. Although these documents have been declared illegal by the Land and Survey Department, they are at the core of this process of legitimisation of a parallel legal system adopted to circumvent state control on land, whereby the "hujja system [is] elaborated in a complex system of illegal transaction with all accompanying rights and obligations" (Razzaz, 1994:13). Interestingly, the illegal process of settlement and land transaction was based on the role played by older settlers acting as wasta for the new ones and by the tribal landowner with a reputation of honest dealing (*mu'azib*, host).

Towards the end of the 1980s, the government tried to limit the ongoing building process, initially with warnings and threats, and in 1983 the prime Minister instructed the security forces to fence off parts of Yajouz and to demolish the illegal homes. As a consequence, the Bani Hassan took up arms to deny security agents the access to their land and violent clashes erupted. Following the clashes, the prime Minister was forced to resign.[99] Notwithstanding the state intervention in solving the dispute, "rather than being resolved, the conflict was transformed from one between the government and the Bani Hassan to one between the government and the new settlers" (Razzaz, 1994).

This case shows a crucial and widespread dynamic in the management of land, just as for other strategic resources such as water: different legal frameworks encounter and clash, a conflict which cannot be read simply as the interface between modernity and tradition, since these alternative forms constitute a process of mutual adjustment. What we face in the dynamic of legal pluralism, is the construction of "semi autonomous social fields" characterized by contradictions and inconsistencies, where social actors mobilize in order to achieve immediate goals for the community. Just like the

[99] In an attempt to co-opt and stabilize the conflict situation, a member of the Bani Hassan was later appointed Minister of Youth.

nation-state possesses the legal discourse and power to grant legitimacy over some social claims and deny it to others, local actors claim rights on the base of tribal legitimacy and kinship idiom: "before the state had right, the tribe had rights. Before the state had land, the tribe had land. If they (officials) want us to respect state rights, they have to recognize ours" (Razzaz, 1994).

## *5.4 Local Water Management of Springs*

A GTZ study (2003) on springs water management shows how the present patterns in using and distributing common resources for irrigation and domestic use have been based on multiple traditional rights concerning water, its distribution system and the systems of operation and maintenance. This survey conducted in the Governatorates of Irbid, Balqa'a, Jerash, Ajloun, Tafila, Karak, Madaba (cf. Figure 2.1) shows the presence of an heterogeneous system of water rights that characterized the area before water management was centralized and today's reality in an overlapping of systems.

In the past, turns of waters derived from springs were generally distributed according to the size of the holdings in consensual agreement of the village, a social unit which was often coincident with a lineage of a tribe as one common community. The water mediator played an important role and was often the head of a tribe or sheikh, deputed to solve disputes around water. Shares of water could be sold or exchanged in a system of reciprocity in order to adapt the time-share system to local needs in a flexible ways. The sale of water right was strictly linked to land. Patterns of traditional systems are still active along side wadis as well as in the Jordan Valley, as in Wady Shayb or Hudjaydjeh, where local communities share water on a temporal schedule without the intervention of the JVA (chapter 4.3).

### 5.4.1 Some Traditional Irrigation Systems

In the past, complex hydraulic structures to convey and distribute water from springs have been developed in both Palestine and Transjordan. Very sophisticated methods have been employed to facilitate the exploitation of springs for irrigated agriculture since ancient times in the Middle East, which shows an accumulation of geo-hydrological knowledge (Appendix 10). Three main types of irrigation systems can be identified:

- Subterranean outflow installations. Tunnels and caves were cut into saturated aquifers until they met the water table in order to concentrate and increase the water flow. Through the years, the flow tunnels, that had a gentle slope, were lengthened and branched, following the receding and lowering water table, in order to renew or increase the water outflow (Kharez, Qanat, foggara systems). This was a "long-proven method of recovering groundwater in sloping, semi-arid regions such as the West Bank" (Rowney 1985). Most of these qanats or *kharezin* are either quite recent in origin or have been maintained and re-developed by Arab villagers (Appendix 10)
- Installation for impounding and distributing water for terrace irrigation;
- Levelled terraces irrigated by gravity. An irrigation system was built as a wide unit, planned in advance with complete compatibility between the location of the spring, its outflow, and the size and pattern of the terrace system.

### 5.4.2 Main Aspects of Local Management Systems

As the GTZ report (2003) shows, some crucial aspects can be highlighted here concerning this pattern of diffuse water use and distribution, which often relies on local management systems.

*Traditional Water Rights*

Traditional water rights are generally expressed through a share system, which includes rules regarding the timings, hours or days, of irrigation in a rotation pattern among the users and entail pattern of conflict resolution and of organization of the maintenance work. As we have seen before (chapter 3), water rights schedules are issued according to the 1937 Settlement of Land Law and the Water Law No.38 of 1946, which were later replaced by the Settlement of Land and Water Law n.40 of 1952 and its amendments. These laws are inevitably written and more rigid and static, while on the other hand, oral and traditional agreements on water rights are generally more flexible, subject to alteration and also to manipulation through time and are therefore influenced by the changes in water resources, the climatic conditions or by the technological development or the changes in irrigation system.

*Water Mediator and Water Committees*

The water-mediator controls the seasonal water schedule and may be paid in cash but also with water-shares. Not every community has opted to 'employ' a water mediator, since it is related to the problems faced and the amount of water distributed, but it is always important that the water mediator is a trusted person inside the community. Different roles are performed by the Water Mediator: informing users on their share and eventual changes of time and duration of their share, mediating in case of water theft and helping in the setting up of a committee composed by tribal elders and representatives. Depending upon the size of the irrigated area and the number of farmers involved, the distribution systems vary. When there are very few farmers involved they may find easier agreements and they use to follow the rules they have accepted. When the number is higher, the area is bigger and the control becomes often a specific function handed to a local mediator, generally linked to the dominating tribe. When the number of farmers involved is vaster, it is sometimes necessary for the users to pay for a guard or a controller to ensure the application of the rules/hours.

Water sharing committees are widespread, which on the base of consensual decision define the water distribution, and always in relation to a time-share of water per unit of land.

*Role of the Tribal Structure*

The tribal structure is often the base in organizing the water distribution, and the role of conflict resolution often lies in the hand of the sheikh of the tribe, in order also to avoid the Governor and the state intervention in the 'internal' affairs of the village. In case of tribal homogeneity, villagers prefer to keep control within the community and avoid any outsider interference; therefore, they prefer not to report violators to the *mutasarref*, the Governor, but try to compose the conflict within the tribal solidarity and alliance system.

In this frame, involving outsider would generally engender a stronger conflict within the kinship system and this is highly avoided. In case of the co-presence of different tribes, the shares are also organized around the tribal divisions and according to the amount of land owned and irrigated. Even the agreements reached during the last two decades when water shortages were faced, are sometimes called "tribal agreement" although they are signed at the Governor's office as form of an external recognition according an official value to the document. These new shares of water are organized on the basis of the traditional temporal units of water.

### 5.4.3 Changes Witnessed by Local Management Systems

In the last decades this diffuse and heterogonous management of springs and minor but strategic water sources has undergone strong changes due to exponential increase of pressure on water resources and of re-allocation of water, generally to urban and domestic uses. We witness the establishment of water cooperatives but also the increase of conflicts in some cases, an increasing and stronger intervention of WAJ in the management of spring resources, with the expansion of some major cities or with the extension of irrigated agriculture. The growing intervention of the municipalities in water and spring affairs and the development of private markets of water are the two major aspects, which have engendered new conflicts around water and in relation to propriety of land and to the legal pluralism of resources (chapter 5.4 and Box 5-12). The main problems are witnessed in the maintenance operations or in the collection of maintenance fees. Some main dynamics can be summarized here:

The competition for water has increased due to the techniques allowing its transport (trucks and pumps), due to the increase of the population, and finally, due to development of domestic water uses in neighbouring cities (see in chapter 5.4, the case of Amman). Private trucks, private or village pumps are now strongly competing with traditional agricultural uses.

The overexploitation of the aquifers negatively impacts spring flows (chapter 5.6) and often induces water quality degradation (chapter 4.4), while springs can also be polluted through brackish water or fertilizers infiltration.

In the 1950s, water was often plenty and villagers did not always need to organize shares of water due to the collective availability of this resource. It is only with urban expansion, agricultural development and demographic growth that the stronger conflicts arose when powerful users managed to get access to larger shares than others, increasing also the number of cases of thefts and water conflicts at the local level. In some cases, the set up of factories also contributed to the decrease of spring water availability for villagers and new agreements between new actors to reallocate water had to be found. WAJ has often intervened by pumping water near villages, reducing the resource for the inhabitants or their control on the scarce resource. In many villages, the decrease and pressure on water has often led to new consensual agreements on new shares of water, and if the time of each user's share is stable, the hiring of a water mediator is now avoided. Further, problems of maintenance of canal infrastructure are now more common. This reflects a fragmentation of the larger social units on which these cooperative efforts were previously based (it was found that 70% of users group had an agreement for maintenance of water distribution systems). The general problem is a lack of sense of ownership of the distribution system. In the context of a patronage character of the state, it is locally believed that villagers will receive additional and external support for the maintenance of their network. In case of theft, the fact is often reported in front of the Governor (*Mutasarref*) who organizes a committee responsible to verify the theft, composed by some representatives of the Agricultural Directorate or from the District administration or Governatorate. If the violator is found guilty, he has to pay the affected water user a specific amount decided by the Mutasarref.

## *5.5 Water Accounting in a Basin Perspective*

### 5.5.1 Introduction: A Methodology

The description of the transformation of the LJRB given in the preceding sections can now be paralleled by a more quantitative accounting of the resulting (im)balance between supply and demand. The water-accounting exercise presented here draws on the categories of water balance proposed by Molden (1997) and summarized in Appendix 11. The net inflow includes rainfall, basin transfers into the basin, and possible net overdraft of the aquifer and reservoirs. This total inflow is partly transformed through evapotranspiration of crops (irrigated, rain-fed and also natural vegetation) and water bodies, and through municipal and industrial (M&I) processes. The balance flows outside the basin (surface or underground flows): one fraction is committed to downstream use and the remaining uncommitted part is considered usable (if it can be put to use through better management of existing facilities) or not usable (e.g., uncontrollable flood flows).

These definitions are somewhat problematic when applied to the Jordan basin. If we consider the environmental flow needed to maintain the level of the Dead Sea as a “commitment,” then the basin has been having a deficit of around 540 $Mm^3$/yr. since the early fifties (chapter 4.2), at the time Israel diverted the Upper Jordan River and reduced it to a trickle of water. The remaining flow to the Dead Sea is mostly limited to the Yarmouk and side-wadis, resulting in a gradual and constant drop in the water level of the Dead Sea (chapter 4.4). On such a basis, if we consider this environmental flow as one use among others the basin accounting points to an extreme over-commitment, with 540 $Mm^3$/yr. adding to a net overdraft of approximately 32 $Mm^3$/yr. to make up a shortfall greater than all the water used by irrigated crops in the basin. Although this does correspond to reality, considering such a shortfall would distort our water balances to the point of making them meaningless. We have chosen here to consider that there is no commitment of the waters entering the Dead Sea, which is, therefore, considered as a sink. Any freshwater or brackish water flowing into it is, therefore, considered as uncommitted nonusable water.[100]

In such conditions, the meaning of “available water” tends to lose its significance because it is equal to the water depleted, i.e., to the renewable water minus the flow to the Dead Sea. We have, therefore, chosen to use two more meaningful variables: “renewable blue water” is the sum of surface water, aquifer recharge, and imports from both groundwater (distant aquifers) and surface water (desalinated water from the Red Sea). “Controlled renewable blue water” is the “renewable blue water” from which the part of the Yarmouk water that flows undiverted to the Jordan River is deducted, as well as brackish flows from Israel to the river, both resources which are of no use and cannot be controlled (and, therefore, may or may not be disregarded). Molden (1997) defines water depletion as a use or removal of water from a water basin that renders it unavailable for further use (the depleted fraction being the share of the water which is depleted, often expressed in percentage of the net or gross inflow). Water depletion is a key concept for water accounting, as interest is focused mostly on the productivity and the derived benefits per unit of water depleted. It is extremely important to distinguish water depletion from water diverted to a service or use, as not all water diverted to a use is depleted. Water is depleted by four generic processes (Molden 1997):

- *Evaporation*: water is vaporized from surfaces or transpired by plants (rain-fed or irrigated).

[100] Alternatively, one may consider this remaining outflow to be committed to environmental preservation: this does not change the calculation of the available water within the basin since we consider there is no uncommitted-usable water. Water reaching the Jordan River is of too low quality to be used.

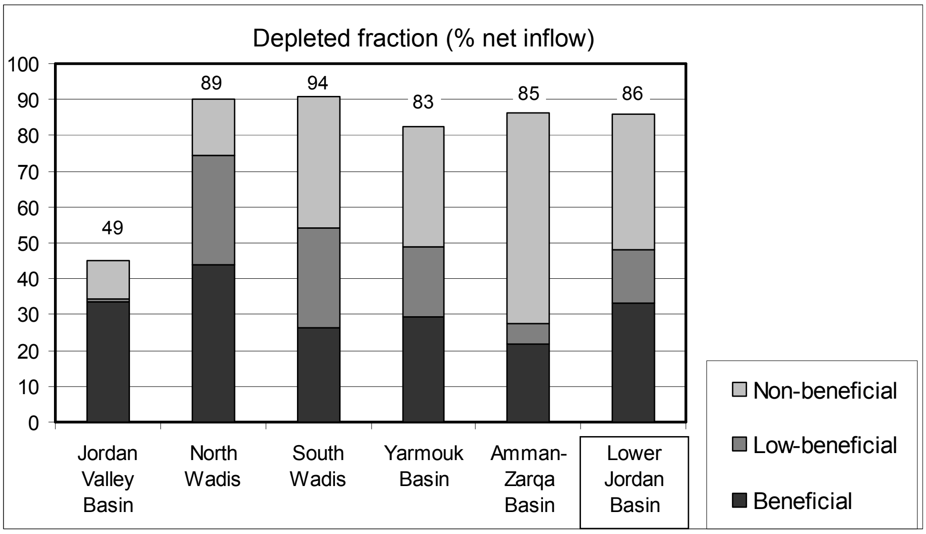
- *Flows to sinks*: water flows into a sea, saline groundwater, or other location where it is not readily or economically recovered for reuse.
- *Pollution*: water quality gets degraded to an extent that it is unfit for certain uses.
- *Incorporation into a product*: through an industrial or agricultural process, such as bottling water or incorporation of water into plant tissues.

The water accounting of the basin for the year 2000 is based on the data appearing in chapter 4.2 and land-use data combining remote sensing data (THKJ, MWI and JVA 2004) and official statistics. Flow data for years 1950 and 1975 are those appearing in the flow charts presented earlier. For these two periods, land-use patterns have been interpolated from the 2000 data, using figures for the total cultivated area and historical descriptions of land use (notably Baker and Harza 1955; THKJ 1977; Khouri 1981; Elmusa 1994, Medagri, 2003). We first give a detailed accounting of the water flows in 2000 (current situation) and then observe historical changes in land use and in the components of the water balance.

### 5.5.2 Water Accounting in 2000

Figure 5-42 first provides the depleted fraction (expressed in percentage of the net inflow) for each subbasin (see chapter 2.2 and the diagram of subbasins in Appendix 12).

*Figure 5-42. Percentage of the net inflow depleted (i.e., depleted fraction) on the Lower Jordan basin and subbasins, base year 2000).*




We can see that, in the Jordan Valley (hydrological subbasin) only half of the net inflow is depleted. This is due to the high amount of uncontrolled water since, at the moment, out of the 200 $Mm^3$/yr. "imported" from the upper Yarmouk basin, only 90 $Mm^3$/yr. can be controlled and diverted to the KAC, the remaining 110 $Mm^3$/yr. flowing uncontrolled to the Dead Sea (chapter 4.2). On the other hand, very little water flows out of the other subbasins and part of this water (especially in the Amman-Zarqa basin) is made up of return flows from cities. Overall, the Lower Jordan basin consumes 86 percent of its net inflow (i.e., rainfall, interbasin transfers and lateral groundwater flows) through evaporation and processes. We can further distinguish as follows:

- *Beneficial depletion* refers to evapotranspiration from both irrigation and rain-fed agriculture as well as M&I uses.

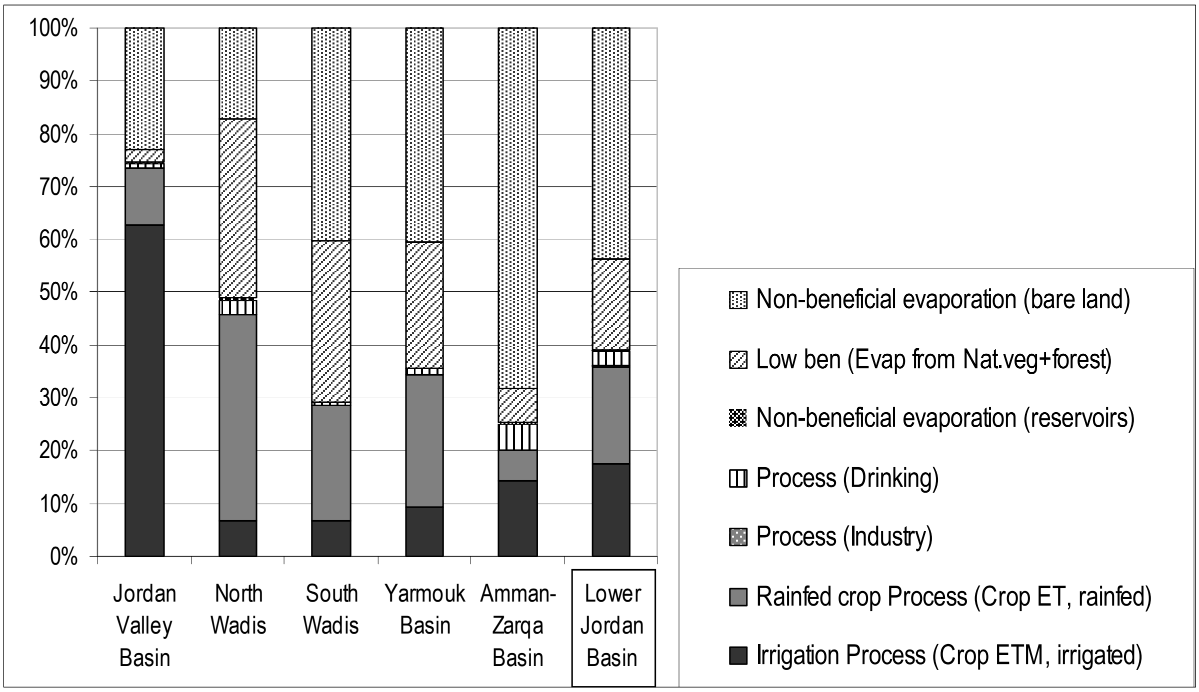
- *Low beneficial depletion* refers to evaporation from natural vegetation and forest.

- *Non beneficial depletion* refers to evaporation from bare land, deserts, and water bodies.

In the LJRB the beneficial depleted fraction accounts for 22 percent of the net inflow, the low beneficial depleted fraction for 6 percent, and the non-beneficial depleted fraction for the remaining 59 percent.

Figure 5-43 shows these three categories (beneficial, low-beneficial and non-beneficial fractions) in more detail and in relative terms (% of the total depleted fraction). It illustrates that beneficial depletion (corresponding to the sum of the four "process" fractions) is higher in the valley where it reaches approximately 76 percent of the total depleted fraction, and lower in the Zarqa basin where it only represents 31 percent of the total depleted fraction, while the non-beneficial evaporation/use (bare land and water bodies) is highest because of its large desert area. The low beneficial depleted fraction corresponds to forests and grasslands mostly grazed by sheep and is highest in the mountain area (north and south-wadis basins).

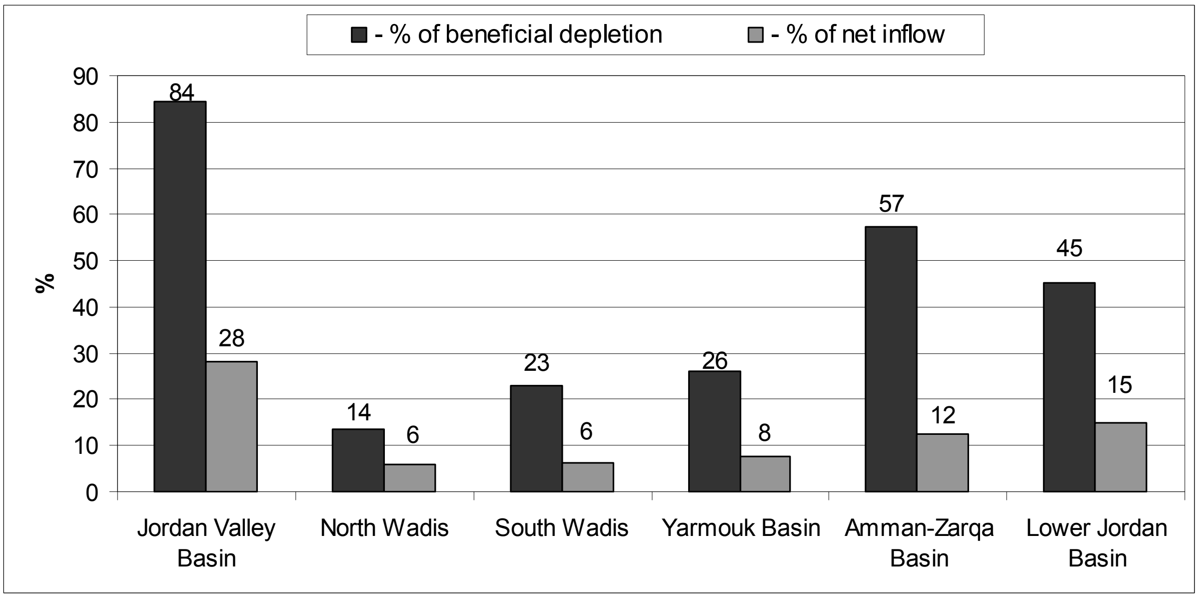
Figure 5-43. Categories of depleted fractions (Lower Jordan basin and subbasins, base year 2000).




With the exception of the valley, where it amounts to 63 percent of the total depleted fraction (Figure 5-43), the share of the irrigation process (crop ETM, irrigated), which stands for water depletion in irrigated agriculture, remains limited (respectively 7, 7, 9 and 14% of the total depleted fraction in the north wadis, south wadis, Yarmouk and Amman-Zarqa basins). On the entire Lower Jordan River basin, irrigation process accounts for 18 percent of the total depleted fraction. Finally, over 40 percent of the rainfall which is depleted in the basin is lost with no benefit whatsoever (mainly through evaporation of bare land). The figure also shows that despite all the allocation conflicts between the cities and agriculture, the share of M&I uses[101] (process drinking and process industry on Figure 5-43) is negligible, representing only 3 percent of the total depleted fraction in the LJRB, but rises to 14 percent when compared with irrigation depletion.

The importance of irrigation is better demonstrated by Figure 5-44. The depleted fraction in irrigated agriculture makes up 45 percent of the "beneficial" depleted fraction, on the entire LJRB that is, irrigation almost equates rain-fed agriculture although irrigated areas are three times smaller than rain-fed ones (chapter 3 and 4.11). Irrigation depletion is particularly high in the Jordan Valley subbasin where it reaches 84 percent of the beneficial depleted fraction. In terms of fraction of the net inflow, however, the share of the irrigation fraction drops down to 15 percent basin-wide (but remains very high in the valley at 28%), due to the significance of the low-beneficial and non-beneficial depletion.

*Figure 5-44. Water depleted in irrigation (irrigation fraction) in each subbasin, as percentage of beneficial depletion and net inflow.*



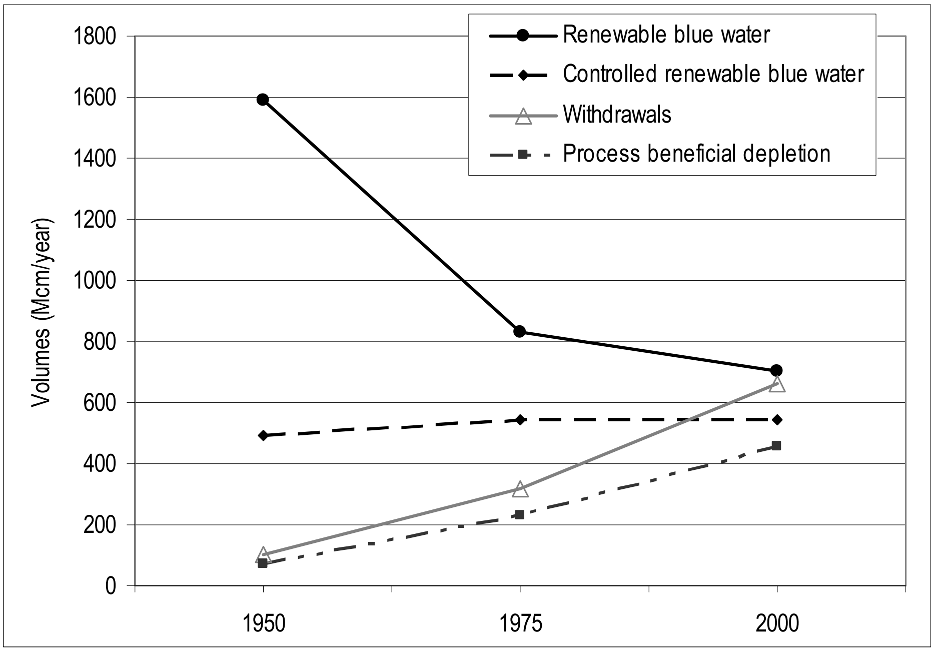

### 5.5.3 Evolution of the Terms of the Water Balance in the Lower Jordan River Basin

In parallel to land use changes that we have described in chapter 3 and 4.11, from a situation in the 1950s when few of the surface water and groundwater resources were put into use, to the current situation of overexploitation, the terms of the water balance have presumably varied from one extreme to the other and the examination of these changes is likely to be very instructive. The net inflow into the basin moved from over 3,300 $Mm^3$/yr. in 1950 to around 2,600 $Mm^3$/yr. in the following periods, because of the diversion of the Jordan River by Israel and growing abstraction of the water of the Yarmouk River by Syria. Deducting rainfall water directly evaporated from crops and bare soil, Figure 5-45 focuses on the renewable blue water and shows a similar drop by 50 percent, with a slump at 671 $Mm^3$ in 2000. The controlled renewable blue water (CRBW) is significantly lower, since uncontrolled and/or brackish flows from the Yarmouk or Israel are discounted. Strikingly, withdrawals (gross

[101] The depleted fraction in M&I uses is taken as 30 percent. This is higher than values corresponding to industrial and human consumption but includes the depleted fraction of outdoor uses (city gardens, car wash, etc.).

diversions of surface water plus abstracted groundwater) now amount to 127 percent of CRBW (i.e., 660 $Mm^3$/yr.), because of groundwater overabstraction and multiple diversions (return flows from wadi-irrigation or from Amman are reused downstream). Withdrawals have continuously and dramatically increased in the last 50 years: they were at 101 $Mm^3$/yr. in 1950 (20 percent of the CRBW), at 314 $Mm^3$/yr. in 1975 (58 percent of the CRBW), and at 660 $Mm^3$/yr. in 2000. In 2000, only 315 $Mm^3$/yr. ends into the Dead Sea and this amount decreases to 165 $Mm^3$/yr. if we do not consider the (still uncontrolled) flow from the Yarmouk and from Israel to the Jordan Valley.

Figure 5-45. Evolution of net inflow and available water in the Jordanian part of the LJRB.




The figure also shows the evolution of the process beneficial depleted fraction (in irrigated and rain-fed agriculture, and in M&I), which almost equates CRBW in 2000: effective rainfall and aquifer overdraft are coincidently close to the nonconsumed part of CRBW. Aquifers began to be overexploited during the last quarter of the century (the groundwater budget still presented a positive balance of 51 $Mm^3$/yr. in 1975), the situation being now worrying since the overdraft reaches 32 $Mm^3$/yr. The evolution of the depleted fraction, distributed over three categories (process/beneficial, low-beneficial, and non-beneficial depletion), is given in Figure 5-46. It can be seen that the biggest change occurred in the 1950–1975 period, when the total beneficial depletion increased dramatically from 391 to 756 $Mm^3$/yr. (or from 21% to 37% of the total depleted fraction). This happened when cropped areas increased and when the net inflow was curtailed by the diversion of the Upper Jordan River by Israel. This trend continued in the last quarter of the century and took the beneficial depleted fraction to 39 percent of total depletion (867 $Mm^3$/yr.; partly due to the overexploitation of aquifers). At the same time, the depleted fraction (expressed in percentage of the net inflow) increased from 58 percent to 86 percent. Figure 5-46 also illustrates that the non-beneficial depleted fraction stayed (and will remain) roughly constant since 1950, while its relative share continuously decreased because of the expansion of the cropped area (both rain-fed and irrigated) contributing to the beneficial depleted fraction.

Figure 5-46. Evolution of depleted fractions in the LJRB (nominal values and percentage).

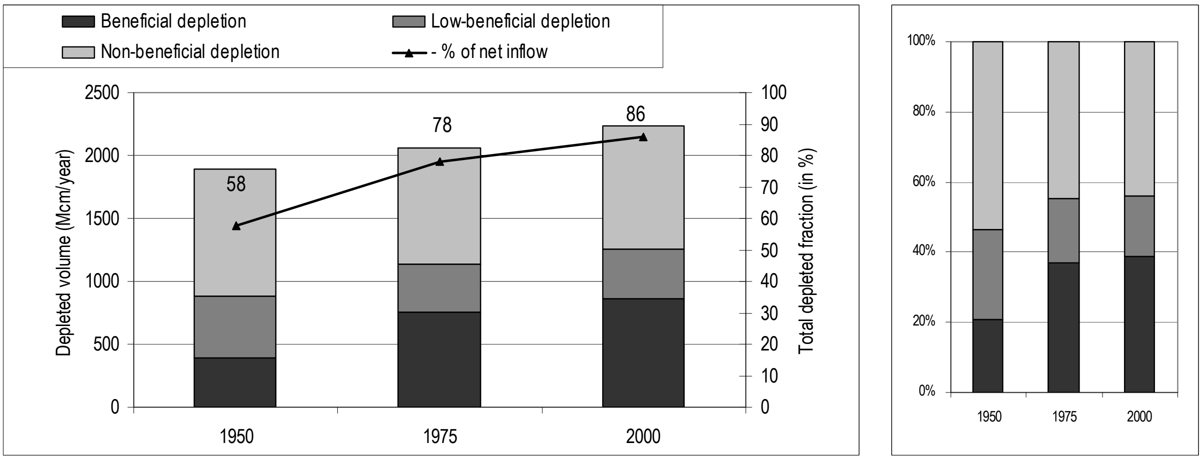



Figure 5-47 zeroes in on the irrigation fraction, i.e., the percentage of water depleted in irrigated agriculture as a percentage of the total beneficial depletion and of the net inflow. It indicates a quite dramatic increase from 2 percent of the net inflow in 1950 to around 18 percent at present (making up 45% of the beneficial depleted fraction). It is interesting to note that the shares of both the valley and the highlands in the irrigation depletion fraction are almost identical (not shown). This is due to comparable irrigated areas in these two regions of the basin.

Figure 5-47. Changes in the fraction of water depleted in irrigation (irrigation fraction) expressed as a percentage of beneficial depletion and available water.

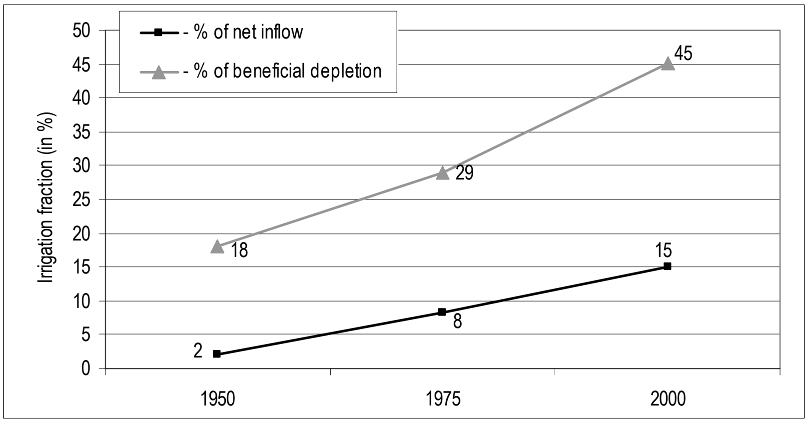



Table 5-11 provides details of all the terms of the water accounting for the whole LJRB as well as for its five subbasins.[102] Appendix 12 also provides a flow chart for each of the subbasins, indicating the rainfall, ET fraction, groundwater net balance, imports and exports for the year 2000, while Appendix 14 shows the terms of the water balance for each subbasin.

[102] It has been hypothesized that the Mukheibeh wells, located in the Yarmouk basin and used to supply the KAC with some 20 $Mm^3$/yr. of additional freshwater (it is expected that this water will be used for drinking purposes in 2025), abstract water from the Yarmouk aquifer. Following Salameh (1990) and Salameh and Bannayan (1993), we have computed a groundwater flow of 25 $Mm^3$/yr. from the Yarmouk aquifer to the north side-wadi basin. As a result, the balance of the Yarmouk aquifer shows a substantial overdraft (-13 $Mm^3$/yr.) while, on the contrary, the aquifers of the side-wadis show a yearly net gain of 22 Mm3/yr. (in the north side-wadis).

*Table 5-11. Details of water accounting for the Jordan River basin and each subbasin.*

| | Jordan Valley Basin | North Wadis | South Wadis | Yarmouk Basin | Amman-Zarqa Basin | Lower Jordan Basin |
|---|---|---|---|---|---|---|
| **Inflow** | | | | | | |
| Direct rainfall | 190 | 460 | 253 | 530 | 801 | 2235 |
| Import/inflow from other basins | 477 | 17 | 0 | 9 | 75 | 310 |
| Lateral groundwater flows | 0 | 25 | 0 | 0 | 28 | 28 |
| Gross inflow | 667 | 502 | 253 | 539 | 904 | 2573 |
| Storage change Reservoirs | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil (groundwater depletion) | 0 | 22 | -0,1 | -12,5 | -41 | -32 |
| Net inflow | 667 | 481 | 254 | 552 | 944 | 2605 |
| **Depletion** | | | | | | |
| Beneficial | | | | | | |
| Irrigation Process (Crop ETM, irrigated) | 188 | 29 | 15 | 42 | 117 | 391 |
| Rainfed crop Process (Crop ET, rainfed) | 32 | 170 | 50 | 114 | 46 | 413 |
| Process (Industry) | 0 | 0 | 0 | 0,2 | 2 | 2 |
| Process (Drinking) | 3 | 11 | 2 | 5 | 40 | 61 |
| Non-beneficial evaporation (reservoirs) | 1 | 2 | 0,2 | 0 | 2 | 5 |
| Non-beneficial evaporation (bare land) | 69 | 74 | 93 | 185 | 557 | 978 |
| Low ben (Evap from Nat.veg+forest) | 6 | 147 | 70 | 108 | 53 | 385 |
| Total depleted | 299 | 434 | 231 | 455 | 816 | 2235 |
| **Outflow** | | | | | | |
| Committed water | 0 | 17 | 18 | 52 | 13 | 0 |
| Non committed water (usable) | 0 | 0 | 0 | 0 | 0 | 0 |
| Non committed water (non-usable) | 318 | 30 | 5 | 0 | 35 | 318 |
| Export to other basins | 50 | 0 | 0 | 45 | 80 | 52 |
| Total outflow | 368 | 47 | 23 | 97 | 128 | 370 |
| **Renewable blue water (RBW)** | | | | | | 705 |
| **Controlled renewable blue water (CRBW)** | | | | | | 545 |
| Aquifer net overdraft | 0 | 22 | 0 | -13 | -41 | -32 |
| **Indicators** | | | | | | |
| Depleted fraction (Percentage) | | | | | | |
| -of net inflow | 45 | 90 | 91 | 82 | 86 | **86** |
| Process fraction (Percentage) | | | | | | |
| -of net inflow | 33 | 44 | 27 | 29 | 22 | **33** |
| -of depleted water | 74 | 48 | 29 | 36 | 25 | **39** |
| Low beneficial depletion (Non-process) | | | | | | |
| -% of net inflow | 1 | 31 | 28 | 20 | 6 | **15** |
| -% of depleted water | 2 | 34 | 30 | 24 | 7 | **17** |
| Non beneficial depletion (Non process) | | | | | | |
| -% of net inflow | 11 | 16 | 37 | 33 | 59 | **38** |
| -% of depleted water | 23 | 18 | 40 | 41 | 68 | **44** |
| Irrigation Process (Crop ETM irrigated) | | | | | | |
| - % of beneficial depletion | 84 | 14 | 23 | 26 | 57 | **45** |
| - % of depleted water | 63 | 7 | 7 | 9 | 14 | **18** |
| - % of net inflow | 28 | 6 | 6 | 8 | 12 | **15** |

*Note:* All data refer to the situation *circa* 2000. Figures for inflows, outflows and different indicators of water depletion are given in $Mm^3$/yr.; fractions are given as percentages. Data are based on the chart presented in chapter 4.2 (Figure 4-6) and are drawn from a comprehensive list of figures presented in Appendix 14). All numbers have been rounded. Most of the numbers given for subbasins are summed up to obtain the figure corresponding to the entire LJRB. However, transfers between subbasins do not add up at the basin level because some of the transfers are internal to the basin. Water is actually moved from one reservoir to another without affecting the global water balance of the basin.

### 5.5.4 Water Use Efficiency at the Basin Level

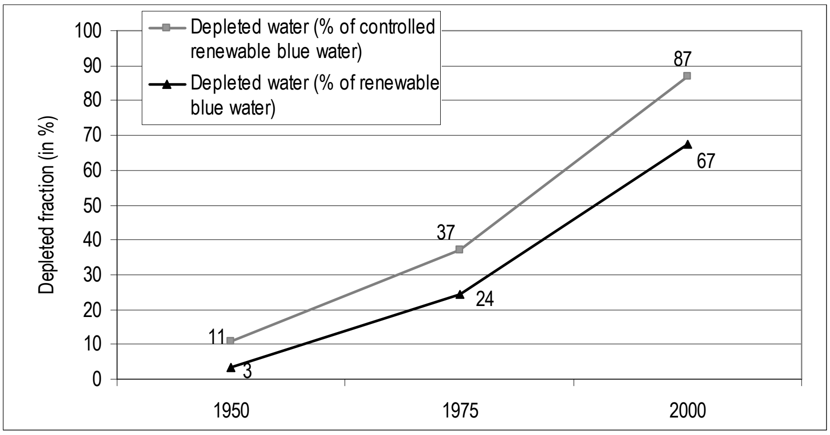
These basin-level figures prompt some reflections on the question of efficiency in water use. Groundwater-based irrigation efficiency in the highlands has increased in the last two decades, with an almost complete shift from surface water irrigation to micro-irrigation (Elmusa 1994; THKJ 2004). This, in many cases, has allowed the discharge obtained from each well to be "spread" over a larger area (Venot 2004, chapter 5.1), bringing more benefit to the farmer but resulting also in more evapotranspiration and less return flow to the aquifer, thus compounding the net overdraft. As mentioned earlier, there is evidence that percolation losses from irrigation in the highlands return to the aquifer and are, therefore, not significant in terms of net water balance or savings. (Secondary benefits from improved efficiency come from reduced pumping costs.) Areas irrigated by diversion of wadis along the main valleys also have high efficiencies because return flows are quickly reintegrated to the main stream.

In the valley, the shift to micro-irrigation owes more to the intensification of agriculture than to water scarcity per se since it started 20 years before talks of a water crisis emerged. Cultivation of vegetables under plastic mulch that controls weeds competing with vegetables makes micro-irrigation necessary and also allows better application of water and "fertigation." Other more extensive crops (notably citrus) as well as part of the banana crop are still irrigated by gravity but the defined JVA-quotas (chapter 5.2) keep application losses to a minimum since quotas are less than full crop requirements. In the long term, adoption of micro-irrigation in the valley is beneficial because it allows a reduction of allocations and because the return flow is little used: surface runoff quickly flows to the Jordan River, where it mixes with brackish water and is not diverted further downstream; part of the percolation losses is drained by the Jordan River and the main part replenishes the Jordan Valley aquifer but the use of this aquifer is limited since only the upper part of this aquifer is not too brackish and can be used for non-salt-sensitive crops (also note cases of desalination for banana cultivation in the southern part of the valley). Therefore, gains in efficiency are desirable when they limit runoff to the Jordan River, but with a possible impact on downstream groundwater users.

However, water use efficiency at the plot level is already rather high (it is generally taken at 80% for drip irrigation; see THKJ 2004) and possible on-farm savings are, therefore, limited. More significant gains will be realized at the basin level when the Wehdah dam will allow managers to control water in the Yarmouk and distribute it throughout the year according to real requirements. Even this benefit is partly unclear because the current benefits of excess water availability in KAC (in months when flows in the Yarmouk are abundant) in terms of salt lixiviation are not well known and might be understated (McCornick et al. 2001).

Appendix 13 provides additional water accounting indicators which allow us to evaluate the overall efficiency of water use in the basin, considered as a system. This efficiency has continuously increased since the depleted fraction expressed both in percentage of RBW (3% in 1950; 24% in 1975; 67% in 2000) or in percentage of the CRBW (11% in 1950; 37% in 1975; and 87% in 2000) has sharply increased.

Figure 5-48. Basin management efficiency.




This underlines the fact that the LJRB is a closed river basin, where almost no water resource is left to be mobilized and used. It is noteworthy that the process of closure has been very rapid since the development of the basin dates back only to the early 1950s and is fast approaching completion. With the caveat regarding our earlier assumption on environmental flows, the basin efficiency stands around 90 percent at present. In other words, there are very few prospects to alleviate the Jordanian water crisis by technical improvement aiming at increasing water use efficiency since overall, at the basin scale, this efficiency (volume of depleted water expressed in percentage of the volume of water withdrawals) already reaches 72 percent. This does not mean that saving water through improved fine-tuning of irrigation supply in the valley or through water-saving technology does not need to be considered, but it does set a drastic limit to what can be achieved through conservation means (chapter 6).

### 5.5.5 Refining Water-Use Categories

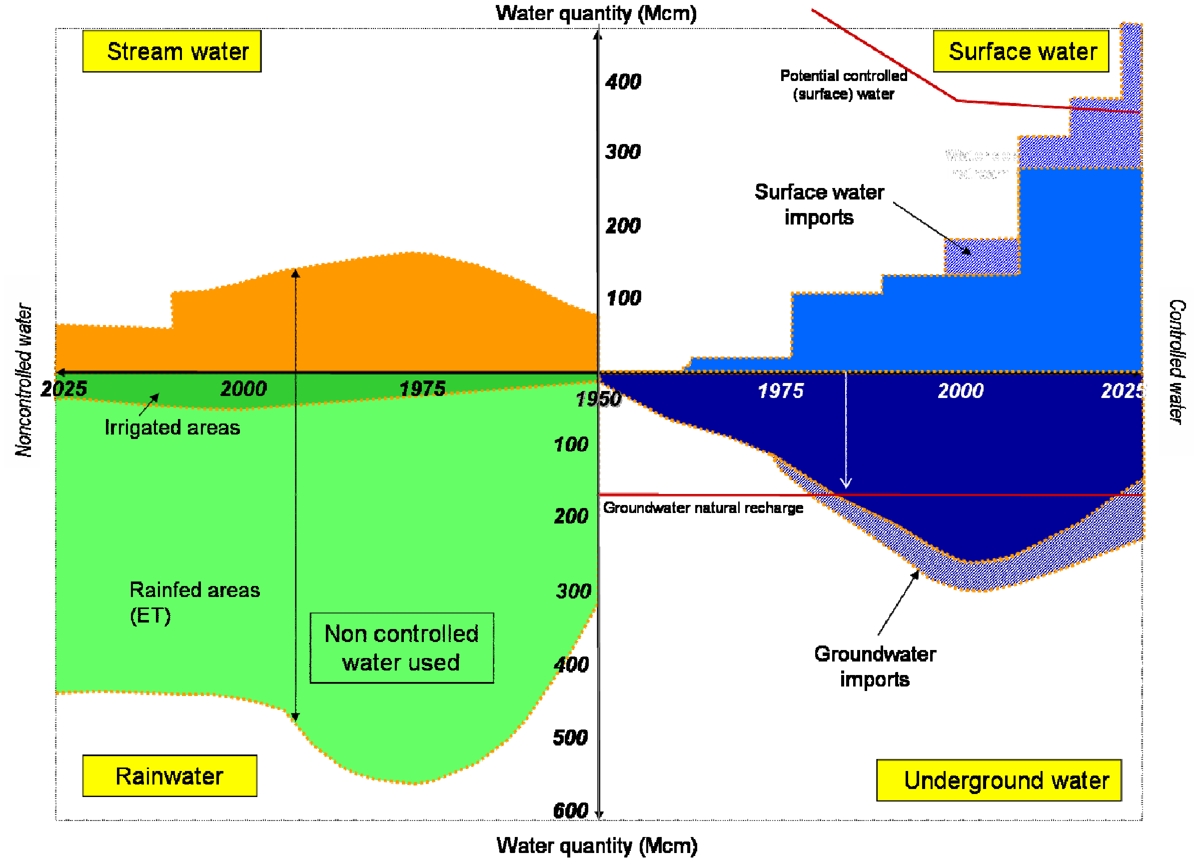
A limitation of the water accounting is that the water use (withdrawals) category pools together four different kind of water sources that are groundwater, surface water (controlled by dams), stream water (uncontrolled flows that are diverted), and efficient rainfall (used by irrigated and rain-fed crops) (Molle 2003). These categories of water are not equivalent because the degree of control we have on these four resources varies highly (in decreasing order in the above list). It is, therefore, instructive to disaggregate water use into these four categories and to plot these fractions against time. By so doing, we obtain a view of both their relative importance and time dynamics, as illustrated in Figure 5-49: it first shows that rainfall on rain-fed crops constitutes the major category of beneficial water, even in such arid conditions.[103] It is due to the large extent of areas of rain-fed crops within the basin (chapter 4.1). It is also striking that groundwater use (gross abstraction) in the LJRB now appears as a source of greater magnitude than (controlled) gross diversions of surface water (275 $Mm^3$/yr. against 120 $Mm^3$/yr. in 2000), although this will be reversed when the Red-Dead project is in operation (chapter 6).

Surface water follows the construction of the dams, while stream water includes side-wadis and Yarmouk diversions: this term increased with the construction of the KAC (supplied by water diverted

[103] While all other three quadrants show gross withdrawal values, the rainfall quadrant shows the fraction used by the plants only. If we consider total direct rainfall the difference would be even more considerable (912 $Mm^3$ in 2000, for example).

from the Yarmouk) but decreases as dam construction shifts water from the stream water category to the surface water category.

Figure 5-49. Four-quadrant diagram presenting water withdrawal trends in the LJRB from 1950 to 2025 according to several water "categories."




The total natural recharge of the aquifers (158 $Mm^3$/yr. for the LJRB, as evaluated by THKJ (2004)) is indicated in the "groundwater quadrant." The notion of safe yield as the level of abstraction that does not impact on existing users or ecological sustainability is very fuzzy. In general, water pumped from the aquifer incurs both a "de-stockage" of the aquifer itself and a reduction in the base-flow and spring discharge. Current hydrogeological knowledge does not allow us to establish an accurate balance of all these flows, all the more because both recharge and abstraction fluctuate in time. While abstraction is often compared to natural recharge (or some value of safe yield), recharge by return flows of urban and agricultural uses is often not considered despite their magnitude.

The total return flow through percolation of groundwater use in the LJRB is currently estimated at 89 $Mm^3$/yr.,[104] against 153 $Mm^3$/yr.[105] for the natural recharge (calculated as direct recharge by rainfall plus possible lateral flow minus base-flow) pointing to the fact, that it is imperative to take such flows

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[104] This figure is an evaluation of the authors assuming that agricultural irrigation efficiency is about 80 percent (figure largely used in the literature: Al-Weshah 2000; ARD 2001; THKJ 2004), and that the efficiency of urban water supply reaches 70 percent (Abu-Shams 2003; Decker 2004).

[105] It is worth noting that the annual recharge considered here is lower than the one presented in the THKJ 2004 by about 39 $Mm^3$/yr. Estimates of overabstraction will, therefore, be higher than in THKJ 2004.

into account, although more information on their dynamics is needed.[106] Not taking into account such return flows leads to evaluating of current abstraction at 180 percent, against 119 percent in the opposite case. This shows how numbers can vary depending on the hypotheses made and how they may support very contrasting conclusions and lead to different policies.

It is useful to emphasize that the four categories distinguished in Figure 5-49 are not, and cannot be, "waterproof," in the sense that some pumped groundwater, for example, can return to the aquifer, make its way to the river as base-flow, be stored and/or diverted again to other uses. The interconnectedness of the hydrological regime and the reuse of some fraction of water flows make it impossible to disaggregate water flows and stocks into fully independent categories.

The concomitant decrease of inflow (due to upstream diversions by Israel and Syria), later partly compensated for by imports from other basins, and increase in total withdrawals have reduced the nondiverted fraction of "stream water" to almost nil: from 1,335 $Mm^3$/yr. in 1950 to 489 $Mm^3$/yr. in 1975 and to 252 $Mm^3$/yr. at present. This is once again, an illustration of the rapid closure of the Jordan River basin in the last 50 years. Very little water remains unmobilized and the basin can hardly be developed further without interbasin transfers that will play a major role in the future (chapter 6).

[106] Return flow from cities (leakage, percolation from outdoor uses and sewers, etc.) and agriculture (now reduced because of the generalization of micro-irrigation) are not well known. It is possible that some fraction is taken up by evapotranspiration (capillarity and phreatophytes) but studies on water quality identifying a high level of nitrates near agricultural wells (JICA 2001) point to a significant return flow to the aquifer. The time lag for the transfer from the surface to the aquifer is also not well known.

# 6 Looking ahead: Transformations in the lower Jordan River basin

The preceding chapters have detailed the historical transformations of the water sector in Jordan and sketched out the current crisis. This chapter now looks at the future, reviews the different solutions at hand, estimates the water balance and the terms of the supply/demand ratio in 2025, and discusses alternative scenarios.

## *6.1 Emerging Problems and Challenges*

Jordan is already facing a sheer imbalance between available resources and actual uses (chapter 4.2). This imbalance is expected to grow with population and will have to be mitigated by a wide range of actions and policy reforms. The main water problems on Jordan's agenda, and those which are to acquire increased relevance by the year 2025, include:

- *Population growth*. The rapid increase in water needs (due to an improvement in living standards and to a still high demographic growth of 2.82% notably in urban needs (the cities concentrate nearly 70% of the population [chapter 2]). The recent in-migration from Iraq after the second gulf war is also adding extra-pressure on urban sprawl and resulting water needs.

- *Growing cost of supply*. The ever-increasing costs of tapping additional water resources, supported until now by the government[107] and international aid (expensive dams, long-distance transfers, elevation costs, desalination, etc. see Kolars, 1992; GTZ, 1998; Nachbaur, 2004) but which may have, in the next decades, to be increasingly borne by the population (the present financing being unsustainable in the long term), with possible impact on the poorest households of the Jordanian society (Darmane, 2004).

- *Groundwater overdraft*. The overexploitation of aquifers and the decline of their quality. Irrigated agriculture, in particular, leads to a deterioration in their quality (induced salinization, nitrates contamination, etc. chapter 4.4) and thus jeopardizes the possible future use by cities of this high quality and low-cost water.

- *Growing vulnerability to droughts*. The unchallenged policy of transferring increasing freshwater volumes from irrigated agriculture to urban uses, makes the agriculture sector more vulnerable to droughts because its share is both reduced and more uncertain. During dry years (2000 to 2002), for example, the Jordanian government froze the quantity of water reserved for cities, while drastically reducing the amount allocated to agriculture in the Jordan Valley (chapter 5.2).

- *Maintenance of infrastructures*. Several measures have already been taken to reduce the unaccounted for water in Amman's water supply (Darmane, 2004). The financing of O&M has always been minimal (and mainly borne by the public sector), resulting in degradation. There is a clear need for closely considering the O&M of these systems, notably if their efficiency is to be maintained. This also applies to JVA's infrastructure for which O&M costs recovery is within reach.

[107] The cumulated deficit of the Jordanian water sector corresponding to the amount of money invested (construction of water facilities, subsidies on water prices, etc.), owing to public deficit, has been evaluated by the World Bank (1997) at $476 million in 1995 and has been increasing since then at an average rate of $90 million/year (i.e., 0.9% of the GDP) (Central Bank of Jordan, quarterly reports).

- *Health and environmental hazards*. Apart from the problem of unsustainability associated with the overexploitation of the aquifers, other environmental problems have to be underlined. These include health hazards linked to the use of treated wastewater in agriculture, the drop of the Dead Sea level, the disappearance of the Azraq oasis, as well as the contamination of groundwater and surface water (chapter 4.4).

- More specifically the future of irrigated agriculture raises a set of technical, social and economic questions:

  - *Redefine agriculture in the highlands*. Irrigated agriculture in the highlands has mainly developed during the last three decades because of large private investments. The 500 to 1,000 investors concerned belong to the high society (Members of Parliament, senators, entrepreneurs, sheikhs, etc.); their influence on the government makes measures to reduce abstraction more unlikely.

  - *Degradation of water quality*. The situation in the southern Jordan Valley, which receives blended fresh/treated wastewater from Amman instead of freshwater coming from the north (now transferred to the capital), is expected to be extended to the whole valley during the next decade (see McCornick et al., 2002; THKJ et al., 2002; THKJ et *al.*, 2004b). Degradation of water quality may generate a wide range of problems: workers' and consumers' contamination, soil degradation, clogging-up of irrigation system emitters, disappearance of certain sensitive crops (strawberries, beans, citrus, etc. [FORWARD, 1999; Grattan, 2001; McCornick et *al.*, 2002]), consumer's lack of confidence in the quality of the products, drop in prices, and loss of some export markets.

  - *Declining profitability*. Notwithstanding the increase in water costs, marketing currently is the main problem faced by producers (ASAL, 1994; World Bank, 1999, chapter 4.1). Since the mid 1980s, the profitability of the Jordanian agriculture sector has thus decreased and this decrease might become more pronounced in the near future, strongly affecting farms' profitability and farmers' revenue.

  - *Threat to the trade balance*. Exports of fruits and vegetables now represent, on average, 14.6% of the value of Jordanian exports (Central Bank of Jordan, 2004; chapter 4.1). Due to the strategic social and economic nature of these agricultural exports, any reduction of the production will raise macro-economic questions. If imports of cereals (sometimes defined as "virtual water" [Allan, 2002]) have never been a controversial issue in Jordan,[108] maintaining the export of high-value crops is essential for stabilizing the trade balance,[109] which shows a sharp deficit since the country has only few natural resources (potash and phosphates of the Dead Sea) and its economy is mainly based on services (chapter 2).

  - *Vegetable/fruit local markets*. Moreover, Jordanians are big consumers of fresh vegetables (tomatoes, cucumber, eggplant, zucchini, onion, etc.) all year long. Therefore, it is necessary

[108] In areas where rain-fed cereals can be grown, possible improvements in term of yields and volume are very limited. On the other hand, the development of irrigated cereals has always been limited, the preference being given to vegetables and fruits.

[109] Based on figures of the Department of Statistics, exports coming from the Jordan Valley account for 66% of the total vegetables and for 40% of the total fruits exported from Jordan; the rest is exported from the highlands.

to maintain a production oriented towards local markets, notably in the Jordan Valley.[110] Every drastic reduction in local production would actually lead to an increase in the local prices of these common products.

- *Free trade*. Jordan has favored the development of new economic sectors (tourism, services, and industry) and signed several agreements (chapter 4.1), which could lead entail, in the next decade, shifts in the profitability of certain agricultural productions that are still protected (e.g., bananas and apples).

- *Water institutions and the question of participation*. The loss of communal patterns of water management, the social heterogeneity and multiple terms of belonging present among water users have amplified the problem of how and to whom delegate part of the irrigation management and how to develop a more transparent relation in relation to water distribution. The conflict and the vicious circle of water stealing are main problems that reflect state-citizen relationships in a context of legal pluralism regarding resource management.

- *Impact on labor force*. Another important social problem is the fact that two-thirds of the workers in the agriculture sector are migrants, mainly coming from Egypt, and that the majority of the entrepreneurs are Jordanians of Palestinian origin. This prompts some interest groups, using a Transjordanian nationalistic discourse, to argue that the social impact of a drastic reduction of irrigated agriculture would only have little impact on the "Jordanian society."[111]

- *Sectoral Competition.* Irrigated agriculture consumes two-thirds of the national water resources (THKJ, 2004) and competes with growing domestic and industrial uses, which receive priority (THKJ and MWI, 1997b). Reallocation from agricultural to non-agricultural uses has up to now been relatively smooth because of the concomitant augmentation of supply (notably through TWW) but conflicts may intensify if uncertainty in irrigation supply and risks of decreasing water quality remain high.

## *6.2 Available Policy Options*

Options available to face problems of scarcity and meet current demand come under three categories (Molle, 2003). The most conventional is supply augmentation (use more capital to face growing "demand"); the second is called here demand management, and has two main dimensions: conservation (avoid losses) and (re) allocation (redistribute scarce resources according to "societal" priorities). We review here the main options at hand along these three categories; macro-level supply management are presented first, while demand management options are broken down according to the region (Jordan Valley and Highlands).

[110] Intensive irrigated agriculture in the Jordan Valley seems to us to be less questionable than in the highlands mainly because it uses renewable surface water. Some problems of irrigated agriculture in the Jordan Valley have, however, to be considered, including water pollution by nitrates and soils degradation (Orthofer, 2001; Orthofer and Loibl, 2002).

[111] This discourse opposes the "true Jordanian society" composed of inhabitants of the former Transjordan (east bank of the Jordan River) to foreigners (Egyptian and Syrian migrants) and Palestinians (although most of them have acquired Jordanian nationality). Refer to chapters III and 4.13.

### 6.2.1 Supply Augmentation: Reopening the Basin

Up to now, water needs have been largely met by a continuous mobilization of surface and groundwater. Diverse technical solutions were successively implemented: earth and masonry canals, dams, pumps, canalization and pressurized irrigation networks, deep wells, long distance transfers, increasing use of marginal quality water (brackish and treated wastewater) and desalination. Such solutions have increasingly high investment and operational costs. Dam sites are less favorable, water more salty or deeper, transfers more distant. The epitome of inter-basin transfers is the project of transferring seawater from the Red Sea to the Dead Sea.

#### 6.2.1.1 The Red Sea-Dead Sea Project

The idea of a canal from the Red Sea to the Dead Sea (dubbed the "Red-Dead" project) has been mentioned repeatedly since decades but the objectives pursued have evolved with time. The idea comes from the fact that the Dead Sea is separated from the Red Sea by a mountain ridge of modest proportions and is located under sea level, while its salinity is even higher than that of the Red Sea. During the 1970s, and following the two oil booms, Israel considered the project for hydropower generation but was widely criticized for its unilateral initiative. In the late 1980s, early 1990s, an Israeli research looked at the idea of transferring water to the Dead Sea to produce desalinated water but concluded that a transfer from the Mediterranean Sea was more cost-effective than a transfer from the Red Sea (Harza JRV Group, 1998). As part of the peace process between Israel and Jordan, a transfer of water to the Dead Sea is, for the first time, addressed in terms of regional cooperation and is often presented as a way to solve the “Palestinian question” (the Palestinian Authority is involved in the discussions and some water would be transferred to Palestinian territories). A pre-feasibility study done by the American Harza group was concluded in 1997 and presented the project whose main objective is the production of 850 $Mm^3$ of desalinated water per year using the process of reverse osmosis desalination as a multi-country venture expected to contribute to the Peace Process in the region.

Water transferred from the Red Sea and conveyed by a pipe to the Dead Sea, 400 m below, would offer good conditions for hydropower generation and the electricity generated could be used in the desalination process. Many possible alternatives exist but, on average, a total of 141 km of tunnels and pipe lines as well as 39 km of open channel are required to conduct sea water from the Red Sea to the Dead Sea (Appendix 15). The entire conveyance system will be constructed within Jordan, with its intake structure at Aqaba. A reverse osmosis plant will be located south of the Dead Sea. A total transfer of 1.5 $Bm^3$/year is planned to both supply the main cities of Jordan, Palestine and Israel and stabilize the Dead sea level (chapter 4.4 and Figure 6-4), transferring into the Dead Sea a volume close to that historically brought by the Jordan River (between 800 and 1,000 $Mm^3$/yr, chapter 3.6). The capacity of the reverse osmosis plant will be 850 $Mm^3$/yr, while the conveyance system from the Dead Sea to Amman will be 570 $Mm^3$/year, the remaining third being supplied to Israel and the Palestinian Territories (Harza JRV Group, 1998): at full capacity, the project would allow to increase by 66% the renewable blue water presently available in the LJRB (860 Mm3/yr [chapter 5.6]). In our projection for 2025, we have considered that only the first step of the project will be implemented with the production and transfer of 100 $Mm^3$/yr of desalinated water to Amman (e.g. two thirds of the water diverted to Amman in the early 2000s).

The scheme also supports a comprehensive development of the Jordan Rift Valley. In addition to the benefits originating from the provision of desalinated water, additional benefits are expected in terms of tourism, industry, agriculture and trade. Moreover, an additional objective emphasized by Jordan and Israel at the Earth Summit of Johannesburg in 2002 is to increase the level of the Dead Sea, or at least to halt its decline (Harza JRV Group, 1998). The World Bank has been appointed to draft the term of references for the feasibility study by a tripartite committee (Jordan, Israel and Palestinian Authority) and the study is seen by the international community as a means to contribute to the Peace Process in the region. Justifications also heavily draw from religious feelings (the cradle of Christianity and Judaism). Ten years will be needed for project completion: 540 $Mm^3$/yr of freshwater are planned to be sold at year 10 (two thirds of which in Jordan), and 850 $Mm^3$ at year 30.

Total costs of the project have been evaluated at US$ 5 billion (1.3 billion for the Sea Water transfer and 3.7 billions for the desalinization and freshwater transfer facilities; Harza JRV Group, 1998). Energy costs of the project will be massive: 830 GWh/year will be needed to pump the water at the Red Sea. Head difference between the Red Sea and the Dead Sea will allow producing the needed energy to desalinate 850 $Mm^3$ of water per year and to produce an extra 140GWh/yr that will be entirely used since pumping water to the cities will require between 3,960 GWh/year and 6,950 GWh/year. At the end of the day, the extra amount of energy needed in Jordan will be between 3,100 GWh/year and 5,300 GWh/year. This represents an increase of 60 to 100% of the present energy consumption in Jordan and an added costs of US$ 180 to 318 million/yr (at 0,06$ per kWh). The total cost of water will reach 1.3 $/m^3$ (half of which is due to the pumping of freshwater from the Dead Sea to Amman).

Although several indirect positive impacts on the people in the project area are emphasized (Harza JRV Group 1998) the project carries considerable economic and environmental risks (www.foeme.org):

- The construction will affect biological diversity notably by disturbing the endangered species of the Dana nature Reserve located close by; impacts on coral reefs in the Gulf of Aqaba have also to be studied.
- Density stratification is expected through the discharge of concentrated sea water into the Dead Sea. Evaporation from the Dead Sea as well as precipitation of gypsum through mixing of concentrated sea water with Dead Sea water will certainly increase.
- Due to nutrients imports, algae blooming cannot be excluded. Anoxic conditions in the lower layers of the Dead Sea could be re-established.
- Discharge of sea water into the Dead Sea will have an impact on the Dead Sea level. Water from Dead Sea could thus infiltrate surrounding aquifers and contaminate them with highly saline water. Groundwater could also be polluted from accidental leakages, as a result of a serious seismic event.
- For the potash company, a rise of the Dead Sea level will jeopardize the stability of evaporation pond dikes, which were designed according to the current level of the Dead Sea. They may not endure the increased pressure on them. The project will also jeopardize the stability of the dikes when water from the Red Sea will be discharged. It will decrease the efficiency of the mineral recovery process due to the change in chemistry and concentration of Dead Sea. This, in turn, will limit the future expansion of two plants planned northwards (Harza JRV Group, 1998).
- Worldwide experience with megaprojects in general (Flyvberg et al., 2003) suggests that the Red-Dead project will almost certainly undergo massive cost overruns, let alone the uncertainty on future energy prices that have the potential to send the cost per $m^3$ of water

skyrocketing. With likely costs at 2 or 3 $\$/m^3$ (not considering environmental costs), the project compares unfavourably with current production costs of drinking water in Amman at $\$1.5/m^3$ (chapter 5.4).

#### 6.2.1.2 Other Long-Distance Inter-Basin Transfers

Other large transfers have long been envisaged (transfer of freshwater from Lebanon, Iraq and Syria; transfer of saline water from the Mediterranean Sea to the Dead Sea [GTZ, 1998]) but these transfers have never been implemented because of the regional political instability and of their very high costs in terms of investment and O&M ($\$0.7$ to $1.5/m^3$; see chapter 5.4). On the other hand, transfers within the basin and from neighboring basins, located in Jordan, are already developed (transfers from the Azraq and the Dead Sea) and should, in the mid-term, decline because of the general overexploitation of these basins.

On the other hand, a large transfer from the fossil aquifer of Disi, located about 300 km south of Amman (and, in elevation, 800 m below), is envisaged and a Build Operate and Transfer (BOT) scheme is presently considered.[112] This transfer would cost US$625 million and it is foreseen that 50 $Mm^3/yr$ could be transferred to Amman for a 50-year period at a price of $\$0.786/m^3$) (Figure 6-4) while the present (2000) private utilization of the Disi aquifer for local agricultural irrigation in the midst of the desert (50 $Mm^3/yr$, MWI-Water Resources Department records) would have to be discontinued or at least strongly decreased (and limited to fruit trees). The governmental decision to exploit this strategic fossil aquifer illustrates the severity of the problems to be solved in Jordan in the short term.

#### 6.2.1.3 Development of Brackish and Seawater Desalinization

In 2004, an important desalination plant of the brackish groundwater of the Jordan Valley (Deir Allah, 15 $Mm^3/yr$ [MWI, 2002]) was implemented and supplied Amman with 10 $Mm^3/yr$.

*Figure 6-1. Desalinisation plant in the Jordan Valley (Deir Allah) (Source: Papin, 2007)*

Some others smaller reverse-osmosis plants have also been developed during the years 2000-2007 in areas where groundwater is brackish, in order to supply cities with potable water as well as to develop

[112] The Government of Jordan is now studying the different offers received from private companies but recent evolutions seem to show that none of these offers is satisfactory. It is thus possible that the idea of a BOT scheme will be given up and that the government will invite tenders for this huge water transfer.

agricultural activities in the south of the Jordan Valley (private facilities, essentially for banana cultivation). We consider in our projections that these plants will be still in use in the mid-2020s. We also consider in our projections some large projects of desalination of saline springs (Zara-Maïn, 35 $Mm^3$/yr, completed [MWI, 2002]) and of brackish aquifers in the Jordan Valley (Hisban, 10 $Mm^3$/yr to be developed within the next decade). Moreover, we consider that Israel, in compliance with the 1994-Peace Treaty, will desalinate the 20 $Mm^3$/yr it now dumps into the Jordan Valley and will transfer half of this volume to Jordan.

#### 6.2.1.4 Construction of the Last Reservoirs

The last reservoirs which are likely to be built (along the side-wadis) are generally far from consumption centers, small and expensive, with the exception of the Jordanian-Syrian dam on the Yarmouk River (Wehdah dam). Its construction, long delayed by the opposition of the Israelis, has been completed in 2005/2006. This has added 110 $Mm^3$ of storage (the annual inflow from Syria is evaluated at 85 $Mm^3$/yr [THKJ, 2004] but the reservoir did not fill up in 2006/2007). The construction of smaller storage facilities is planned on the remaining non-controlled side-wadis and on neighboring rivers located out of the basin (the Wadi Mujib reservoir has been completed in 2004 and can store up to 35 $Mm^3$).

These new freshwater resources will be diverted mostly to cities (according to governmental plans: 60 $Mm^3$/yr for Irbid and the other northern cities and 65 $Mm^3$/yr for Amman-Zarqa). Consequently, the volumes diverted to irrigated agriculture within the Jordan Valley will remain stable but the regulation of the flow of the KAC and the flexibility allowed by the Wehdah dam will allow an improved fine-tuning of irrigation supply, although it might also have an impact on soil salinization (see chapter 5.2.1 and later section). The consequence of these dams will be a reduction in the total flow reaching the Dead Sea.

#### 6.2.1.5 Development of Irrigation and Public Management Enforcement in the South of the Jordan Valley

If most supply augmentation projects aim at meeting the current water demand, new projects (and new requirements) are also being considered, notably in the agriculture sector in the south of the Jordan Valley. In our scenarios, we assume that the JVA will enforce its public management in the south of the Jordan Valley and implement its rules of water pricing and water allocation in a rehabilitated 14.5 km project (the last section of the KAC [chapter 5.2.1]). 5,100 hectares will be newly irrigated and this will have the following implications:

- An increase of water diversion to the southern directorate by about 25 $Mm^3$/yr. As in the north and middle directorates, water will be charged to recover O&M costs.
- New investments will be made, including the Hisban dam ($ 4.2 million); the rehabilitation of the Hisban-Kafrein triangle ($ 7 million) and the rehabilitation of the 14.5-km project ($ 22.5 million). Extension of irrigation will be made possible thanks to an increasing volume of treated wastewater available in the Jordan Valley (see later).
- In our scenario, we assume that the 5,100 hectares of the 14.5-km project will be cropped with vegetables (2/3 of the area) and date palm trees (1/3 of the area). The corresponding agricultural production would have a value of $ 76.5 million/year.

### 6.2.2 Demand Management in the Jordan Valley

Awareness of water problems has greatly increased within the Jordanian society in the past few years. Yet, in the present regional political arena, water shortages are too often wholly attributed to the creation of the State of Israel. Beyond the relevance of this cause this acts as an emotional catalyst that tends to occult some deeper internal causes, often ignored or even denied by the entire society. An issue that commonly comes along with water scarcity is that of efficiency in water use: agriculture is often designated as a wasteful user and low efficiencies of irrigation networks are reported. Regulation of use and allocation of water are addressed here.

#### 6.2.2.1 An Increase in Public Water Prices

In the early 1990s, Jordan's officials shifting their water policy focus from supply augmentation towards demand management (Al-Jayyousi, 2001). The World Bank and other development agencies were influential in calling for an agenda that would include demand-management instruments to encourage efficient water use, transfer water to nonagricultural higher-value uses, and reduce groundwater overdraft (Pitman, 2004). Pricing of irrigation water was chosen as an instrument to reduce demand for water (World Bank, 2003a). In the Jordan Valley, a block-rate tariff system associated with crop-based quotas had been in place for some time (chapter 5.2.1) and the debate revolved around possible increases in water charges: more expensive water was expected to bring about improvements in irrigation efficiency and a switch to less water-intensive crops, thus releasing water for Amman (World Bank, 2003a). It would also assist in recovering state expenditures in public irrigation schemes: "The water price shall at least cover the cost of operation and maintenance (O&M) and, subject to some other economic constraints, it should also recover part of the capital cost of the irrigation water projects. The ultimate objective shall be full cost recovery subject to economic, social and political constraints" (THKJ and MWI, 1997a; see also THKJ and MWI, 1998b, 2004b; JRVIP, 2001).

Under certain conditions pricing policies can help regulate irrigation water demand by farmers (Molle and Berkoff, 2007). Likewise, increased cost-recovery may also be very important to ensure proper O&M of the scheme. Venot et al. (2007) have shown that while O&M costs can be covered through relatively modest increases in prices and impacts on revenues, several elements contribute to limiting the scope for pricing mechanisms to achieve improvements in irrigation and economic efficiency.

Suboptimal irrigation efficiency is first of all linked to unstable pressure in collective pressurized networks, which makes the functioning of poorly designed on-farm distribution networks very precarious. These on-farm networks are subject to many technical problems, such as the clogging of emitters, non-uniformity of water application, and non-optimized blocks and rotations. Another source of inefficiency independent from farmers is the lack of storage capacity at the system level. With inadequate storage, water supply can exceed demand at times during the year. To some extent, excess water can be used for leaching salts or stored in the soil profile, but those activities are not perfect substitutes for surface storage facilities. In situations where excess water cannot be stored, and where irrigation deliveries are controlled by strict quotas when demand exceeds supply, the potential for saving water is limited.

These conditions explain why the full cost recovery of O&M costs pursued by the Ministry of Water and Irrigation is unlikely to lead to "increase conveyance system and on-farm water use efficiency", as anticipated in the 2004 Masterplan (THKJ, 2004). From the correct assumption that "low prices for irrigation water provide limited incentive to improve on-farm efficiencies" it is too hastily inferred that raising prices will automatically improve on-farm efficiency and should therefore be "a prime target for implementing improvements" (USAID, 2006). A World Bank (2003a) report acknowledges that "it was anticipated that increased water tariffs [of 1995] would reduce agricultural water use. This did not happen."

With limited scope for achieving water savings, farmers will potentially respond to increasing water costs by intensification. In intensive and profitable systems (vegetable and greenhouse farms) water costs are negligible compared to input and labour costs, and they will remain so at any politically acceptable water price level (Wolf *et al.*, 1996). Farms with more extensive agricultural strategies will be more affected, including primarily: 1) mixed farms (often poor/indebted) and small orchards of citrus or banana (Salman, 2001a, and Van Aken, 2004 underline that indebtedness and vulnerability are major problems of agriculture in the Valley), and 2) absentee urban owners and rentiers with other sources of revenue. Price-induced pressure would have a beneficial impact if these farmers were to adopt improved technology and higher-value crops, intensifying farming. As noted earlier, these options were already available to these farmers and there are sound reasons why—despite their high return on paper—they did not adopt them earlier. Farmers engaged in extensive agriculture are often indebted (or weary to be so**)** or lack capital to embrace such ventures that incur considerable risk; rentiers lack the interest to burden themselves with intensive management and value their farm for other reasons. Intensification must be driven by market opportunities and not forced by circumstances that would first make farmers financially more vulnerable and then push them into risky ventures with a higher probability of going bankrupt (see Doppler *et al.,* 2002 for the prevalence of risk in the Valley). With growing competition from other countries in the Middle East, identifying crops with a good return and limited risk is not easy and has become a policy priority (Montigaud et al., 2006; Nachbaur, 2004; Salman, 2001b). With adequate support to intensification and marketing, water price increases thus have the potential to raise economic efficiency by inducing changes in citrus and banana cultivation. Likewise, economic benefits arise from small farmers renting out their plot to investors growing higher value crops, but these farmers must find alternative occupations or incomes.

#### 6.2.2.2 Use and Impact of Treated wastewater in Irrigated Agriculture, northern Jordan Valley

Presently, about 80 $Mm^3$ of freshwater are used each year in the northern part of the Jordan Valley.[113] 60 others $Mm^3$/yr of freshwater are mixed with blended waste water coming from the King Talal reservoir and are used in the middle and the south of the Jordan Valley. Total volume of freshwater used in the Jordan Valley amounts to 140 $Mm^3$/yr, while 50 $Mm^3$/yr are pumped from the Valley to supply Amman (chapter 4.2).

It is forecasted that in 2025, Amman (and the neighboring cities) will produce more than twice as much wastewater as in 2000 (155 $Mm^3$/yr; Figure 6-4).[114] In our projections, we consider that this wastewater, blended in the King Talal Reservoir with freshwater coming from the Zarqa River, will be used in the south of the valley (allowing, therefore, the irrigation of all the area which can be

[113] The northern part of the Jordan Valley designates the section lying between the KAC intake on the Yarmouk river and the Abu-Zighan canal (near the village of Deir Alla; see figure in chapter 5.2.1) bringing water from the King Talal reservoir to the south of the Jordan Valley. It is supplied with 95 $Mm^3$/yr among which 80 $Mm^3$/yr are freshwater, 5 $Mm^3$/yr are blended water coming from the KTR (mix ratio of 1:1) and the remaining 10 $Mm^3$/yr are blended water (mix between freshwater from the north of the valley and blended water from the KTR; mix ratio of 1:2)

[114] THKJ (2004) presents that 230 $Mm^3$/yr of treated wastewater could be available in 2020 in Jordan. 155 $Mm^3$/yr would be reused both in industry (30 $Mm^3$/yr) and in irrigation (125 $Mm^3$/yr) (the remaining being lost in transfer and storage).

potentially irrigated in this region). It is also likely that the north of the Jordan Valley will be supplied with blended water. This would be possible due to the development of waste water treatment plants in the cities of northern Jordan. These treatment plants will have a capacity of 30 $Mm^3$/yr, of which 25 $Mm^3$/yr will be supplied to the Valley to be used for agricultural purposes and partly counterbalance the increasing freshwater transfers from the Valley to Amman, which have been estimated at 90 $Mm^3$/yr in the mid-2020s (Figure 6-4). On the other hand, it is forecasted that total freshwater available in the Valley would include 45 $Mm^3$/yr from the northern side wadis; 20 $Mm^3$/yr from the Mucheibeh wells; 90 $Mm^3$/yr from the Yarmouk River and 55 $Mm^3$/yr from Israel.[115] A total of 130 $Mm^3$/yr of freshwater would be used in the Valley: increasing treated wastewater use in irrigation would allow saving 10 $Mm^3$/yr to be transferred to Amman.

A generalisation of blended water use in the north of the Jordan Valley would be costly yet it could be the cheapest of many options as this would facilitate a relatively cheap transfer of freshwater to be used for domestic purposes in Amman (chapter 5.4). Investments to renovate or build the needed waste water treatment plants in northern Jordan and the dams to control water along the still free flowing side wadis (it is planned that an extra 25 $Mm^3$/yr could be stored) have been estimated at US$ 218 million (O&M costs of the plants and their related irrigation network would cost $4.95 million per year [JICA, 2001; THKJ et al., 2004a and 2004b]). In addition, the $150 million upgrade of the As-Samra treatment plant is being completed in June 2007. In our scenarios, we assume that O&M costs of the new treatment plants and irrigation networks will be covered through water charges. Transferring an extra 40 $Mm^3$/yr of freshwater to Amman is expected to cost $22.2 million per year (in comparison, this would cost $32 million per year [disregarding overruns] if the same water had to be transferred from Disi).

Generalizing blended water use in irrigation would also have agricultural and environmental costs as water and soil salinity will increase. Environmental costs are not assessed here. Based on Grattan (2000), we estimated the losses in agricultural value that would be due to a yield decrease.[116] Water quality will remain by and large relatively good due to a high blending ratio (1 to 3 [TWW/freshwater]) and on a regional scale, consequences will remain limited: the vegetable and fruit productions are expected to decrease by 1 and 5%, respectively e.g. a total value of $2.4 million per year (1.5% of the total value of the production in the Jordan Valley).[117]

Table 6-1 segregates the impacts of a shift to blended water use in the north of the valley for each farming system (as presented in chapter 5.1). If family citrus farmers will be marginally affected (their revenue would decrease by about 3%); the profitability of absentee citrus and banana farms will be significantly reduced by about 10%: this evolution could be heightened by an increase in water charge

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[115] 45 $Mm^3$/yr will come from the Lake Tiberius and 10 $Mm^3$/yr from desalinisation of saline springs.

[116] The value of agricultural products could also decline due to a decrease in their quality (due to the low quality of TWW more loaded in heavy metals, phyto-oestrogen , boron, pesticides residues than freshwater) and to a drop in market prices linked to the lack of confidence among consumers regarding the use of TWW for fruits and vegetables production. Those aspects are not quantified here and our evaluations are at constant prices. The cropping pattern of the Jordan Valley is considered constant too: we do not evaluate the consequences a shift to salt-resistant crops (for example date palm trees) would have (see chapter 5.1 and the section on increasing water charges for the reasons that could hinder this shift).

[117] The value of the production has been calculated according to cropping patterns presented in chapter 5.1 and to farm gate prices of $11,000; $33,000; $4,100 and $19,500/ha for vegetables in open field, vegetables under greenhouses, citrus and bananas, respectively (date production fetch $22,500/ha). Total production in the Jordan Valley has been evaluated at $160 million.

(see above) and the lifting of custom duties on bananas (see later section). Productive greenhouse farms will be only slightly affected (their revenue is expected to decrease by 4 to 7%). Finally, revenues from open field vegetable farms will decrease by 8 to 9%) and mixed (poor) farmers will loose more than a fourth of their already very low revenue (chapter 5.1).[118] The more intensive open field farmers are likely to intensify their production by shifting crops, improving their irrigation systems, closely managing their inputs, adopting greenhouses (see Molle and Berkoff [2007] for the reasons that could hinder this intensification) but the poorer will be driven out of agriculture (some small owners being able to get some dividends by selling their land). There is a clear need to develop attendant measures in order to soften the social impacts that a shift to blended water in the north of the Jordan Valley could induce.

*Table 6-1. Impact of a generalisation of treated blended waste water use for irrigation on the farming systems in the north of the Jordan Valley*

| | Decrease in | |
|---|---|---|
| | Gross output (% of actual gross output) | Net revenue (% of actual net revenue) |
| Entrepreneurial banana farms | 6 | 10 |
| Family citrus farms | 1 | 3 |
| Absentee owner citrus farms | 1 | 10 |
| Entrepreneurial greenhouse farm | 1 | 4 |
| Family greenhouse farm | 1 | 7 |
| Open field vegetable family farm | 3 | 8 |
| Open field entrepreneurial farm | 3 | 9 |
| Mixed farms (poor farmers) | 3 | 27 |

#### 6.2.2.3 Technical improvements in distribution networks

As shown by the results obtained by the IOJoV project (see section 5.2.1), retrofitting of on-farm networks coupled with improved allocation and management rules at the pumping station level has a great potential for improving pressure in the network and uniformity of irrigation. Better scheduling and homogeneity of application translates into higher yields and better quality products that pay for the investment.

Key changes include in general substitution of secondary pipes at the farm level (larger diameter), use of new flow limiters with the design flow of 6 l/s definition of internal blocks and rotation by using a specialized software, improvement of filtering, rehabilitation of water meters (protection from clogging and tampering, but meters remain visible by all through a grid on the top of the FTA to facilitate their regular checking by both JVA staff and users); transfer of the responsibility for

[118] All evaluations consider an electro-conductivity of the water (ECw) of 1.2dS/cm. Impacts would be much higher (with farm profitability decreasing by 20 to 80%, depending on the farming systems) with an ECw of 1.9 dS/cm as observed currently in the southern Jordan Valley.

operating FTAs to the users in order to be able to implement hydraulically optimized rotation schedules.

Such possible improvements show the importance of technical information and support in using sophisticated equipment but also the establishment of more transparent relationships between JVA and farmers.

#### 6.2.2.4 Fine-Tuning of Water Allocation in the Jordan Valley

Water supply in the Jordan Valley is based on allocation rules constrained by crop-based monthly quotas (chapter 5.2.1). These rules were first developed based on studies done during the 1950s and according to the cropping techniques at that time (chapter 5.2.1). Despite several modifications, the current system of water quotas is not well adapted to farmer's water demand (chapter 5.2.1). These monthly quotas are essential to regulate and limit use during the driest months of the year (April-October), when demand exceeds supply from the Yarmouk. During the rest of the year, demand is generally below the quota and farmers can more easily ask for extra water (JVA has even promoted use of extra water –whenever available- in order to increase salt lixiviation [Wolf *et al.*, 1996]). It is clear from that situation that the upstream storage capacity offered by the just-completed Wehdah dam on the Yarmouk River will allow to better distribute water along the year, not only saving water in the winter time but also enhancing supply during water-short months (Al-Jayyousi, 2001; Salman et al., 2001; Shaner, 2001; Courcier and Guérin, 2004). Ideally quotas could be made annual, so that each farmer would enjoy the flexibility of using water whenever deemed optimal (Petitguyot, 2003). In the long run, with increased control on individual consumption, quotas could be made transferable, thus providing real financial incentive for technical and economic gains (Development Alternative, 2004). This, however, would imply that the aggregated demand at the level of the pumping stations would not be fixed on a daily or even monthly basis, which would require a much tighter information flow between water user groups and the JVA, a crucial current problem (chapter 5.2.2). Potential water savings to be expected from this measure are not well identified.

#### 6.2.2.5 Groundwater Control in the Jordan Valley Basin

In 2004, 22 $Mm^3$/yr were abstracted for agricultural purposes in the Jordan Valley Basin, most of which in its southern part for bananas orchards managed by entrepreneurial farmers. Implementing the By-law No. (85) of 2002 (chapter 5.3.1) in the south of the valley where aquifers are brackish (ECw=1.5 to 2.5 dS/cm) is expected to have slight impacts on banana farming systems (Appendix 16) and could accentuate the shift from banana to date palm trees orchards mainly motivated by the agricultural market liberalization (see next section). Converting all groundwater irrigated banana plantations (488 ha) and part of groundwater irrigated open field vegetables (800 ha)[119] in the south of the valley to date palm trees orchards could allow decreasing groundwater abstraction by about 12.4 $Mm^3$/yr to reach a sustainable level of aquifer exploitation. The agricultural value produced would increase by $10.7 million per year.

[119] In entrepreneurial banana farms, vegetables are cropped on part of the area of the farm in order to regenerate soils after several years of banana cropping (this brings an additional revenue instead of letting the land fallow; chapter 5.1; Appendix 16)

#### 6.2.2.6 Agricultural Market Liberalization

Jordan's continued protection of its banana production incurs a cost to society and may obstruct the development of alternatives crops with similar (or even higher) added value e.g., date palm in the valley, which has the advantage to be low water consuming (10,000 $m^3$/ha/yr), relatively salt-resistant (Grattan, 2001; McCornick et al., 2003) and highly profitable (chapter 5.1; Venot, 2004c). However, date production has several drawbacks from the perspective of small-scale extensive farmers. In particular, date palms do not produce during a period of 5 years, post-harvest operations are difficult to master, and only high-quality products find their way to the most profitable market niches.

Jordan has entered a period of market liberalization and lifting custom duties on high value protected crops, as mentioned in the GAFTA and WTO agreements (chapter 2 and 4.11), like apples and grapes in the highlands (see below) and bananas in the Jordan Valley could have strong consequences on the profitability of some farming systems.[120] Custom duties on banana imports consist of a fixed tax of $350 for each imported ton and of a variable tariff according to the volumes imported (Montigaud et al., 2006). We assess here the impacts that the suppression of the fixed tax of $350/t would have on the Jordanian agriculture sector.[121]

Assuming that farm gate prices decrease by as much as the lifted quota ($350/t) and that all production costs remain constant; farm profitability will decrease by 50 to 70% in family farms and by 45 to 90% in entrepreneurial farms in the north and the south of the Jordan Valley, respectively.[122] All banana farming systems but entrepreneurial farms in the north of the Jordan Valley will still remain highly profitable with net revenues similar to those of intensive vegetable farms with greenhouses. Banana entrepreneurs in the north of the Jordan Valley will see their revenue decrease to $1,000/ha (a low profitability, similar to the actual profitability of mixed farms managed by poor farmers) and are likely to intensify their production (adoption of modern irrigation techniques, closer management, shift to date palm trees, etc. [see above]).

At the basin level, banana production has been evaluated at about 48,700 tons. Assuming a price decrease of $350 per ton, the net financial loss linked to banana market liberalization will reach $17.1 million per year (10.6% of the total value of the Jordan Valley production. Banana market liberalization could also lead to a partial shift from banana to vegetable (in the north) and date palm trees (in the south of the valley) (Scenario B in Table 6-2). For the sake of illustration we assume hereafter (see scenarios) that half the area of banana in the north of the valley (e.g. 178 ha cropped by entrepreneurs with gravity irrigation) could be replaced by open field vegetables (more profitable after the banana quota suspension). In the south, banana orchards irrigated with freshwater coming from the Shueib, Hisban and Kafrein wadis (650 ha among the 1,138 ha of banana orchard in the south of the valley; freshwater from the wadis will be partially reallocated to domestic uses in the south of the valley) could be replaced by date palm trees: both family and entrepreneur farmers will be attracted by

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[120] In 2007, custom duties on banana imports were not yet lifted, facing the opposition of local producers, belonging to the influentl Al-Adwan tribe. His Majesty the King also owns large banana areas on the shore of the Dead Sea, out of the Lower Jordan River Basin.

[121] This underestimates the consequences of a complete suppression of the custom duties but gives interesting hints on the possible evolution of banana cultivation in Jordan (moreover, quantifying the suppression of the proportional part of the tariff is difficult as it requires knowing the volumes imported by each importer, for each shipment).

[122] We considered yields of 25 and 35 tons per hectare in the north and the south of the Jordan Valley (where farms are more intensive), respectively.

the high prices fetched by dates (see chapter 5.1). In that case, we consider that farmers would receive water quotas adjusted to their new crops (date palm trees receive citrus allocation; chapter 5.2.1).

Table 6-2 summarizes the impacts of two scenarios: one assumes a change of cropping pattern, the other not. Table 6-2 clearly illustrates the financial benefits of shifting from banana to other crops (agriculture losses would be reduced from $17.1 to 3.7 million) at the basin level. However, the same obstacles we mention in the section on increasing water price still hold true here (the financial push factor of decreasing revenues being yet much stronger). Shifting to other crops would also allow the reallocation of 28.8 $Mm^3$/yr to domestic uses (locally or in Amman) while this volume should be transferred at a higher cost (for example from Disi) if no change in cropping patterns are observed.

*Table 6-2. Costs-benefits analysis of import tariff suspension on banana for two scenarios*

| | Scenario A- Business as usual | Scenario B- Cropping pattern change |
|---|---|---|
| Banana area (ha) | 1850 | 1022 |
| Extra vegetable area (ha) | - | 178 |
| Extra date palm trees area (ha) | - | 650 |
| Loss in production value (import tariff suspension; $ million) | 17.1 | 11.9 |
| Loss in production value (lower banana area; $ million) | - | 8.4 |
| Gain in production value (vegetable production; $ million) | - | 2.0 |
| Gain in production value (date production; $ million) | - | 14.6 |
| Water Savings ($Mm^3$/yr)* | - | 28.8 |
| Production costs of saved water (Amman domestic use-0.423 $/m$^3$; $ million) | - | 12.2 |
| Transfer from Disi (Amman domestic use-0.801 $/m$^3$; $ million) | 23.1 | - |
| Total Costs (excluding water mobilisation; $ million) | 17.1 | 3.7 |
| Total Costs ($ million) | 40.1 | 15.9 |

* We assumed that banana orchards in the north of the Jordan Valley are currently supplied with 12 mm/day/ha all the year long. In the north water allocation are as follow: 5,050; 10,100 and 15,000 $m^3$/ha for vegetables, citrus and bananas.

#### 6.2.2.7 JVA, farmers and Water User Associations: Looking for New Communities

Many projects mention the need to create and empower water users groups for water management in the Jordan Valley. Since 2001 for example, a GTZ funded project called Water Management in Irrigated Agriculture (WMIA) has been launched and aims at increasing the efficiency of irrigation in the Jordan Valley. By creating water users groups, the project aims in joining forces of all stakeholders (farmers, JVA) to create transparency and equity of access to water, physical protection from the infrastructures from transgressions and technical viability of water distribution services (GTZ, 2002).

Building-up those users groups is a long and difficult process hindered by extant cultural and social structures. This would require significant institutional transformations and changes in the agency (JVA)-farmer relationship (Van Aken, 2004; see chapter 5.2.2 and VI). Some important questions are at stake here such as the sharing of tasks between JVA and the user groups. This is still being discussed: some farmers consider those groups as lobbies to negotiate more water with the Jordanian authorities while others think they should be involved more in the management of irrigation networks.[123]

Willingness of JVA to assist those groups vary from one interlocutor to another within the bureaucracy and clear political orientations will probably be necessary before any real and long-term transfer of operation and maintenance tasks are feasible (San Filippo, 2006). With a more controlled water regime, this transfer could be accompanied by bulk allocation and bulk charging procedures,

[123] Some groups, lacking a clear understanding of the concept of WUA even want to use the associations as cooperatives for production and marketing.

whereby the water user association would be in charge of managing a yearly amount of water and recovering charges (JRVIP, 2001). The corporation law adopted in 2001 recognizes the existence of the WUAs as a legal organization of farmers. However, although the JVA law authorizes the “JVA to involve a third party to improve water distribution”, in the fields no technical responsibility is really taken by the great majority of water user groups and, for the moment, none of them has the capacity to manage this rather complex system.

In contrast with the idealized images of participation and community that are projected, farmers express widespread scepticism about the possibility that WUAs could work as an efficient means to get partial control of water management. First, Water User Associations in the valley remind farmers of the bad experience of the few past cooperatives, which collapsed after personal mismanagement or cases of stealing. Second, WUAs are inevitably new political institutions that may reproduce old social pressure of main interest groups within the WUA, amplifying an already present state of inequity at the local level. The process of devolution and of support of local farmers’ organization is an attempt to shift state–community relationships, and therefore it inevitably involves political issues of relation of power, of representativeness of local actors and of the patterns of active participation on common affairs (Mosse, 1998).

In order to transform what is perceived as a state affair regarding water management into a public domain with more transparent rules in the access to this resource, a change of the present relationships between farmers and the state and their asymmetries has to take place. The irrigation management regime has to make adjustments in its own structure and functions, and not only the farmers. The state-driven ideologies of community development can in fact do more harm than good if they are not paralleled by a critical analysis of the complexity of the local context. The ongoing process of constitution and spread of WUAs in the Jordan Valley, a process led in the last years by several GTZ projects in the Jordan Valley, is definitely an attempt to build a new frame of community. Indeed, in some areas the social homogeneity of one tribe or one common lineage may help in constituting a common group of interest around water use (transparency and participation in defining water turns and extra hours delivery; delegating the opening/closing of FTAs to users; maintenance of water meters; avoiding stealing water in a frame of a collective responsibility undertaking, as main examples), but in many other regions water users belong to different families or social groups, and this makes common organization more difficult. Facing this new process, one of the fears of many farmers is that the JVA and state administrations will retain their power and privileges, and that the WUA promotion will just be another state-driven process to co-opt, in some cases control, farmers and intervene in their affairs. It is also perceived as a tool to delegate and pass tense issues over to farmers, like water stealing or tribal affairs.

#### 6.2.2.8 Adjusting quotas

The most efficient way to reduce diversions to the Valley (and to free more water for Amman) would be to gradually reduce quotas in order to force adjustments (high-tech management, change in crops, etc). Yet, this has already been the case since 1998, with effective supply in the last 9 years varying between 50 and 80% of theoretical entitlements and crops facing water deficit during some periods of the year (MREA and JVA, 2006). Additionally, a bonus might be granted to those who accept to shift from a high tree quota to the vegetable quota (if proper market opportunities for vegetables are ensured); this, of course, would be hard to justify in the face of the recent contradictory measure of recognizing more citrus allocations. For the sake of illustration, we can estimate what would happen if half the banana area were replaced by date palm trees (eligible to the citrus allocation) and a third of the present citrus area were replaced by vegetables. According to the quotas summarized in Table 5-4, this shift would reduce agriculture freshwater diversion by about 14.3 $Mm^3$/yr, that is around 12 percent of the water released to the northern and middle directorates between 1999 and 2002.

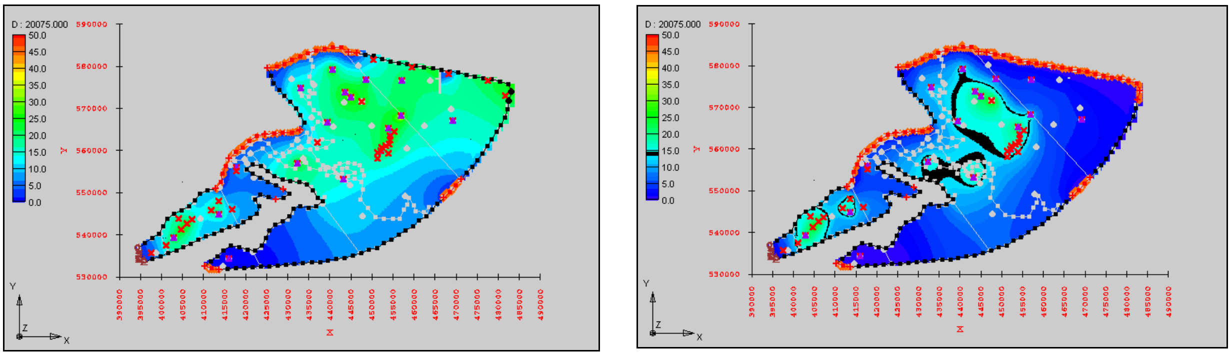
### 6.2.3 Demand Management in the Highlands

#### 6.2.3.1 Business as Usual: A Degradation of Water Quality and Increasing Costs

Water quality conservation is of central importance for environmental, public health and economic reasons. Any water quality decrease affecting aquifers located near consumption centres (Yarmouk and Amman-Zarqa Basin notably)[124] would have dramatic consequences. Continued use of these aquifers for domestic purposes would only be possible through costly investment in water treatment facilities. ARD and USAID (2001b) showed that, at the present rate of overabstraction (chapter 2 and 5.16), the salinity of the Amman-Zarqa basin (AZB) can be expected to gradually increase from current levels of 400-1,000 ppm to a range of 1,000-5,000 ppm by the year 2020. The study also indicated that groundwater salinity in the Amman-Zarqa Basin would average 1,500 to 2,000 ppm, due to both the drawdown of the aquifer and infiltration of fertilizers (chapter 4.4).

Figure 6-2 illustrates the potential drawdown of the Amman-Zarqa aquifer in two different situations, at the horizon of 2020. Scenario 1 assumes that groundwater exploitation in Jordan will not be controlled and that recharge from Syrian mountains decreases by 50% due to increased use. Scenario 2 assumes that agricultural and urban exploitation of groundwater in Jordan will be decreased by 40 $Mm^3$/yr.

*Figure 6-2: Drawdown map of Amman-Zarqa aquifer: left panel=Scenario 1; right panel=Scenario2 (ARD and USAID, 2001b)*[125]



Under Scenario 1, it is estimated that 70% of the wells located in the north-east of the AZB will dry up within the next 15 years (notably in Dulheil area; chapter 5.3.1) due to a drawdown of 10 to 30 meters in many points of the aquifer (Chebaane et al., 2004). Under Scenario 2, a drop of the water table of 5 to 15 meters will still be generally observed in many points of the basin. On the other hand, in areas

[124] The side wadis basin is not considered in this impact assessment. Irrigated agriculture is limited and groundwater abstraction lower than the annual recharge. It is unlikely that measures to be implemented in Jordan will affect in any way the local and current practices within this groundwater basin.

[125] ARD and USAID (2001b) further quantify the hydro-geological impacts of two scenarios assuming a groundwater exploitation decrease by 55 and 85 $Mm^3$/yr. Such decrease of groundwater abstraction is highly unlikely and these scenarios are not considered here.

where groundwater exploitation will significantly decrease it is expected that the water level will increase by 0.5 to 3 meters (Dulheil and Al-Hashemiya). If no measures are taken to limit groundwater exploitation, the water table drop and the increasing groundwater salinity will have the following consequences:

- An average loss of agricultural value by about $33.1 million over the next twenty years in the Amman-Zarqa basin (Fitch, 2001 and Chebaane et al., 2004).[126] The agricultural value will decrease because of lower yields and progressive disappearance of high value crops due to increased salinity. In the AZB, the agricultural sector will register further losses due to the need to deepen and repair wells ($7.1 million);[127] due to increasing pumping costs ($8.3 million); and due to the abandonment of some wells ($25.6 million) (Chebaane et al., 2004).

- In the Yarmouk basin we assume that no wells will dry up while salinity will affect three fourths of the current irrigated area (as in the AZB [ARD and USAID, 2001b]) inducing losses of about $12.7 million in the value of the agricultural production over the next twenty years. 20% of agricultural private wells will have to be deepen or repaired (30 wells, $2.2 million over the next twenty years); 4% entirely reconstructed (6 wells, $1.3 million); and pumping costs will increase ($1.8 million over the next twenty years).[128]

- Total losses in the agricultural sector will thus reach $92.1 million over the next twenty years in the Highlands of the LJRB (e.g. an annual loss of $2 millions at current prices).

- The need for new investments to treat the water pumped and used for domestic and industrial purposes. Groundwater exploitation for domestic purposes has been evaluated at 78 and 10 $Mm^3$/yr in the Amman-Zarqa and the Yarmouk basin, respectively (while 7 $Mm^3$/yr were pumped for industrial purposes in the AZB). In these conditions water exploitation costs are expected to increase from $0,185/$m^3$ to $0.565/$m^3$ due to the need to desalinate brackish groundwater ($0.38/$m^3$). We assume that groundwater exploitation for domestic and industrial purposes will remain constant until 2025.[129] Volumes of treated water treatment will progressively and regularly increase until 2015 depending on the development of the treatment plants needed. Total costs of water treatment (Operation and Maintenance of new plants) would reach $1.45 billion over the next twenty years (e.g. an average annual value of $31.7 million at current prices). Total investments for the water treatment plants could amount to $150 million.

- The aquifer drawdown will also induce higher pumping costs for domestic and industrial uses ($0.0055/ $m^3$ as evaluated by Fitch, 2001). At current rate of abstraction (85 and 10 $Mm^3$/yr in

[126] For all calculation, but figures presented by Fitch (2001) and Chebaane (2004), we considered inflation and discounting rates of 3.5% and 8%, respectively. Costs over the next twenty years express the future value of all costs to be incurred during the next twenty years.

[127] Fitch (2001) evaluated at 30 to 45%, the number of wells to be merely deepened or rebuilt over the next twenty years in the AZB (average cost of US$ 26,435 per well). In the same basin, 5 to 10% of the wells would have to be completely rebuilt (average cost of US$ 86,000).

[128] In the Yarmouk basin, there are 210 wells among which 134 are private agricultural wells (MWI-database). We used the same figures than expressed by Fitch (2001) for the Amman-Zarqa basin.

[129] Growing needs of the population will be met thanks to the development of new water sources (chapter 6.2.1 and Figure 6-4).

the AZB and Yarmouk basins, respectively [chapter 5.3.1]), this would represent an added cost of $26.3 to 39.1 million over the next twenty years if energy costs remain constant or increase by 5% annually, respectively (e.g an average annual cost of $0.6 to 0.85 million at current prices). We also assume that 30% of domestic and industrial wells (140 wells) will have to be rehabilitated at a total cost of $11.9 million over the next twenty years (e.g. an average annual cost of $260,000 at current prices).

- Finally, a "business as usual" scenario in the highlands would cost $1.7 billion over the next twenty years, e.g. an average annual cost of $36.9 million at current prices.

Given the current domestic and industrial uses of groundwater in the LJRB (the latter will only be marginally decreased [see below]), it would be necessary to stop all agricultural groundwater use in order to reach a sustainable level of groundwater exploitation. This is highly unlikely and would change the entire agricultural landscape of Jordan which would have to import fresh products in summer (instead of exporting them at the moment). Moreover, this would have dramatic sociopolitical impacts and policies needed to reduce irrigated agriculture in the highlands are likely to be delayed and only partially implemented.

In our projection to 2025 we have considered an average scenario for the entire society, whereby the groundwater irrigated areas would be reduced to 1,200 and 7,500 ha using 10 and 40 $Mm^3$/yr of groundwater in the Yarmouk and Amman-Zarqa basin, respectively. An extra 30 $Mm^3$/yr of treated wastewater would be supplied for agriculture in the Amman-Zarqa basin. Agricultural groundwater abstraction would then decrease by 55 $Mm^3$/yr and total exploitation of the LJRB aquifers will remain far from sustainable rates, notably in the Amman-Zarqa basin where, according to actual figures of the MWI, abstraction rate will be brought down to 163% of the annual recharge. These modest results would be attained only if several measures are implemented, among which: (i) the By-law No.(85) of 2002; (ii) a reduction of olive trees irrigated areas; (iii) a suppression of vegetable and fruit exports originating from the highlands; (iv) the buy-out of agricultural wells by the government, (v) the development of treated wastewater use are strongly implemented; (vi) the implementation and generalization of irrigation advisory services. The potential impacts of each of these measures are discussed below and a first costs/benefits analysis is presented in a latter section.

#### 6.2.3.2 Implementation of the Groundwater By-Law No.85 of 2002 (after Venot et al. 2007)

*Limited Impacts to be Expected*

Objectives and problems linked to the implementation of the groundwater By-law No.85 of 2002 have been presented in chapter 5.3.1; (see Venot *et al.* 2007 for further details on farm level impacts of this water pricing policy and possible adjustment strategies of farmers). We focus here on possible short term impacts that an effective implementation of the By-law could have at the river basin scale in terms of water savings, agricultural area decrease and WAJ-revenue increase. Long term impacts as employment losses and migrations are not presented here. We focus here on the AZB and Yarmouk basins, the two main groundwater basins where the By-law could have some impacts if it is effectively implemented. Information on the different classes of agricultural wells according to their yearly production in the two groundwater basins of Amman-Zarqa and Yarmouk (MWI records for 2004) shows that out of the 606 wells located in the Amman-Zarqa and Yarmouk basins, only 182 yield more than 150,000 $m^3$/yr and will thus be concerned by the bylaw. Discounting government wells that produce more than 500,000 $m^3$/yr for domestic use, this figure drops down to 166 wells that represent 38 percent of water abstracted in the Amman-Zarqa and Yarmouk basins (Venot et al. 2007). Finally, only settled Bedouins with vegetables or mixed farms and absentee owners with vegetables are to be significantly affected by the bylaw (Venot *et al.* 2007). Thus only 83 wells (90% of these in the Amman-Zarqa basin) will eventually be affected by the bylaw in the eastern desert: the wells concerned correspond to only 18 percent of the total water abstraction (16.1 and 1.8 $Mm^3$/yr in the Amman-Zarqa and Yarmouk basins, respectively). Regional impacts can be assessed by aggregating farm level strategies according to five main strategies: A) farmers pay their water fees; B) farmers maximize water savings (by pumping 150,000 $m^3$/well/yr) and accordingly reduce their irrigated area; C) farmers maximize water savings, improve irrigation efficiency and slightly reduce cropped area; D) farmers improve efficiency while keeping constant the cropped area; E) farmers improve irrigation efficiency and accordingly increase their irrigated area (water consumption constant) (see Table 6-3)

*Table 6-3. Impact of the bylaw on vegetable farms at the basin level (eastern desert zone).*[130]

| | Abstraction ($m^3$ per year and per well) | Gross water savings | | Net water savings | | Depleted fraction in vegetables ($Mm^3$/year) | Government revenue from Vegetables farms (Million US$) | Overall government revenue (Million US$) |
|---|---|---|---|---|---|---|---|---|
| | | $Mm^3$/year | % of current gross overdraft | $Mm^3$/year | % of current net overdraft | | | |
| Present situation | 216,000 | - | - | - | - | 11.1 | - | - |
| Strategy A: Payment of water fees | 216,000 | - | - | - | - | 11.1 | 0.21 | 0.84 |
| Strategy B: Maximizing water savings & constant efficiency | 150,000 | 5.5 | 4.0 | 3.4 | 4.2 | 7.7 | - | - |
| Strategy C: Maximizing water savings & improved efficiency | 150,000 | 5.5 | 4.0 | 1.7 | 2.1 | 7.7 | - | - |
| Strategy D: Improving efficiency area constant | 179,700 | 3.0 | 2.2 | - | - | 11.1 | 0.012 | 0.63 |
| Strategy E: Improving efficiency increased area | 216,000 | - | - | -2.3 | -2.9 | 13.4 | 0.21 | 0.84 |

Table 6-3 shows that upper (optimistic) estimates of reduction in gross water abstraction (if all vegetable farmers decreased their water application and irrigated area by one-third on average, while maintaining their actual water use efficiency: strategy B) point to a decrease by 5.5 $Mm^3$/yr, a drop in an ocean of overabstraction, and quite short of the 40-50 $Mm^3$ hoped for.[131] Strategy C leads to similar gross water savings but lower net savings due to increased efficiency and lower return flows. In strategy A; nothing is changed except for a transfer of $0.21 million from vegetable farmers to the state coffers, or a total of $0.84 million if all farm payments are considered. Improving efficiency without increasing cropping area (strategy D) would lead to gross water savings of 3.0 $Mm^3$/yr and the regional gross overdraft would be decreased by about 2.2 percent. Net abstraction would not be affected by this change. Finally, strategy E would lead to increasing the depleted fraction by about 2.3 $Mm^3$/yr (as cropping area and efficiency increase, and return flows are reduced), which defeats the objective of the bylaw. Generally speaking, encouraging higher efficiency in conditions where land is not a constraint is counterproductive to the objective of reducing the depletion of water resources. The

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[130] For scenarios C and D, all calculations have been done considering an achievable irrigation efficiency of 75% (in vegetable farms). For scenarios A and B we considered the present efficiency in vegetable farms (62%). System efficiencies in olive and other orchards have been considered homogeneous at 70% and 80%, respectively in the four scenarios. Gross and net overdrafts indicate the gaps between gross or net abstraction and annual recharge, respectively.

[131] If abstraction of <u>all</u> private wells was to be reduced to 150,000 $m^3$/yr, total gross water savings would reach 12.5 $Mm^3$/yr. ARD and USAID (2001c) evaluated that enforcing the previous abstraction licenses could yield water savings of about 10 to 15 $Mm^3$/yr after 10 years.

fact, however, that expanding cultivation by using saved water is—on paper—financially profitable (see Venot *et al.* 2007) but not observed suggests that the real costs of increasing efficiency may be higher and that farmers face other constraints to developing their agricultural activity, notably higher opportunity costs for entrepreneurs with multiple economic activities (Van Aken 2004).

Revenue to the government is expected to vary between $0.63 and 0.84 million per year, not considering the costs of collection and enforcement, and losses in agricultural value could reach $2.5 million per year (not shown).

*Ways forward*

Would higher tariffs (like in the pre-amendment price table, for example), or a lower threshold for the first block, be more effective? Was the bylaw nullified by the downward revision of the charges in 2004? With higher charges, olive orchards and fruit-tree farms would remain insulated but the pressure would be made to bear on the most vulnerable vegetable and mixed farms; with a lower threshold, olive orchards would be under pressure too. In all likelihood, few of these farms would be in a position to invest in order to achieve better efficiency (and the existing potential gains from intensification (due to higher yields) would be curtailed by any water price increase). Affected farmers might just decrease their area and water abstraction (incurring a loss in their income) until they reach the threshold and avoid water charges.

They might as well sell their water to neighboring fruit farmers, rent out their wells (if they own them), and move out of agriculture. This would amount to a shift in production from vegetable farming and olive trees to higher-value fruit production, and would definitely raise the productivity of water, but a) benefits would accrue to wealthier entrepreneurs; b) this would defeat earlier social policies aimed at settling Bedouins by providing them opportunities in the agriculture sector (Chebaane et al., 2004), unless these are able to find equivalent or better job opportunities; c) the amount of water use would not be radically altered; d) water demand would become extremely inelastic because of the high crop return. Worse, the shift to higher efficiency fruit (or other) production could have the perverse consequence of allowing expansion of orchards, with lower return flow to the aquifer, greater depletion of water, and thus worsening of the status of the aquifer (Strategy E).

Because of the large share of unaffected farmers and likely impacts in terms of crop shifts rather than of improvements in efficiency (see Venot *et al.* 2007), a substantial drop in water abstraction can only be obtained through the diminution of either the cultivated area or the number of wells in use. As demonstrated above, negative incentives (reduced thresholds, higher tariffs, petrol taxation, stricter enforcement, etc.) cannot achieve this without displacing weaker farmers and strictly prohibiting the selling of wells. Recent political crises suggest that such extreme measures are unlikely to be accepted. Attendant positive incentives, such as buying-out of wells (a measure envisaged by the government and considered positively by 50% of farmers [Chebaane et al., 2004]), compensation for the uprooting of olive trees in the eastern desert (Fitch, 2001), and substituting treated wastewater for groundwater (ARD and USAID, 2001c) are more promising. Additional measures which may assist in decreasing groundwater abstraction include reduction of losses in urban networks and educational and public awareness programs for water users (chapter 5.4). Allowing transfer of water to neighboring orchards or the possibility of having vegetables farmers renting out their wells would offer financial compensation but would not contribute to conservation objectives [Chebaane et al. 2004]). Last, the removal of petrol subsidies for well operation or higher taxation of water must be accompanied by measures that provide alternatives to people moving out of low-value agriculture, such as subsidies or secure market opportunities to help viable farms to intensify production.

#### 6.2.3.3 Reduction of Olive Trees Irrigated Areas

Table 6-4 provides the agricultural value and the volume of groundwater abstracted for the different types of crops grown in the highlands. Stone fruit trees are the most valuable crops, followed by vegetables and then olive trees. Total value of the agricultural production of the LJRB Highlands is evaluated at $87.5 million per year (expected annual costs of the business as usual scenario is about 42% of this value [see above]. Irrigated olive orchards extend on 5,930 hectares and are low profitable (chapter 5.1): limiting the recent extension of these orchards which deplete the Jordanian aquifers by more than 30 $Mm^3$/yr would be one of the cheapest options to effectively reduce aquifer degradation. A complete phasing out of irrigated olive orchards in the highlands could save 32.6 $Mm^3$ of water each year while corresponding losses in agricultural value would total $8 million per year. For the sake of comparison, a complete disappearance of vegetables in the highlands would only allow savings of 15.8 $Mm^3$/yr while social and economic impacts would be more important (Table 6-4 and chapter 5.1). To save the same amount of water, 48.2% of stone fruit trees orchards would have to be phased out, incurring a cost of about $34.6 million/year (almost equivalent to the annual costs of the business as usual scenario [see above]).

*Table 6-4: Crop wise agricultural value and groundwater abstraction in the eastern desert of the Jordanian Highlands*

| | Irrigated Area (ha) (Venot et al., 2007) | Mean production value ($/ha/yr) | Total production value ($million/yr) | Total groundwater abstracted* |
|---|---|---|---|---|
| Vegetables | 1,865 | 4,200 | 7.8 | 15.8 |
| Stone fruit trees | 4,040 | 17,750 | 71.7 | 46 |
| Olive trees | 5,930 | 1,350 | 8 | 32.6 |
| Total | 11,835 | | 87.5 | 94.4 |

* We used average gross abstraction rates as follows: 8,500 and 11,400 $m^3$/ha for vegetables and fruit trees, respectively (average between Fitch (2001) and our surveys) and 5,500 $m^3$/ha for olive trees

A suppression of any irrigated olive orchard in the highlands (and notably in the Eastern Desert area) seems to be one of the most adequate options to control groundwater use and conserve its quality, from both a social and economical perspective. It actually allows a minimizing of net financial losses while limiting social impacts since phasing out non profitable olive orchards will not threaten livelihoods in the Highlands (chapter 5.1). However, these olive orchards constitute a true political capital for absentee urban owners who often have strong support in the parliament and in the economic elite. Any measure aiming at constraining their practices seems difficult to implement since it would tackle both the privileges and loyalties that have been linked to water in the tribe/state relationship and in the main attempt to maintain internal stability. Different measures to limit or stop the observed expansion of irrigated olive tree orchards could be envisaged. We will particularly study: (i) the subsidies for orchard uprooting[132], (ii) and the buy-out of wells by the government. Moreover

[132] These subsidies could remain low since both the income earned and the investments made on irrigated olive orchards are low.

particular attention should be given to areas where brackish water will be used in order to limit olive trees development which are relatively salt resistant.

#### 6.2.3.4 Suppression of Fruit and Vegetable Exports

Fruit and vegetable productions oriented towards local and export markets are crucial for the Jordanian economy (chapter 2 and 4.11). On the other hand, in the highlands, the export oriented fruit and vegetable productions are depleting the Jordanian aquifers and limiting them could be a mean to smoothen the present national water crisis. Some production like grape and apple could be particularly targeted as they are 1) not central in actual cropping patterns; and 2) are likely to be affected by the liberalisation of the agricultural market [chapter 4.1]. Such measure will face strong opposition from entrepreneurial and influent farmers who have highly profitable farms (chapter 5.1).

Highland farms produce between April and August (when cultivation is hardly possible in the Jordan Valley) and about 2,250 and 100 ha of vegetable and orchard areas are cultivated for the export market (e.g. one third and 1.5% of all vegetable and fruit irrigated areas of the LJRB highlands, respectively [DoS database]). Phasing out all export production from the Jordanian highlands would cost about $11.2 million per year (e.g. 5% of the actual agricultural gross domestic product) but would allow reducing groundwater abstraction by 20.3 $Mm^3$/yr. Buy-out of wells by the government to encourage farmers to stop their activity is one of the measures that could be envisaged to phase out this type of irrigation in the Highlands (see next section).

#### 6.2.3.5 Buy-Out of Wells by the Government

Buy-out of wells is the most straightforward and efficient measure to reduce groundwater abstraction. Alternatively, licenses can be bought because it is the license which gives the well owner the right to abstract water (Fitch, 2001: p32). The money can be seen as a pension to help the farmer retire, or as a compensation for lost livelihood or investment; it could also be adjusted to the salinity of the well water, since saline well have far less value. Buy-out could first target olive tree orchards and, second, fruits and vegetables areas located in the Highlands and oriented towards export.

ARD and USAID (2001c) evaluated at $10 to 30 million over five years, the costs of a well buy out scheme that would allow saving 15 to 20 $Mm^3$/yr (e.g. an average value of $3.4 million at current prices, every year, for five years). Costs depend on the type of well/farm bought (olive orchards and vegetable farms qualify as the main targets of such measure due to their low profitability and low level of investments; buying out schemes are less attractive for stone fruit tree farmers unless compensation are taken to very high levels) and on the level of compensation given to farmers (the latter depend whether investments, gross incomes or net incomes are considered to calculate a “fair compensation”). Total agricultural value will drop by $11 to 15 million per year when all wells would have been bought (1,500; 850 and 330 hectares of vegetables, olive orchard and stone fruit trees orchards are expected to disappear).

#### 6.2.3.6 Use and Impacts of Treated wastewater in Irrigated Agriculture

In the highlands, use of treated wastewater in agriculture will remain limited to areas located near urban centres and treatment plants and to areas where the water table drops dramatically. ARD-USAID (2001c) mentions, for example, the regions of Dulheil and Hashemiya near the As-Samra treatment plant where irrigation has been continuously developed since the 1970s (chapter 5.1). ARD and USAID (2001c) evaluates at 15 $Mm^3$/yr, the quantity of treated wastewater to be used in the

Amman-Zarqa basin in a ten years period. In comparison, THKJ (2004) mentions a higher volume of 25 to 30 $Mm^3$/yr of TWW to be used in the LJRB Highlands (among which 5 $Mm^3$/yr would be used for industrial purposes [see Figure 6-4]). In addition, 5 $Mm^3$/yr could also be used for agriculture along the northern side wadis.

Current over-abstraction could thus decrease by about 10 $Mm^3$/yr.[133] However, costs of TWW are high ($0.54/$m^3$ [JICA, 2004] compared to $0.185/$m^3$ for groundwater pumping) and the extra cost of $3.5 million per year is likely to be shouldered by the MWI, worsening public deficit. In addition, TWW may cause clogging and filtration problems (see the current problems in the Jordan Valley presented in chapters 5.11 and 5.12). Farmers would certainly have higher costs (efficient filters, chloride, skilled labourers, etc…), while yields are expected to decrease by about 15 to 20% implying a loss of agricultural value of about $ 1.4 million per year. Attendant and supporting measures like financial compensation may have to be taken to encourage generalization of TWW in the highlands. These measures would have to be conditioned by an effective decrease in groundwater abstraction by farmers. Environmental and health consequences of such generalization should not be overlooked (ARD and USAID, 2001c).

#### 6.2.3.7 Irrigation Advisory Services (IAS) and On-farm Management

Hanson (2000) as well as ARD and USAID (2001c) mention that IAS could result in water savings of about 15 to 20%. On the basis of present groundwater abstraction (THKJ, 2004), a 15% saving represents 5.6 and 9 $Mm^3$/yr, respectively in the Yarmouk and Amman-Zarqa basins.[134] IAS impact would be quite limited: only 5 and 1.5 $Mm^3$/yr could respectively be 'saved' in the Yarmouk and Amman-Zarqa basin. Costs of IAS implementation will be low at about $0.5 millions over a period five years and could be easily counterbalanced by savings in energy pumping costs (ARD-USAID, 2001c).

However, water use efficiency is high both at the plot and basin levels (chapter 5.6) and such water savings seem unlikely. Technical improvements and intensification with improved irrigation efficiency are likely to push farmers to increase their cropped area (this is highly profitable; see Venot *et al.* 2007) rather than to save water. In these conditions, we assume that this measure will not have any impacts in terms of direct water savings in the Lower Jordan Basin in Jordan. At the same time, raising awareness on water use efficiency among farmers and other users is still highly needed in Jordan.

#### 6.2.3.8 Reduction of Municipal and Industrial Groundwater Abstraction

JICA (2001) evaluated at about 30 to 35% the water unaccounted for due to physical losses in urban supply networks. Reducing these losses by half through the rehabilitation of the Amman drinking water supply network notably (chapter 5.4); could allow further gross water savings of 10 $Mm^3$/yr (ARD and USAID, 2001c). This would require very high investments as mentioned in chapter 5.4 (disregarding overruns, $250 million have been invested in the Amman network rehabilitation) Demand in urban areas can also probably be partly managed with a rise in prices. Net abstraction is

[133] Farmers receiving TWW will certainly continue pumping freshwater to blend it with TWW and soften the impacts of the latter on crops and yields.

[134] With agricultural abstraction of 83 and 63 $Mm^3$/yr (chapter 5.3.1); IAS could allow "saving" up to 9.5 and 12.5 Mm3/yr in the Yarmouk and Amman-Zarqa basin, respectively.

unlikely to be affected by such improvement and we do not consider such savings in our projections at the Horizon 2025.

## *6.3 Projections at the 2025 Horizon*

Previous sections have shown that many investment and reform projects have been floated in order to meet the increasing urban water needs within the country during the next 20 years. Some of them have already been initiated (2007) or are in their final phase of definition or implementation. We first show here that Jordan has a long history of water re-allocation towards domestic water uses and that this re-allocation is made all the more necessary by the fact that water use efficiency at the basin level is very high (chapter 5.6). We then examine the projected situation at the 2025 horizon, considering projects that are already implemented or under way (in 2007) and those that seem to be the most likely implemented in the near future.

### 6.3.1 Water Demand Projections

#### 6.3.1.1 Water Demand Scenarios: A Country-Wise Assessment

*Table 6-5: Gross water demand evaluation (Mm$^3$/yr) in Jordan and in the LJRB at the horizon 2025 (Source: THKJ, 2004)*

| **Jordan** | | | | | |
|---|---|---|---|---|---|
| | 2005 | 2010 | 2015 | 2020 | 2025 |
| Agriculture | 1,093 | 1,072 | 1,040 | 983 | 983 |
| Municipal | 367 | 404 | 444 | 493 | 544 |
| Industry | 59 | 77 | 100 | 120 | 129 |
| Tourism | 5 | 10 | 16 | 20 | 21 |
| **Total** | **1,525** | **1,564** | **1,600** | **1,615** | **1,676** |
| **Lower Jordan River Basin** | | | | | |
| | 2005 | 2010 | 2015 | 2020 | 2025 |
| Agriculture | 728 | 707 | 682 | 636 | 636 |
| Municipal | 304 | 332 | 365 | 405 | 447 |
| Industry | 37 | 48 | 62 | 74 | 67 |
| Tourism | 3 | 3 | 4 | 4 | 5 |
| **Total** | **1,072** | **1,090** | **1,113** | **1,120** | **1,155** |

Table 6-5, adapted from THKJ (2004), highlights that water use mainly occurs in the LJRB. This will not change during the next 20 years: in 2025, 66% of total water demand will originate from the LJRB. During the next twenty years and on aggregate terms, total water demand is expected to increase by 7% from 1,072 to 1,155 Mm$^3$/yr in the LJRB. In Jordan as a whole, the increase is expected to be higher (+ 10%, notably because of an important increase of industrial water use in Aqaba, in the south of the country). Two main processes are highlighted in these tables: water demand in irrigation is expected to decrease (-12% in the LJRB to reach 636 Mm$^3$/yr due to a decrease of irrigated agriculture in the Highlands) while other uses are expected to increase. In the LJRB, during the next 20 years, industrial and municipal water demands are expected to increase by 53 and 81% to reach 447 and 67 Mm$^3$/yr, respectively. In 2025, Municipal and Industrial demand for water will represent 45% of total water demand (31% today). Agricultural water demand will decrease to 55% (against 70% today).

#### 6.3.1.2 A Long History of Water Reallocation towards M&I Water Use

In addition to these data we may also investigate the evolution of sectoral water use over the last 50 years based on the water accounting presented in chapter 5.6. Figure 6-3 provides a striking representation of how agricultural withdrawals (gross river diversions plus groundwater abstraction) have leveled off since the mid-1970s. In contrast, Municipal and Industrial (M&I) withdrawals reached 31% in 2000 and are expected to go up to 52% in 2025 (a figure higher than that presented by THKJ, 2004). This evolution will be similar to that observed in Israel, where agricultural water use remains, by and large, stable but increasingly relies on treated wastewater, while M&I uses benefit from increases in supply and eventually supersede agriculture. The share of groundwater in M&I is dominant but this situation will also be inverted with the supply of the Red-Dead project.

*Figure 6-3: Evolution of sectoral water use (nominal values and percentage)*

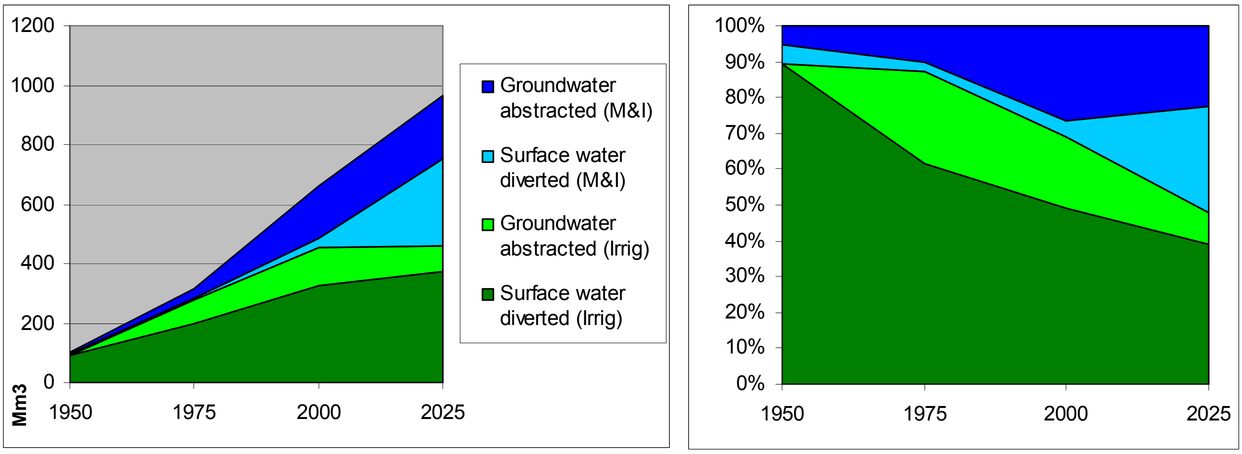



Table 6-6 indicates how these withdrawals relate to population change, with the annual growth between 2000 and 2025 being computed at 2.8% per year. Industrial withdrawals have been respectively estimated at 37 and 80 $Mm^3$ in 2000 and 2025 for the entire Jordan (i.e. lower figures that the demand presented in THKJ, 2004). In the Lower Jordan Basin in Jordan, municipal per capita daily endowments were at 127 l/capita/day in 2000[135] and will rise up to 184 l/capita/day in 2025, due to an increase in supply through imported water. This last value is slightly higher than the one considered in the 2004 Master Plan (THKJ, 2004) on the entire Jordan. Low values for 1950 and 1975 indicate the higher weight of rural areas and perhaps improper knowledge and computing of M&I diversions at the time.

### 6.3.2 Water Accounting: Projection in the mid 2020s

As done earlier for the period 1950-2000, the qualitative description of water development can be paralleled by a more quantitative exercise of water accounting. Considering the same indicators used in chapter 5.6, we can assess the water balance of the Lower Jordan Basin in Jordan at the 2025 horizon.

[135] This value corresponds to the whole Lower Jordan basin and is lower than the average for Amman (150 l/capita/day).

*Table 6-6. Evolution of per-capita withdrawals in the LJRB*

| Year | 1950 | 1975 | 2000 | 2025 |
|---|---|---|---|---|
| Population (1,000) | 498 | 1,539 | 4,283 | 7,261 |
| Irrigation withdrawals ($Mm^3$/yr) | 90 | 275 | 445 | 485 |
| M&I withdrawals ($Mm^3$/yr) | 10.5 | 41 | 205 | 507[136] |
| Per capita total withdrawals ($m^3$/year) | 202 | 205 | 152 | 137 |
| Per capita M&I withdrawals ($m^3$/year) | 21 | 27 | 48 | 70 |
| Per capita M&I withdrawals (l/c/day) | 58 | 73 | 131 | 191 |
| Per capita municipal withdrawals (l/c/day) | | | 127 | 184 |

- A subsequent increase by 23% of the renewable blue water (RBW) is projected for 2025. RBW will account for 861 $Mm^3$/yr. This expected increase mirrors the imports and the larger share of the Yarmouk diverted, thanks to the Wehdah dam. The net inflow to the basin appears stable between 2000 and 2025 (about 2,600 $Mm^3$/yr): the increase in imported water is compensated by less groundwater use and evaporation losses in the Wehdah dam. The non-diverted fraction of stream water will reach 113 $Mm^3$/yr in 2025 (against 252 $Mm^3$/yr today);

- Total withdrawals are expected to reach 980 $Mm^3$/yr in 2025 (i.e. an increase of 300 $Mm^3$/yr). It represents 113% of renewable blue water and 119% of controlled renewable blue water. Percentages higher than 100% reflect the water imports expected to be developed during the next 25 years (Figure 6-4);

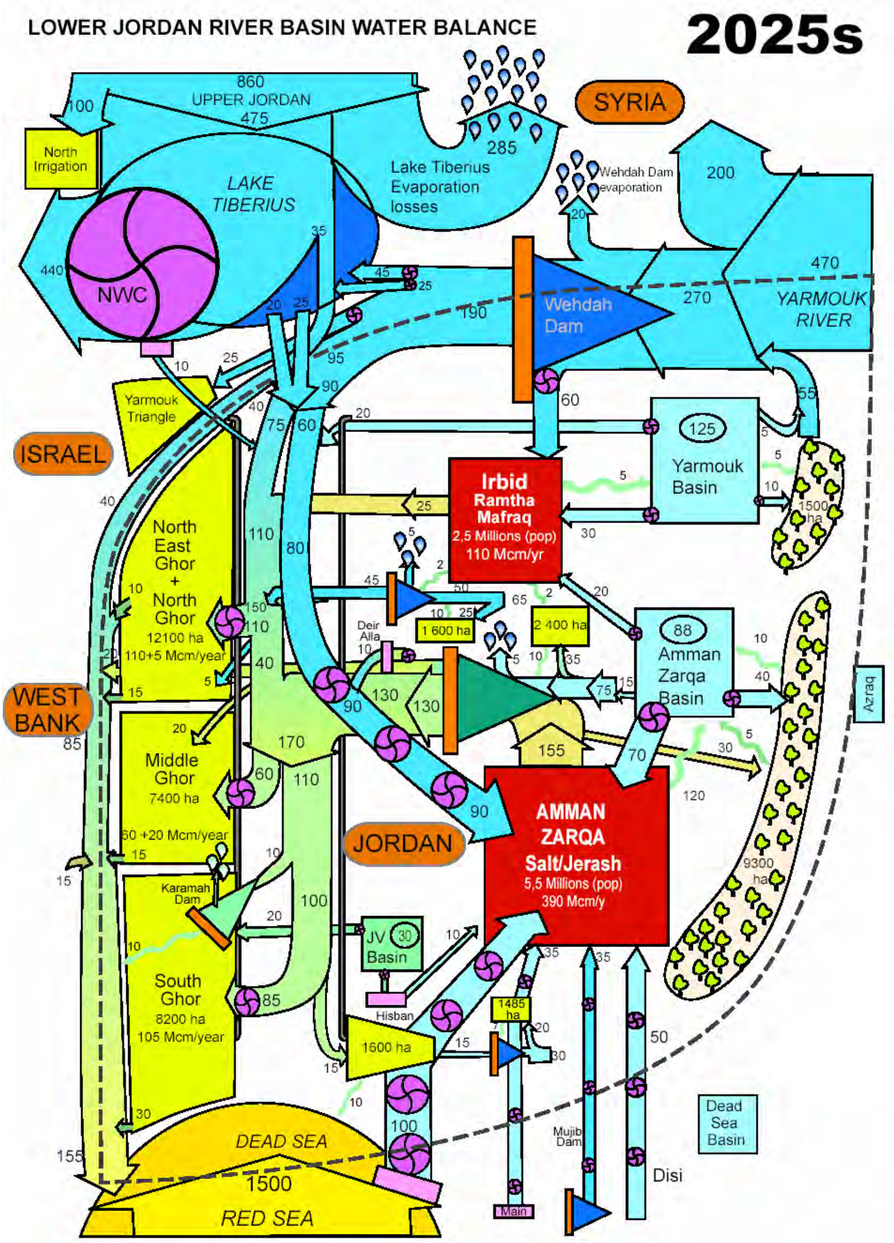
- Depleted water expressed in terms of percentage of RBW and CRBW is expected to reach 82 and 87% (against 67 and 87% today; process beneficial depletion levels off after 2000, as increase in M&I is counterbalanced by a decrease in highlands irrigation [see above]). Water use efficiency at the basin scale (volume of depleted water expressed in percentage of the volume of water withdrawals) is expected to reach 73% (against 72% today). This highlights that there are very few prospects to alleviate the Jordanian water crisis by technical improvement aiming at increasing water use efficiency at the local level. This does not mean that saving water through fine-tuning of irrigation supply in the valley or through water-saving technology does not need to be considered (chapter 5.2.1), but it does set a drastic limit to what can be achieved through conservation means.

- Considering groundwater abstraction and aquifer exploitation, a net positive balance of 91 $Mm^3$/yr on the entire LJRB in Jordan is expected to be reached during the next quarter of the century. It is linked to our assumption of 30% decrease in highland agriculture, and to an increase in the return flows associated with the use of water imported from other basins [including the Red-Dead project];

- Total depleted fraction (in % of net inflow) will continue to increase up to 92% in the next 25 years. The percentages of water depleted in irrigated agriculture as percentage of the total beneficial depletion and of the net inflow are expected to decline, under the assumption that highland irrigated agriculture is to be reduced and that more water is imported for cities (irrigation depletion will account for 38% of beneficial depletion against 45% today).

[136] M&I withdrawals presented according to our projections are very similar to the figures presented by THKJ (2004) to evaluate M&I water demand in 2025.

*Figure 6-4. Projected situation of water use patterns by the mid-2020s*




- Total return flow will reach 162 $Mm^3$/yr in 2025 compared with a total expected abstraction of 232 $Mm^3$/yr. Expected net abstraction will only represent 45% of the overall groundwater recharge, but 155% if we disregard return flows. We underline here that the increase in water use allowed by interbasin transfers of freshwater and pumping from the KAC could, by the way of their return flows, counterbalance the present overabstraction of the aquifers, at least locally.[137] The impact of water imports on groundwater recharge is crucial but often overlooked. This conclusion must, however, be considered very carefully: more studies on the characteristics of both the aquifers and return flows from different uses are needed to develop an accurate

[137] A limitation of our approach is that water budgets are done at the subbasin level. High groundwater return flows in the Amman region may not replenish the aquifer uniformly. Moreover, there is also a question of water quality, since return flows replenishing aquifers will be of lower quality.

groundwater budget and to refine quantitative assessments. It must also be emphasized that the figures on net abstraction highly depend on the evaluation of the annual recharge.

## *6.4 Likely Trends and their Impacts: a Quantification of Two Scenarios*

Based on available policy options described above, and on ARD and USAID (2001c); JICA (2001) and WMIS (2003) (among others); this section quantifies the short term impacts of two scenarios: a *business as usual* scenario which assumes only little changes in the water and agriculture sector of Jordan at the horizon 2025 and an *alternative scenario* in which most of the measures and projections mentioned in the preceding sections are effectively implemented and current agricultural dynamics (intensification, shift to low-water consuming crops, etc..) are heightened. An impact assessment is done for the next twenty years: we quantify financial costs and benefits of each measure and the possible water savings those measures could allow. The opportunity cost of water is taken at $0.786/m$^3$ (corresponding to a transfer from Disi, disregarding likely overruns). Long term impacts and changes in social relations are not detailed here as they have been extensively presented in previous chapters (chapters III, 4.13; 5.12 and 5.13, notably). Table 6-7 recaps the main impacts of these two scenarios.

The main difference between the two scenarios is the assumption of decreasing groundwater abstraction for highlands agriculture in the alternative scenario. In the two scenarios, industrial and municipal groundwater abstractions are considered constant, new needs being met by the last supply augmentation projects to be implemented. In the alternative scenario, it is expected that groundwater abstraction in the LJRB highlands will decrease by about 55 Mm$^3$/yr in 2015[138], contributing to the objective expressed by THKJ (2004) to "bring abstraction close to the annual recharge" (12 Mm$^3$/yr will also replenish the Jordan Valley aquifer due to the partial shift from banana to date palm tree plantations). This would be made possible only if high investments are done (the alternative scenario requires $338 million more than the business as usual scenario but could yield aggregated benefits as "freshwater savings" (mainly in the Jordan Valley) could be re-allocated to domestic water use in urban centres at a cost lower than in the Disi transfer. The alternative scenario yields an aggregate "surplus" of $252 million over the next twenty years (compared to the business as usual scenario, due to lower mobilisation costs, lower water treatment costs and despite a decline of the agricultural value produced) which could be used to finance the needed investments (the actual surplus is likely to be even higher as we considered running costs of large water transfers, disregarding probable costs overruns). The implementation of the policy options mentioned above will face strong opposition from different actors, who will see their former rights and privileges gradually disappear, but is crucial if Jordan wants to reach more sustainable water management for its future.

[138] Volumes "saved" in the agricultural sector are not re-allocated to other sectors and decreasing groundwater abstraction only allow slowing down the observed decrease of the water quality in the LJRB aquifers.

*Table 6-7. Cost and benefits of two scenarios of evolution at the horizon 2025*

| Available Policy Options and Evolution | Implementation date and expected impact | Investment costs (nature and costs) ($ million)* | Total running costs over 20 years ($ million)** | Yearly water mobilisation costs ($ million)*** | Other yearly running costs ($ million)**** | Other yearly running gains ($ million)**** | Freshwater "mobilisation" or transfer ($Mm^3$/yr) |
|---|---|---|---|---|---|---|---|
| **Business as Usual** | | | | | | | |
| Agricultural market liberalisation –constant cropping pattern | 2007 | - | 242 | - | 24.7 | - | - |
| Water infrastructure development (Dams on side wadis) | From 2007-ten years | 38 | 105 | 10.7 | - | - | 25 |
| Extension of TWW use and irrigation in the south of the Jordan Valley | From 2007-ten years | $184^{\alpha}$ | Gain of 246 (767-521) | $53^{\gamma}$ | - | 78.1 | 30; blended water used in the valley |
| Groundwater Bylaw Highlands | 2007 | - | 36.9 ($35.4+1.5^{\delta}$) | - | 3.6 | 0.84 (paid by farmers) | 5.5 (optimistic) |
| Red-Dead Project ($1.3/$m^3$) | Progressive from 2017 | 5,000 | 254 | 25.8 | - | - | 100 |
| Disi Conveyor ($0.786/$m^3$)✧ | 2017 | 600 | 480 | 48.9 | - | - | 88.8 |
| Water Quality degradation | 2007 | 150 | 340 (311+29) | 31.7 | 3 | - | - |
| **Total** | | **5,972** | **1,212** | **117.1** | **31.3** | **78.1** | **-** |
| **Alternative Scenario** | | | | | | | |
| Agricultural market liberalisation – shift in cropping pattern | From 2007 10 years shift | - | 225 (113+112) | 11.5 | 11.4 | - | 28.8 |
| Water infrastructure development (Jordan Valley) | From 2007-ten years | 38 | 105 | 10.7 | - | - | 25 |
| Extension of TWW use and irrigation in the south of the Jordan Valley | From 2007-ten years | $184^{\alpha}$ | Gain of 246 (767-521) | $53^{\gamma}$ | - | 78.1 | 30; blended water used in the valley |
| O&M costs recovery (Jordan Valley) | 2007 | - | Gain of 9.4 | - | - | 1 (paid by farmers) | 0 |
| TWW use in the north of the Jordan Valley | From 2010 | $218^{\beta}$ | 104 (70+34) | $7.1^{\gamma}$ | 3.5 | - | 10 |
| Groundwater Bylaw Jordan Valley | 2007 | - | Gain of $108+0.3^{\delta}$ | - | - | 11+ 0.3 (paid by farmers) | 12.4 (balancing abstraction/recharge) |
| Groundwater Bylaw Highlands | 2007 | - | 36.9 ($35.4+1.5^{\delta}$) | - | 3.6 | 0.84 (paid by farmers) | 5.5 (optimistic) |
| TWW use in the LJRB highlands | 2007-2012 | 80 | 211 ($191^{\theta}$+20) | 19.5 | 2 | - | 15 (10 in agriculture; 5 in industries) |
| Buy out of wells: Uprooting 2/3 of olive orchards | 2007-2012 | 40 | 65 | - | 6.6 | - | 20 |
| Buy out of wells: Disappearance of ¾ of highland vegetables for export | | | 87 | - | 8.8 | - | 15 |
| IAS | 2007 | - | 0.5 | No extra water savings (IAS will go with other measures such as buy-out of wells) | | | |
| Red-Dead Project ($1.3/$m^3$) | Progressive from 2017 | 5,000 | 254 | 25.8 | - | | 100 |
| Disi Conveyor ($0.786/$m^3$) ✧ | 2017 | 600 | 231 | 23.5 | - | - | 50 |
| Water Quality degradation$^{\wedge}$ | 2017 | 150 | 66 (57+9) | 7.8 | 1 | - | - |
| **Total** | | **6,310** | **960** | **98.8** | **35.9** | **78.1** | **-** |
| **Costs/Benefits Ratio of the Alternative Scenario** | | **-338** | **252** | **18.3** | **-4.6** | **-** | **-** |

<u>*Notes:*</u>

We assumed an inflation of 3.5% and a discounting rate of 8%.

✧ The base scenario accounts for a transfer of 50 $Mm^3$/yr from the Disi aquifer;

⅄ This assumes a lower treatment cost (\$0.2/$m^3$) due to lower groundwater salinity as well as a later date of implementation of the first treatment plants.

* Investments at current prices (2007);

** Express the <u>present value</u> of running costs incurred on a twenty year period (in brackets, the first term is for water mobilisation costs, the second term for other running costs);

*** Express the average annual value of water mobilisation costs to be incurred every year (during 20 years, in current prices) if the same amount of water than is "saved" in the *alternative scenario* had to be transferred from Disi (after 2007) or from local sources (Jordan Valley) (before 2007). The opportunity cost of water saved in the Highlands is accounted in the line "water quality degradation";

**** Express the average annual value of other running costs/gains to be observed every year, during 20 years, in current prices (mainly losses/gains in agricultural value produced);

[α] Including upgrade of the As-Samra treatment plant;

[β] Investments for the Wehdah Dam (completed in 2006; \$90 million) are not accounted here;

[γ] Entirely covered through water charges at O&M costs (2.5 cent/$m^3$);

[δ] Enforcement costs

[θ] We assumed a treatment of 30 $Mm^3$/yr.

# 7 Conclusions

## *7.1 A Basin Trajectory*

This historical perspective on the trajectory of the lower Jordan River basin has revealed a fascinating concomitant change of societies and waterscapes in an arid region subject to dramatic political tensions.

The basin witnessed the first agricultural settlements in history and always played the role of a corridor of communication, for trade, pilgrimages and transhumance. The mobility of social groups and the flexibility in the management of resources are two main central features that provide a sense of continuity throughout centuries.

Mobility had, and still has, a major impact in framing the trajectory of the basin: the tradition of transhumance and nomadism of tribal pastoral groups, interconnected with agricultural settlements, the slave trade (from which originated the remaining groups in the Valley); the two main demographic shocks due to the forced migration of Palestinian refugees; the migration of labour from Egypt that has become instrumental in the development of intensive irrigated agriculture during the past three decades; or the hundreds of thousands of Iraqis who recently found refuge in Jordan. Immigration in the basin has often been paralleled by outmigration, both epitomizing high economic and social mobility.

In addition to migrations and displacement, mobility also refers to contacts with the "outside", including fluxes of exogenous ideologies and institutional actors in the management of resources; to the flux of capital in a rentier economy, and the buffering role of the area in a highly volatile region that has made it a pole of attraction for foreign aid and capital in times of war (first Lebanon, then Iraq): all this elements have been determinant in shaping patterns of water resources development and management.

Water has constituted a main tool in the search for stability, both with regards to regional competition for this scarce resource and in terms of internal stability: an instrument to settle and "root" mobile populations, and to depoliticize a tense context; an issue to cement regional peace and obviate wars; a form of consensus building, of modernization of the nation, and of building up of bureaucracies that were pivotal in the redistribution of resources. But this building up within a fragile nation, navigating in the troubled waters of a regional conflict, conditioned and influenced the political power of social groups in the country and the type of development interventions and policies that are possible, desirable, and funded or not.

This highly political role of water is also explicit in the fact that the Jordan Valley is split by a tense border with the Occupied Territories; the ecological unity is already fragmented and the irrigated valley constitutes a tense military frontier area.

We attempt to synthesize here some main features of this peculiar trajectory of the JV basin, showing both the historical disjunctures and the patterns of continuity in the society/water nexus.

- Bedouin tribes who controlled natural resources, interlinked with peasant settlements, were the first to be targeted by irrigated settlement schemes construed as a basis for nation building: their incorporation and adaptation into the state apparatus has been the counterbalance of the disruption of their pastoral economy but also the basis of the reproduction of tribal solidarity within a new political system.

- Subsidized water and the bureaucratic apparatus have been a major political tool in capital redistribution in order to maintain stability. In this context, kinship and tribal relations have acted as a buffer and a form of protection, a means through which resources could be obtained at different levels in the new economic segmentation. The "local" tribes and refugees have lost their traditional material base (control of land, water, transport, etc) but kin solidarity remained an instrument of political insertion within the administrative apparatus and kin networks provided some room for maneuver beyond the state. At the same time, the nation itself has been built according to a genealogical nationalism, where the King stood as sheikh of shiukh.

- Rural livelihoods have shifted from livestock, rain-fed cereals and olive trees, with spots of seasonal irrigated farming, to an artificial 'plastic' and intensified agriculture partly linked to export markets but also to rentier strategies (irrigated olive trees in the highlands, which waste precious groundwater resources, and some citrus orchards in the Valley).

- The emergence of high-tech agriculture brought tremendous change in the conception of resources, of common goods, and in framing state-citizen relationships. This has led to the intermingling of previous patterns and ideas about managing resources with new models linked to planning and modernization, in a context of legal pluralism and manipulations or evasion of policies and norms.

- The main change linked to agricultural and technological change, in particular the shift from surface to microirrigation, are, first, the closer interconnections and interdependence of water users in a social context which is often characterized, on the contrary, by fragmentation of social networks and forms of cooperation. Further, water has been displaced from a socialized activity of the tribe in a public and community domain, to a delivery through a state-centered bureaucratic apparatus in a context of basin closure and growing scarcity.

- Although agriculture was already connected to the outside world at the end of the 19$^{th}$ century, the economy of rural dispersed settlements largely based on self-sufficiency shifted to one centered on services and ramified abroad through both the Palestinian Diaspora and the financial dependence on foreign aid. At the same time, immigration of foreign laborers have been crucial in the building of the present waterscape of the basin since they allowed the expansion and intensification of irrigated agriculture and compose the often "invisible" water users in agriculture, under the dependence of their patrons and managers.

- Waterscapes have been reshaped from small springs and streams diverted to family gardens, communal patterns of distribution of land (*musha* and *dirah*) and water in the integrated agro-pastoral management, to a centralized bureaucratic system with water pumps and pipes lifting water from the valley bottom 500 m up and from distant aquifers to cities. Water is thus partly deterritorialized, since it has lost its ancient linkages with land and local communities. The interconnectedness and the complexity of the water delivery system itself, particularly in the Jordan Valley, tends to make local participation more difficult.

- Irrigated areas increased from around 10,200 hectares in 1950 to 24,900 hectares in 1975, and to 45,800 hectares at present. The consumption of 67% of the renewable blue water in 2000 against 3% in 1950 points to a critical closure of the basin compounded by an unsustainable use of groundwater resources.

- Environmental change in aquifer systems, springs drying up in oases, and salinizing of groundwater, as well as the depletion of the Dead Sea over several meters.

This landscape first occupied by Bedouins and small rural settlements thus witnessed the emergence, or the occasional presence of actors as diverse as Palestinian or Iraqi refugees, Pakistani or Egyptian workers, Sheikh from the Gulf Region, peace negotiators, greenhouse entrepreneurs, irrigation bureaucrats, foreign development experts, international bankers, tourists, Islamic fundamentalists, urban absentee owners with swimming pool in their orchards, or prestige olive tree gardens watered in the middle of the desert. These actors have found a place in the following chronology.

## *7.2 Basin Trajectory: a Brief Synopsis*

### 7.2.1 Up to the 1960s

While state-driven large scale development of water resources only started in the 1960s, several earlier historical events have been crucial in shaping the water environment and related institutions.

First, the Ottoman period saw the introduction of new concepts of land and water, the immigration of agricultural settlers from the Caucasus, the setting up of a bureaucratic apparatus, the emergence of merchant elites in the agricultural sector, and the increase in the export of agricultural products; yet the *musha* system and communal patterns of resource management remained effective.

The British Mandate then introduced the first planning attempts and the frontiers of the newly funded Kingdom of Jordan interrupted transhumance and pastoral routes, giving rise to a new concept of private propriety and starting to oppose and disrupt local communal systems of management. Further, the Mandate period allowed Zionist projects, also based on irrigation schemes, to expand on the East bank of the Jordan River, making this region a security area. Moneylenders and merchant families increased their influence on landownership and agricultural investment, forming the basis of later capital investments in agriculture, in parallel with the decreasing power of Bedouin tribes.

With the large displacement of Palestinian in 1948-49, international actors came into play, focusing on the development of water infrastructure and agricultural settlement schemes as the basis of the new and fragile nation, still characterized by low density population, scattered area of agricultural water use, and marginal links to the market. The Jordan River was still abundantly flowing into the Dead Sea and water perceived generally as scarce but available if captured and channeled with proper infrastructure.

The influence of external actors became also evident in the “local struggle" between the divergent planning ideas of British aid, mainly linked to Indian colonial experience and stressing local institutional building through small emergency water projects for the refugee population, and the TVA (Tennessee Valley Authority) integrated model brought in by the US that focused on large irrigation schemes and infrastructures. Water was thus already a highly political tool, in the hands of development actors and political players, in a country highly dependent on external relations and regional politics.

In 1950, surface water coming from the Yarmouk River, the side-wadis and the Jordan River itself allowed the irrigation of small areas located along these rivers and in their alluvial fans (around 13,000 ha using 125 $Mm^3$/yr, i.e., 9% of the Lower Jordan River flow); no significant groundwater exploitation were present. Most of the flow of the Jordan River itself, 1.3 Bm3 reached and replenished the Dead Sea.

### 7.2.2 The development period: 1960-1990

In the 1960s, the pressure on water started to increase in a decade that coincided with conflicts and a huge demographic shock due to the arrival of Palestinian refugees, the development of large scale irrigation schemes, and the development of urban centers, with Amman as its core.

Although interrupted by the regional conflict in 1967-1971, since 1950 new ideas and plans were put gradually in place towards an intensification of agriculture, including a land reform, new water infrastructure, a centralization of the management of water resources (the JVA), with high public investments in the frontier area of the Jordan Valley, due to the political tensions and attempts to lay claim on available water by using it. The so called “supergreen revolution” (El-Musa) took place after the new demographic shock, conflict and internal warfare during 1967-1971, and was characterized by a policy bias in favor of urban capital investors, high subsidies in favor of irrigated agriculture, a local unexpected increase of sharecroppers (in contradiction with the alleged objective of building farm owners), and a sweeping capture of the Jordan River resources by Israel, after its full seizure and damming of Lake Tiberias in the late 1950s.

Capital and intermediaries acquired a new and crucial role within a new social and economic segmentation transversal to the different communities present in the valley, while numerous Egyptian migrants substituted the lower-status Palestinian previously engaged in agricultural work. This cheap and flexible labor force, paralleled by a widespread recourse to female family labor, were instrumental in the expansion of irrigated agribusiness.

If the heyday of this agriculture lasted until the early 1980s, increasing economic competition and loss of Gulf markets engendered a gradual decline of agricultural value and export, with continuous economic crisis and public intervention in debt rescheduling, an economic process paralleled by a local devaluation of agricultural work linked to the dependent condition of labor in the new agribusiness.

At the local level, although the tribe and lineage lost their material bases, they reproduced their “tribal solidarity” – the *wasta* system - within the administrative structure and the water bureaucracy: the idiom of kinship, transversal to all local communities has remained a flexible resource, a “buffer” area for the poor in front of the state, allowing a degree of access to resources and vertical mobility through the overlapping of tribal loyalty with the administration, the elite and the growing management bureaucracy.

The Highlands *badia* attracted much less aid and public but the steady increase of private wells and irrigated agriculture completely transformed the landscape of what was, earlier, mainly a pastoral environment. The number of people involved in pastoralism as a main activity dwindled down dramatically but it nevertheless remained as a way of life, a symbol of a moral community. The vast semi-arid environment is now used more as a container of livestock, rather than as a grazing land, since both water and most of the feed are transported by trucks.

In 1975, in the northern and middle parts of the Jordan Valley, 13,500 hectares were irrigated owing to 115 $Mm^3$ of water coming from the KAC each year. In the south, water from several side-wadis and pumping from the aquifers allowed the irrigation of around 4,200 hectares with 55 $Mm^3$/yr (THKJ 1977). In the highlands, 2,150 hectares were also irrigated (35 $Mm^3$/yr) in the side-wadis and the Zarqa River valleys, while around 5,900 hectares were irrigated with groundwater within the Yarmouk and the Amman-Zarqa basins (respectively depleted by 5 and 65 $Mm^3$/yr). The period was also characterized by the strong development of urban areas such as Amman-Zarqa (population of 1.1 million), and Irbid, which then used 30 $Mm^3$/yr of groundwater. By the mid 1980s, the AZB highlands became the land of orchards and vegetable farms, initiating a process of groundwater use that was to become rapidly unsustainable.

### 7.2.3 From 1990 to present

The increase in technological input, microirrigation and greenhouses starkly changed the waterscape in the Valley: sharecroppers have been increasingly substituted by lessees who have a flexible relation to land, bring higher capital, make renewed technological investments, and now face not just the economic crisis of the agricultural sector but growing concerns about water shortages and water cuts. Technological investment in agribusiness has been led by capital-investors who were generally not land-owners: this is true both in the Valley, largely thanks to Palestinian expertise, capital, and linkages to the West Bank (technological transfers) and to the Gulf (markets), and in the Highlands, where the cultivated area is now comparable to that in the Valley (22,800 ha in 2000).

The third demographic shock was the return from the Gulf of Jordanians of Palestinian origin after the 1991 war. This not only led to a new urban expansion, posing new problems of urban water management interlinked to rural areas, but also to an increase in irrigated agriculture and intensification both in the valley and even more in the Highlands. Again, the linkages between war, displacement, flux of capital and expertise are crucial in understanding changes within the context of the basin, emphasizing the interdependence of the basin environment and external factors.

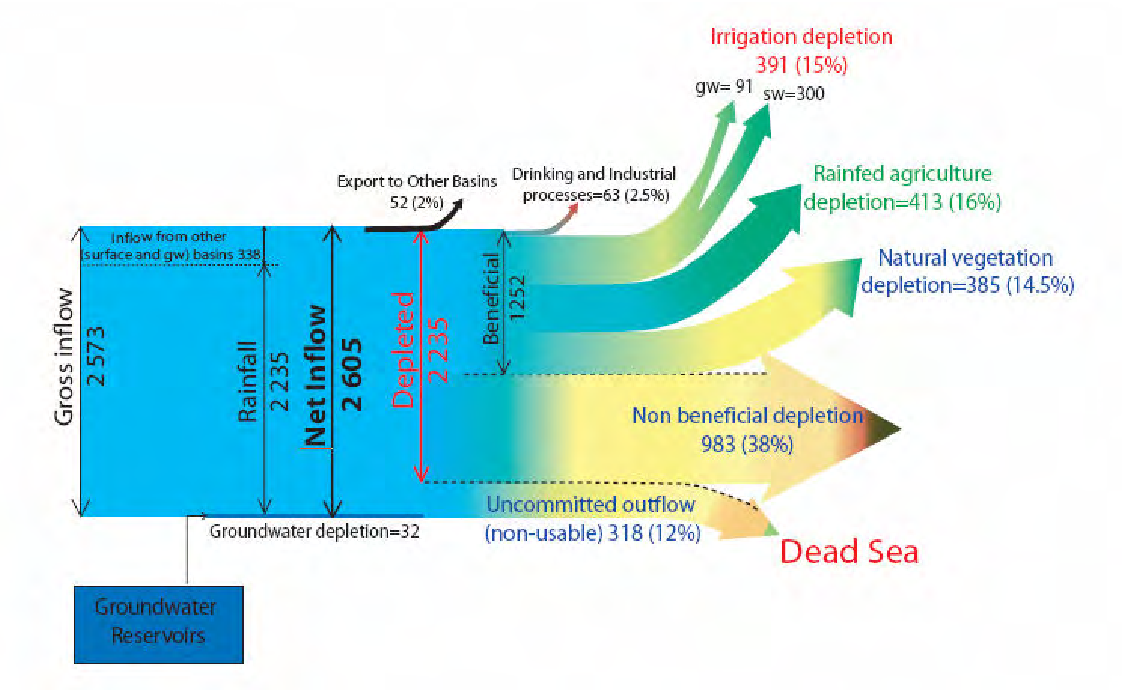
The frontier area of agriculture in the Highlands also expanded through spontaneous private investment of medium urban-based entrepreneurs in high-value fruit production, while steppe degradation posed serious problems due to overgrazing and changing patterns of pastoralism, with the disruption of patterns of transhumance.

The reality of basin closure has become sizeable and has generated local conflicts around water distribution in the Valley (thefts, farmers/JVA mistrust, manipulations) as much as growing competition between urban and agricultural water users. The main features of the current situation in the water sector can be singled out as follows:

- With the completion of the Wehdah dam the control and use of surface water is getting close to its maximum.
- Abstraction of groundwater has gone beyond sustainable levels but its regulation has been and remains problematic.
- Public control of water use (through the definition of quotas) is higher in the Valley. This has allowed a reduction of irrigation water and reallocation to Amman, a loss partly compensated by blending freshwater with treated wastewater from cities.
- As a result, the basin efficiency is very high with only 88% of the available resources being depleted. Additional gains in efficiency in irrigation and urban networks are probably desirable but reduction of the return flows further impacts the status of groundwater.
- Environmental impacts have surfaced and environmental concerns have somehow been incorporated into the debate; but they have not yet gained decisive political significance.
- With growing competition, water has become a central element of political discourse and power and of the redefinition of state/citizen relationships. Besides, the new system of water distribution and technological layout in the Valley have highly increased the interdependence of water users at the local level, amplifying ethnic and class divisions, and daily competition.
- Further substantial supply augmentation options are limited to importing water from outer basins, distant aquifers (Disi), or from the Red Sea (through a process of desalination). The cost of drinking water (and state subsidies) is high and likely to further increase.

Figure 7-1 summarizes the current balance of the LJRB. Outflows only amount to 12% and are termed "uncommitted" although they do contribute to replenishing the Dead Sea. This reminds us that development of water use in the basin has eventually translated into a reduction of the inflow to the Dead Sea to a fourth of its natural value, and to a drop of its water level by 25 m. With population growth, urbanization, costly transfer options and a disappearing Dead Sea, the most severe challenges for the Jordanian water sector lie ahead.

*Figure 7-1. Summarized water accounting of the LJRB (c. 2000)*




## *7.3 Challenges ahead*

Jordan's future remains highly dependent on regional political events and stability. Recently, the conflicts in Lebanon in 2006 and in Iraq have had again direct influence on the country, in particular through the influx of hundreds of thousands of Iraqis in the Amman region. A new cycle of pressure over water resources, continued concentration of power and water use in urban centers, and capital investments is being triggered.

Much of the future tension on water resources will be linked to the competition between urban users and irrigation agriculture and their respective demands. The needs of cities is likely to grow by an order of magnitude of 10% per year, a growth that will not be durably offset by a reduction of losses in distribution networks, however desirable these may be. Likely future scenarios probably resemble those observed in Israel, where allocation of freshwater to irrigation has decreased and been largely compensated by the supply of treated wastewater. Supply augmentation will be limited to providing domestic water through desalination. In the case of Jordan the main option currently discussed is that of the Red-Dead project including operations of conveyance, energy generation, desalination and pumping to supply Amman.

This project bears all the characteristics of megaprojects: a relatively secretive planning and design, an array of justifications that borrow from discourses on state building, national sovereignty and security, peace making (the "peace conduit"), environmentalism (restore the Dead Sea) and religious feelings (the cradle of Christianity and Judaism); and a multibillion dollar cost (~$5 billion) likely to be increased by inevitable massive cost overruns (Flyvberg *et al.* 2003). In the particular context of Jordan, support to the project is likely to be strengthened by what some foreign powers may see as political gains in terms of short term regional stabilization.

Political goals, as often is the case, are likely to override mere economic considerations. It is likely, indeed, that the cost of such desalined water will be far higher than its opportunity cost in agriculture. The relevance of the project is therefore also contingent on what agricultural demand will be. Demand is not considered here in terms of agronomic water requirements but in terms of the political clout of the agricultural sector in the national debate. The intensity with which agricultural interests will demand their share of water, however, is both crucial and uncertain.

Part of the answer lies in the profitability of agriculture itself. This profitability partly depends on state policies (possible lifting of the protections on banana production, price of water, availability of Egyptian labour, etc) but –perhaps more crucially- also reflects output prices in a regional market where competition has markedly increased. High-value export fruits or vegetables for local markets are likely to retain their niches.

But the evolution of agriculture and water use is also linked to its social and political dimensions. Use of groundwater in the upland is conditioned by the political will to control abstraction, itself part of the wider political relationships between the state and the tribes, and the state and Jordanian-Palestinian elites. In the Valley, the technical and social possibility to improve water management and to discourage crops like citruses is also linked to state/citizen relationships. Last, the gradual intensification of agriculture towards a capital and knowledge intensive enterprise has implications in terms of social stratification, access to land, and distribution of benefits. This, in turn, has consequences that are conditioned by wider economic changes and the availability of alternative activities.

In summary, as is typical of closing basins (Molle *et al.* 2007), the LJRB is characterized by an increasing interconnectedness of uses and users through the hydrological cycle: surface water and groundwater interactions are more apparent (e.g. drying up of Azraq oasis; return flows of cities replenish aquifers, etc); the most downstream "user", the Dead Sea is the ultimate looser but technology allows a reversal of gravity and water to be pumped from the Valley to the highlands, in a manifestation of economic and political power of urban users and of sectoral competition over water; in agriculture, entrepreneurs, family farms, and rentiers also compete for water both in the Valley and the Highlands, with their respective strategies and assets, financial, political or otherwise. These intricate influences of social, economic and political factors in the future shaping of the LJRB's trajectory illustrate the inherent and strong coupling of the evolutions of both society and waterscapes.

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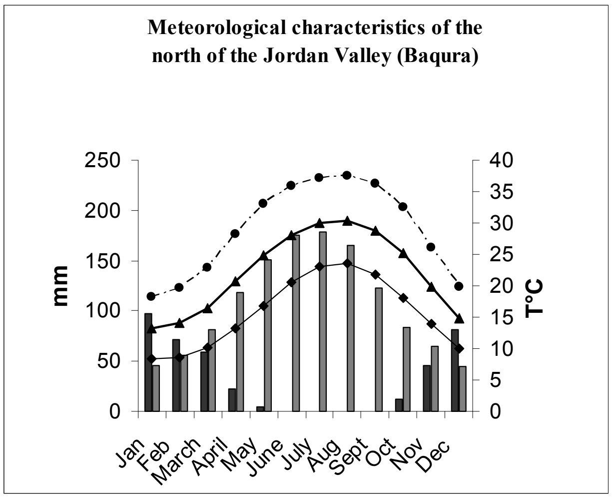
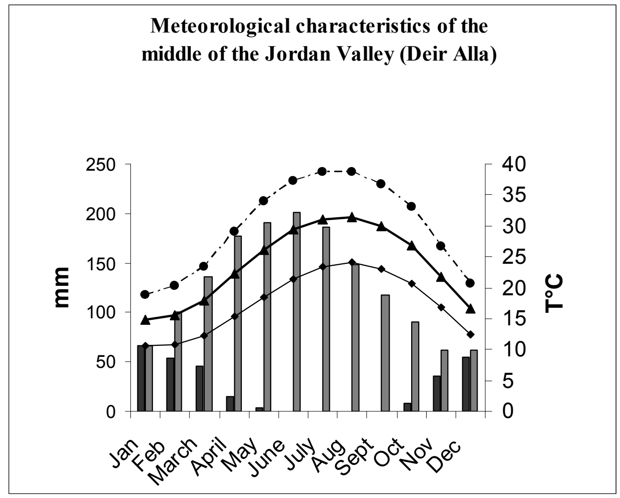
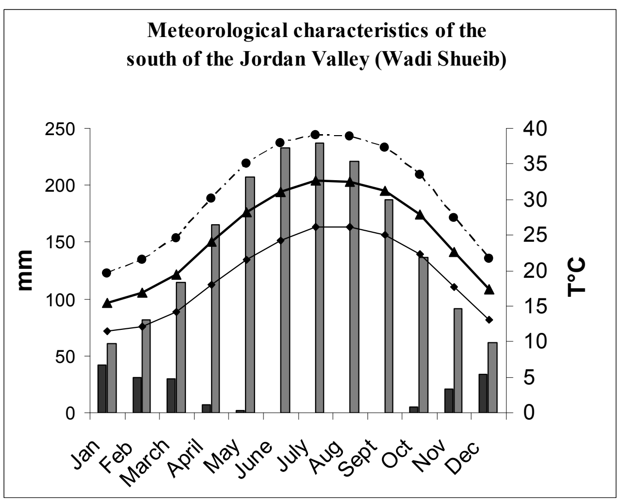
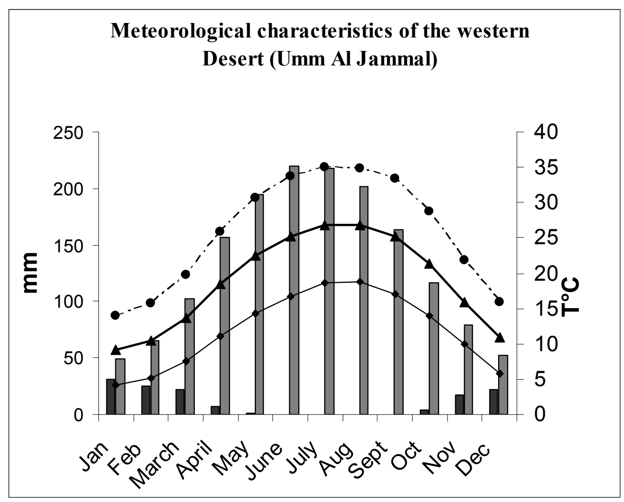
# 9 Appendices

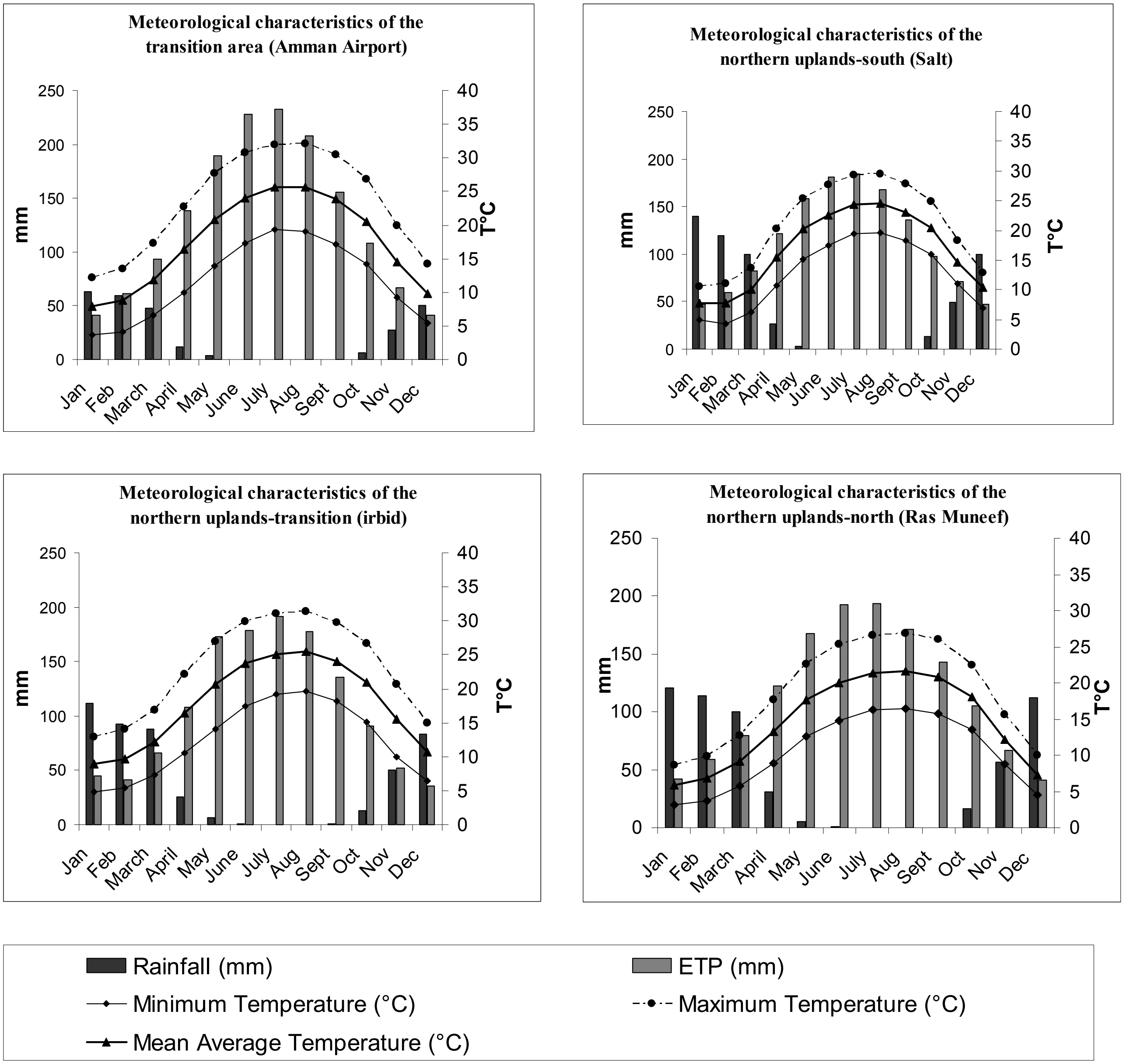
*Appendix 1. Ombrothermic Diagrams for Different Climate Stations in the Lower Jordan River Basin (Source: after THKJ and Meteorological department (2002) and THKJ (2004). See Figure 2-3 for the location of the stations within the Lower Jordan River basin.*



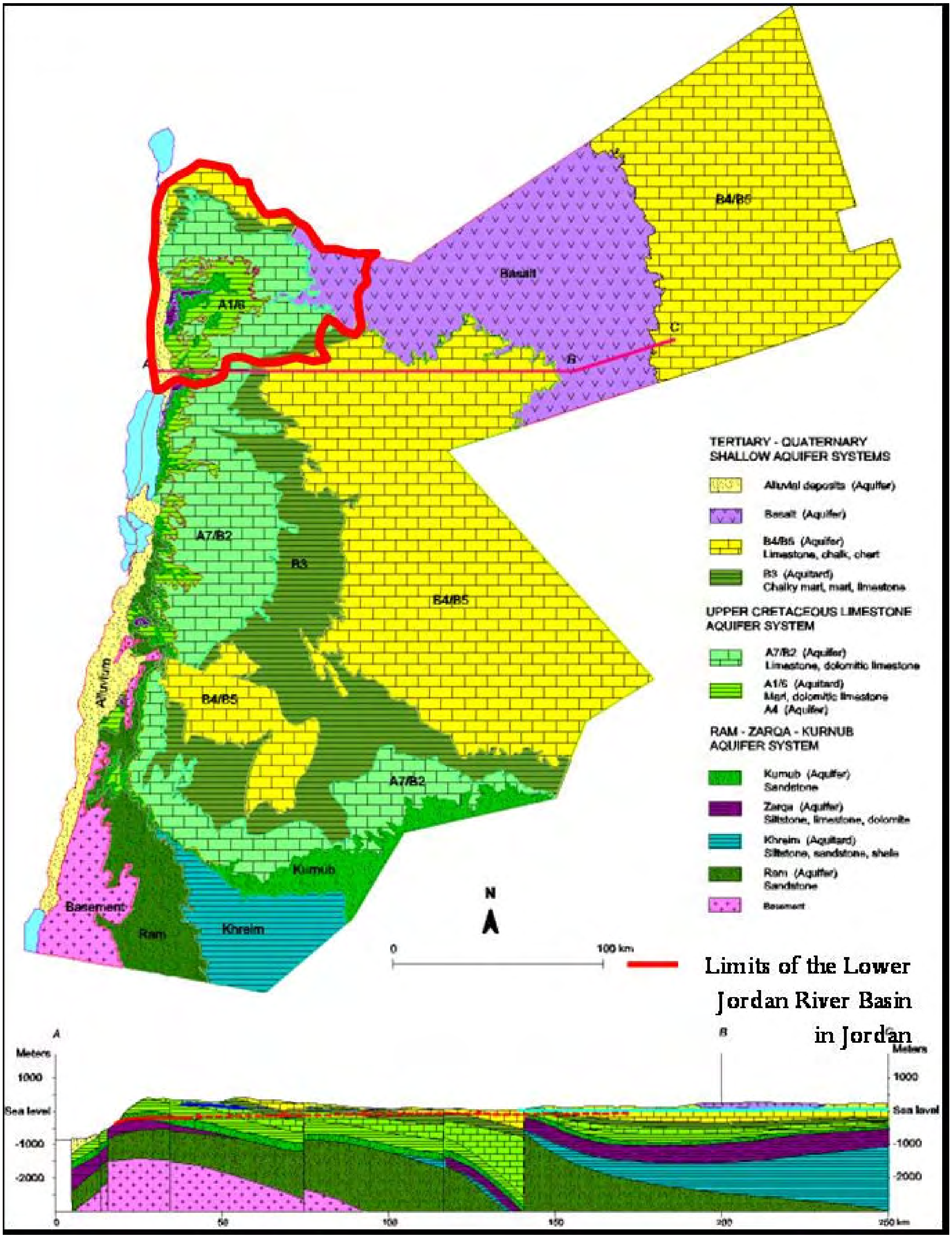



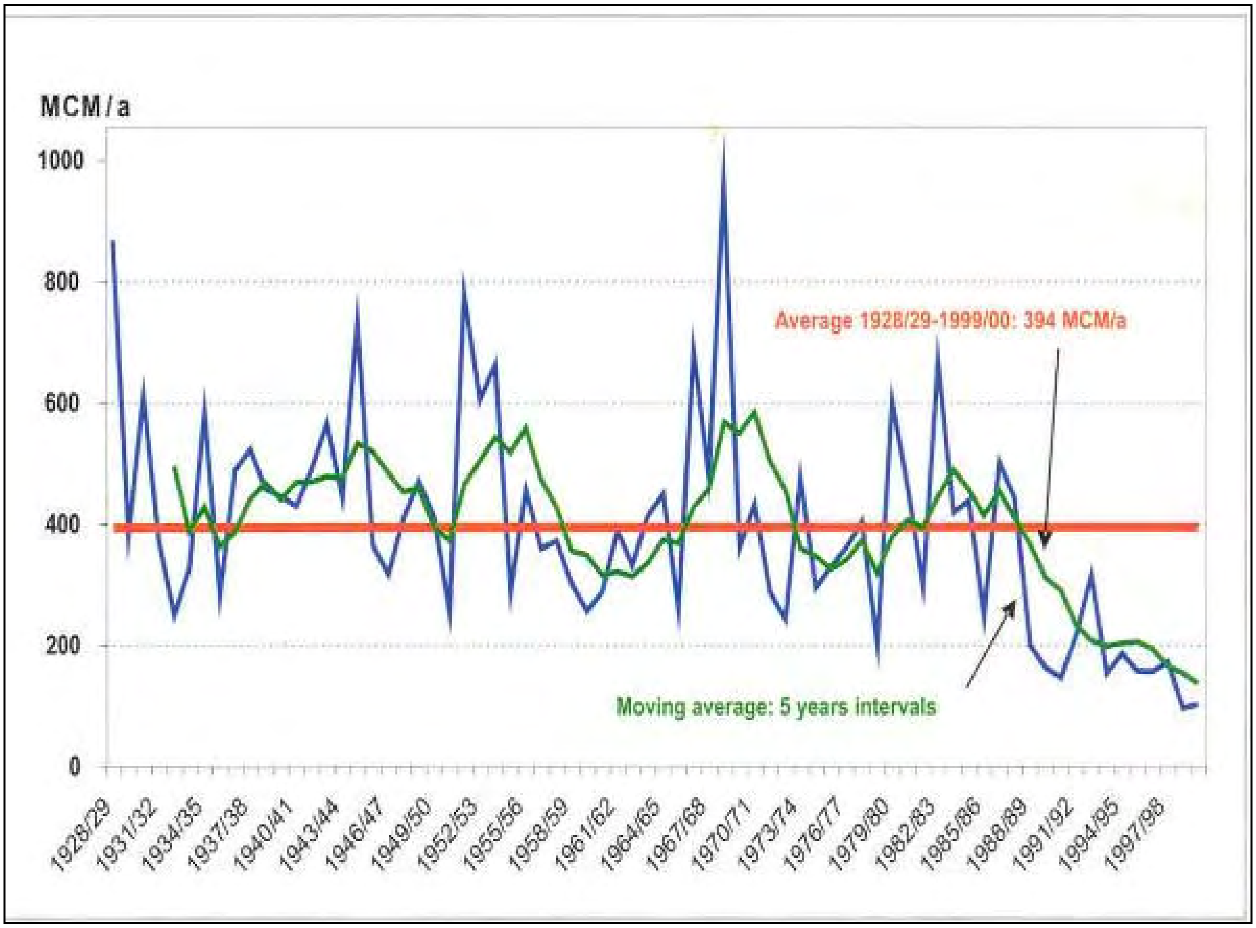




Meteorological characteristics of the transition area (Amman Airport)
Meteorological characteristics of the northern uplands-south (Salt)
Meteorological characteristics of the northern uplands-transition (irbid)
Meteorological characteristics of the northern uplands-north (Ras Muneef)
mm
T°C
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Rainfall (mm)
ETP (mm)
Minimum Temperature (°C)
Maximum Temperature (°C)
Mean Average Temperature (°C)

*Appendix 2. Hydro-geological map of Jordan (Source: THKJ, 2004)*



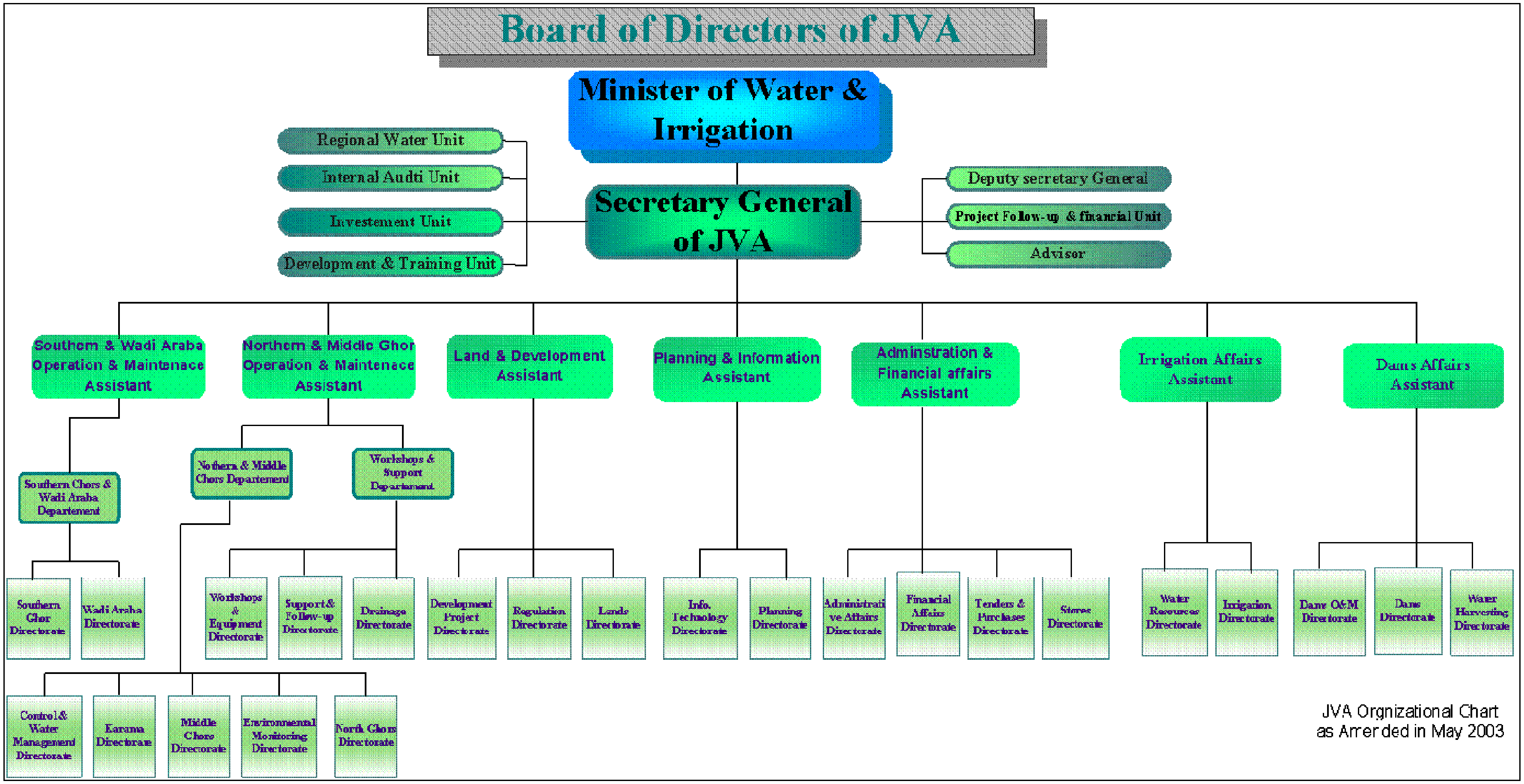
*Appendix 3. Long term Average of the Yarmouk River flow (Source: NWMP, 2004)*

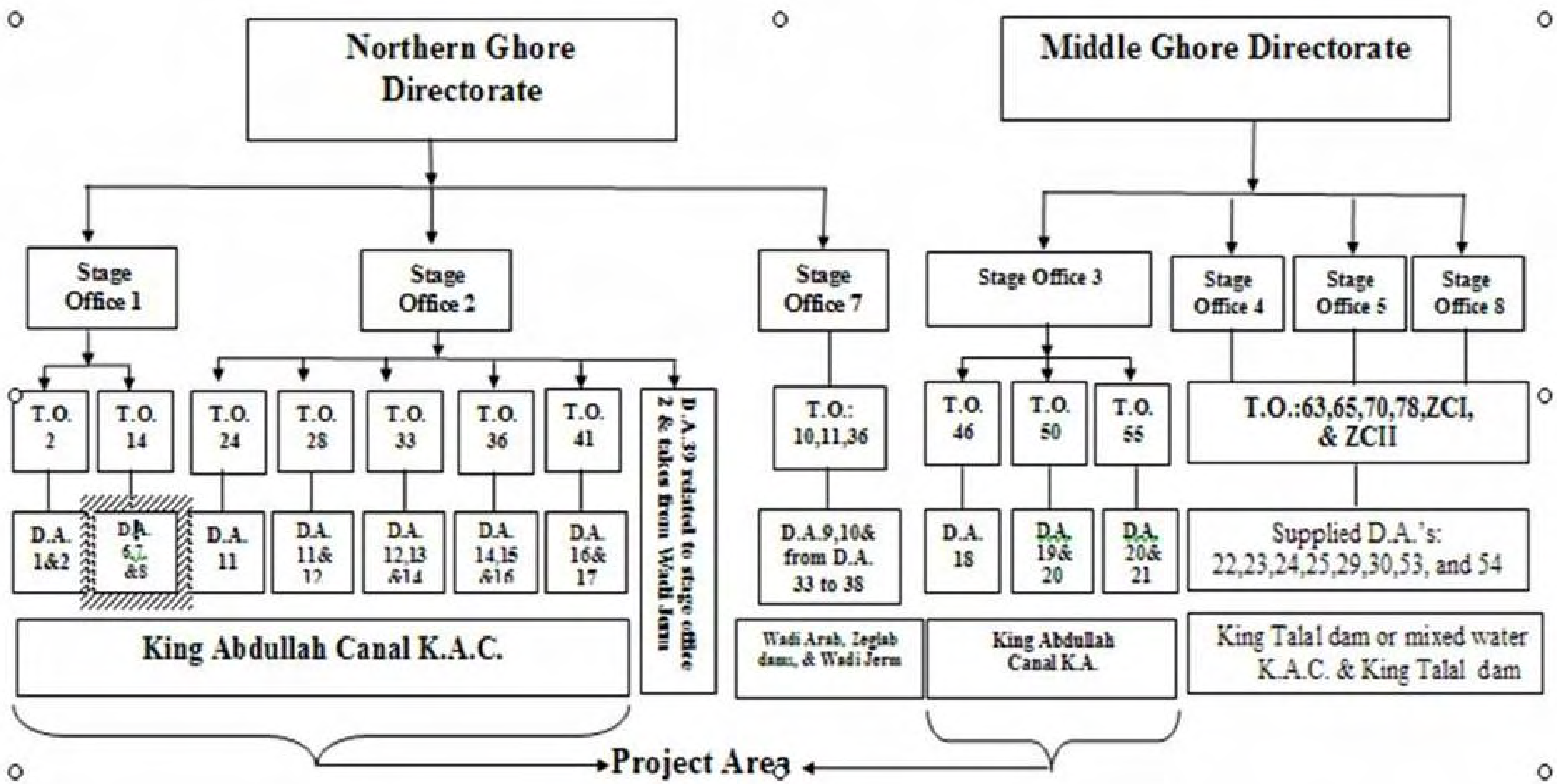


## *Appendix 4: Investment and Cooperation in the Jordanian water sector*

| Funding government or agency | Project name | Amount (US$ millions) |
|---|---|---|
| USA Government-Investments | Desalinization plant and conveyor in Zara-Main spring (Shore of the Dead Sea) 55 Mm3/yr. | 104 |
| | Partial funding of Greater Amman Supply system project | 80 |
| | Rehabilitation of the As Samra treatment plant (donation) | 75 |
| | Transfer of water from the Wehdah dam to irbid (USAID or Japanese government) | 70 |
| | Rehabilitation of various treatment plants (Wadi Mousa, Mafraq, Aqaba) | 37.5 |
| USA Government-technical cooperation | Public awareness program on water uses in agriculture | 12 |
| | Water treatment plant for hotels on the Dead Sea shores | 10 |
| | Public awareness program on water uses in cities | 10 |
| | Optimization of irrigated agriculture (KAFAA') | 8 |
| | Support to financial accounting systems of WAJ and MWI | 3.7 |
| | Wadi Mousa abd southern directorate management contract | 2.2 |
| | JVA Strategic planning | 1.7 |
| | Project management Unit audits | 1.5 |
| | Technical cooperaion supporting WAJ for well's metering and 2002 by-law implementation in the Jordanian Highlands | |
| | Formation of public water company in Aqaba | |
| | Training programs in JVA, WAJ and MWI | |
| German government-Investments | Rehabilitation and extension of waste water treatment plant in Irbid | 127 |
| | Waste water conveyor from Amman to As-Samra treatment plan | 55 |
| | Partial funding of Greater Amman Supply system project | 38 |
| | Partial funding of the doubling of the capacity of conveyor JV-Amman | 27 |
| | Water losses reduction programs in Jerash and Irbid | 19 |
| | Rehabilitation of treated waste water plant in karak | 9 |
| German government-tehnical cooperation | Management support to northern directorates' water administrations (WAJ) | 17.8 |
| | Reuse of TWW in agriculture | |
| | Improvement of irrigation efficiency, formation of WUA in the Jordan Valley | |
| | Strategic planning support-National water master plan | |
| Japanese government-investments | Partial funding of Greater Amman Supply system project + Partial funding of the doubling of the capacity of conveyor JV-Amman | 70 |
| | Rehabilitation of water network in Zarqa | 14.5 |
| | Deselinization plant in Abu-Zighan (13 Mm3/yr.) | 5 |
| | Waste water treatment plant development | |
| Japanese government-technical cooperation | Partial funding of Greater Amman Supply system project | 149.2 |
| | Preparation of a National water master plan | |
| | Training programs in JVA, WAJ and MWI | |
| Arab countries government | Wehdah dam project on the Yarmouk river | 145 |
| | Desalinization and transfer of water from Mujib, Zara and Maïn springs | 100 |
| | Construction of the Wadi Mujib dam (35 Mm3/yr.) | 66 |
| | Construction of the Wala dam | 30 |
| Italian government | Waste water treatment plant rehabilitation projects (Naur, Jerash, Talbieh Suknheh) | 37 |
| | Partial funding of Greater Amman Supply system project | 31 |
| French government | Waste water treatment plant rehabilitation projects (Ramtha, Balqa, Maan) | 15.2 |
| | Extension of LEMA contract for the management of Amman water utilities | |
| | Technical assistance to JVA to optimize irrigation practices in the JV | |
| Canadian government | Waste water treatment plant in the JV | 4 |
| | IRDC support to a FOEME project on the Dead sea area | |
| World bank | Reduction of water losses programs | |
| European Commission and Eurobean Investment bank | Total | 250 |
| | Partial funding of Greater Amman Supply system project | 47 |
| | Karak and Tafileh drinking networks extension | 16.5 |
| | Project management Unit audits | 6 |
| United Nation Development program | Small scale water development and environmental projecrs (GEF Azraq wetland conservation project) | |
| | Institutional support (meeting of all donors of the water sector) and common technical recommendations | |
| Multi-funding | Feasability study for the Dead Sea-Red Sea project | 10 |
| Private participation | DISI-Amman conveyor | 730 |
| | As Samra Treatment plant rehabilitation | 170 |
| Non-yet funded project | Jordan Rift Valley Improvement Project (JRVIP) | 55 |
| | Desalinization plant in Aqaba | 14 |
| | Southern ghors rehabilitation project | 11 |
| | Hisban Kafrein triangle rehabilitation project | 10 |
| | KAC rehabilitation | 5 |

Appendix 5. Organisation chart of the Jordan Valley Authority






ZCI: Zarqa Carrier I.
ZCII: Zarqa Carrier II.

*Appendix 6. Crop water requirement (in mm/day) as presented in the Baker and Harza Study of 1955 and originally used to calculate irrigation quotas in the Jordan Valley (left panel: south of the Jordan Valley, right panel: north of the Jordan Valley)*

| | Vegetables | Citrus | Bananas |
|---|---|---|---|
| January | 1,1 | 0,9 | 1,9 |
| February | 1,4 | 1,1 | 2,3 |
| March | 1,9 | 1,5 | 3,0 |
| April | 2,1 | 1,7 | 3,4 |
| May | 2,6 | 2,1 | 4,2 |
| June | 3,0 | 2,4 | 4,9 |
| July | 3,0 | 2,5 | 4,9 |
| August | 2,9 | 2,3 | 4,7 |
| September | 2,4 | 2,0 | 4,0 |
| October | 2,1 | 1,7 | 3,4 |
| November | 1,7 | 1,4 | 2,8 |
| December | 1,4 | 1,2 | 2,3 |

| | Vegetables | Citrus | Bananas |
|---|---|---|---|
| January | 0,3 | 0,3 | 0,6 |
| February | 0,6 | 0,5 | 0,9 |
| March | 1,2 | 1,0 | 2,0 |
| April | 2,1 | 1,7 | 3,4 |
| May | 2,5 | 2,1 | 4,1 |
| June | 2,9 | 2,3 | 4,7 |
| July | 2,9 | 2,4 | 4,8 |
| August | 2,9 | 2,3 | 4,6 |
| September | 2,5 | 2,0 | 4,0 |
| October | 2,1 | 1,7 | 3,4 |
| November | 1,2 | 1,0 | 2,0 |
| December | 0,5 | 0,4 | 0,9 |

*Appendix 7. Crop and region wise irrigated area in the Lower Jordan River Basin.*

| Net irrigated areas (ha) in the Jordan Valley* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DoS (2005) | | | | Satellite imagery analysis | | | |
| | North Valley | Middle Valley | South Valley | Total | North Valley | Middle Valley | South Valley | Total |
| **Tree crops** | **6,236** | **1,169** | **1,490** | **8,894** | **7,932** | **2,101** | **1,630** | **11,623** |
| Olive | 385 | 76 | 152 | 612 | 459 | 142 | 153 | 755 |
| Citrus | 5,408 | 679 | 390 | 6,477 | 6,805 | 1,192 | 197 | 8,195 |
| Bananas | 216 | 7 | 728 | 951 | 306 | 50 | 1,138 | 1,494 |
| Grapes | 23 | 65 | 16 | 104 | - | 339 | - | 339 |
| Dates | 26 | 256 | 192 | 474 | - | 186 | - | 186 |
| Others | 179 | 86 | 12 | 276 | 361 | 186 | 142 | 689 |
| Seasonal crops | 4,347 | 7,229 | 3,231 | 14,807 | 3,906 | 5,689 | 1,772 | 11,367 |
| Barley and Wheat | 1,190 | 1,241 | 446 | 2,877 | 1,652 | 908 | 350 | 2,901 |
| **Vegetables** | **3,158** | **5,987** | **2,786** | **11,931** | **2,254** | **4,781** | **1,422** | **8,457** |
| **Total** | **10,583** | **8,397** | **4,721** | **23,701** | **11,838** | **7,790** | **3,402** | **23,030** |

* Land use analysis through satellite imagery underestimates vegetable cropped areas while it overestimates orchards plantation.

| Net irrigated areas (ha) in the Highlands of the Lower Jordan River Basin * | | | | | |
|---|---|---|---|---|---|
| | | Annual Crops | Deciduous Trees | Non-deciduous Trees (mainly olive trees) | Total |
| Eastern Desert Area | Area | 2,003 | 4,003 | 5,984 | 11,990 |
| | Percentage | 17 | 33 | 50 | 100 |
| Upper Yarmouk Area | Area | 609 | 0 | 0 | 609 |
| | Percentage | 100 | 0 | 0 | 100 |
| Transition Area | Area | 61 | 427 | 155 | 643 |
| | Percentage | 10 | 66 | 24 | 100 |
| Suburban Area[##] | Area | 51 | 411 | 27 | 489 |
| | Percentage | 10 | 84 | 6 | 100 |
| Uplands Area | Area | 3,391 | 24[#] | 15 | 3,431 |
| | Percentage | 99 | 1 | 0 | 100 |
| Zarqa River Area | Area | 241 | 252 | 606 | 1,099 |
| | Percentage | 22 | 23 | 55 | 100 |
| Total | Area | 6,357 | 5,118 | 6,786 | 18,261 |
| | Percentage | 35 | 28 | 37 | 100 |

* Net irrigated areas have been calculated assuming that 75% and 85% of the gross irrigated areas of trees and vegetables are effectively irrigated, respectively.

[#] Areas of irrigated orchards in the Jordanian Uplands have been highly underestimated. The dense vegetation along Side Wadis makes it difficult to differentiate irrigated and rainfed trees through satellite imagery analysis. Many small orchards (figs, almonds, apricots, cherry, and pomegranates) are supplementary irrigated through earth channels running along side the Side Wadis streams (Figure 5-19).

[##] Irrigated areas in the suburban region have been highly underestimated. Periurban horticulture and vegetable farming (open field or greenhouses) are largely spread but such irrigated areas have not been classified through satellite imagery analysis.

# *Appendix 8. Technical Characteristics of the main production systems of the LJRB*

| | Vegetables in open field | Vegetables under greenhouses | Stone fruit trees | Bananas orchards | Citrus orchards | Olive trees orchards |
|---|---|---|---|---|---|---|
| **Climatic conditions** | Nothing particular | Nothing particular | Do not withstand very high temperature in summer | Do not withstand cold wheater in winter | Do not withstand cold wheater in winter | Do not withstand very high temperature in summer |
| **Location** | The entire basin | The entire basin | highlands | Jordan valley only | Jordan valley only | highlands and northern valley |
| **Initial investments** | **Low to medium** (irrigation systems, mulch...) | **High** (Greenhouses, irrigation system, mulch...) | **Very high** (Plantation, irrigation system…)/Profitability delayed | **Very high** (Plantation, irrigation systems...) | **Medium to high** (Plantation, irrigation System)/profitability delayed | **Medium to high** (Plantation, irrigation System)/Profitability delayed |
| **Annual operational costs (production and wages)** | **Medium to high** (inputs, daily or permanent workers) | **Very high** (seeds, soil fertigation, fertilizers and pesticides, permanent workers) | **Very high** (Inputs and permanents workers) | **Medium** | **Very Low** | **Very Low** |
| **Particular technical skills requirements** | **Low to medium** | **Medium to high** | **High** (modern and 'high-tech' techniques - trees pruning-) | **Low** (there isn't any modern and 'high tech' technologies, there isnt any particular pathologies, no need of particular knowledge) | **Almost zero (there isn't any problem of fungus or other particular pathologies)** | **Almost zero (there isn't any problem of fungus or other particular pathologies)** |
| **Time and management requirement** | **High all the year long** (fine tuning of the irrigation, of fertigation and phytosanitary treatments to free oneself of the risks) CLOSE MANAGEMENT | **Very high all the year long** (fine tuning of the irrigation, of fertigation and phytosanitary treatments to free oneself of the risks)/ CLOSE MANAGEMENT | **Very high, all the year long** (control of irrigation's quality and quantity, of the production's quality, of the employees' work especially at harvesting, of the production marketing)/CLOSE MANAGEMENT | **Very high, all the year long** (control of irrigation's quality and quantity, of the production's quality, of the employees' work especially at harvesting)/CLOSE MANAGEMENT | **Very low** | **Very low** |
| **Inputs requirement** | **High** (fertilizers, pesticides treatments) | **Very high** (fertilizers, pesticides treatments) | **Very high** (fertilizers, pesticide treatments…) | **Very high** (important quantity of fertilizers) | **Very low** | **Very low** |
| **Labour force requirement** | **High all the year long** (seedling, weeding, harvesting and control) | **Very high** all the year long (seedling, weeding, harvesting and control) | **High all the year long** (essentially control) | **Medium** | **Very low** (excepted for the harvest) | **Almost Zero** (excepted for Harvest) |
| **Water quality** | **Low to medium** | **Low to medium** | **high all the year long** | **Very high all the year long** | **Medium** | **Almost zero** |
| **Water quantity** | **Medium** | **Medium** | **high all the year long** | **Very high all the year long** | **High** (notably in summer) | **Very low** |
| **Irrigation's fine tuning** | **Very high** during the 8 months-cropping-season | **Very high** during the 8 months-cropping-season | **Very high all the year long** | **Very high all the year long** | **Medium** (notably in summer) | **Very low** |
| **Risks inherent to the production system** | **Very high** (crops sensible to vagaries, losses can be important) | **High** (even if greenhouses allow softening the risks). Need of a close management to avoid important losses. | **High** (risky production system, need of a fine tuning to insure the quality and the quantity of the production ) | **Vvery Low** | **Low** | **Almost zero** |
| **Profitability ($/dunum/year)** | **Low to medium** | **High** | **Very high** | **Very high** (particular marketing conditions in Jordan with customs duties) | **Very Low** (since the mid of the 1990s) | **Very Low** |
| **Prices of production** | Fluctuating and low | Fluctuating and medium | Stable and high | Stable and very high | Stable but low | Fluctuating and very low |
| **Marketing conditions** | Difficult (overproduction + problems of quality) | Medium (periods and quality of production more favourable than in open field) | Good (if time is granted to post harvest work) | Very good | Difficult (overproduction + problems of quality) | Difficult (overproduction) |

*Appendix 9. Main Strategies of different kinds of farmers according to their location*

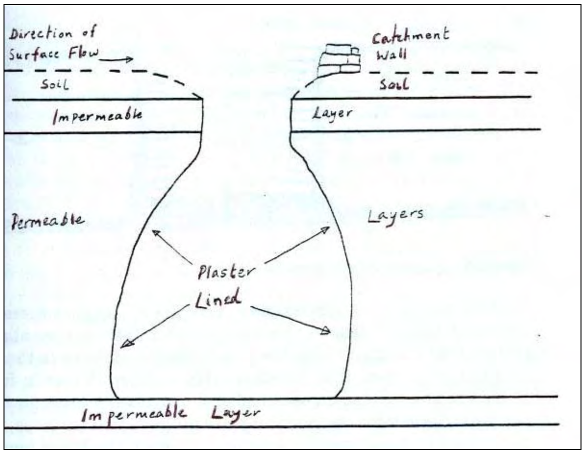
| | | |
|---|---|---|
| **Farmers's objectives and main characteristics** | Intensive entrepreneurial farmers | The entrepreneur often belongs to a Jordanian family of Palestinian origin and generally owns the land he manages (few large farms with vegetables under greenhouses in the middle of the Jordan valley are rented). Agriculture is the main activity of the farmer (whose family can be involved in other economic sector) and the entrepreneur is closely involved in farm management: he is dynamic, has good technical skills and agronomical knowledge; and gives precise directives to his qualified employees. Money is not a limiting factor and the farmer invests in costly, risky, labour and skills-intensive techniques to maximize his revenue. Most the added value is obtained thanks to good post-harvest work and good marketing strategies to export high-value products to the Gulf or even Europe. |
| | Absentee entrepreneurial farmers | Those entrepreneurs can only be found in the Highlands of the LJRB. They are capitalist investors and part time farmers aiming at makink their capital yield. Agriculture is a secondary source of revenue for them. They invest in the same costly techniques than intensive entrepreneurial farmers but farm management is looser (the entrepreneur does not want to invest his time or his energy) and economic results slightly lower. |
| | Absentee owners | Those farmers are absentee investors who want their capital to yield. They are part time farmers without any agricultural skills: for them, agriculture is a secondary source of revenue. They invest in stable, non-risky and low profitable systems that are easily manageable by un-skilled employees. They do not want to invest time or money in a farm they principally enjoy for the social and prestige value it gives them. |
| | Family farmers | Those farmers aim at implementing farming systems yielding revenues high enough for their household with their own workforce. They aim at a balance between maximizing revenues and minimizing risks through close management of the farm. They are full time farmers: agriculture is their main activity but they diversify their practices (different crops, livestock etc...) and some members of the family often have other sources of revenues (a pension of civil servant for the olders, a waged salary for the younger, a shop or a bus etc.). Farming systems are very diverse and depend on the financial capacities of the family who can not invest in very productive techniques. Farmer's lack techical skills, and the management of the fram remain sub-optimal. |
| | Poor farmers | Those farmers aim at optimizing the family workforce to cope with insecurity and poverty. They are family farmers doing all the field work in a farm they generally sharecrop and do not have the financial abilities to modernize their low profitable farming systems. |

| Type of Farmer | Location and importance in the region considered | Strategies developed by the different kinds of farmers* | | |
|---|---|---|---|---|
| | | First choice | Second choice | Third choice |
| **Intensive entrepreneurial farmers** | **North of the valley (10%)** | Bananas with drip irrigation and high level of fertilizer | Vegetables for export under greenhouses | Citrus with plot irrigation, high level of fertilizer, new varieties and frequent renewal of the orchard |
| | **Middle of the valley (40%)** | Vegetables for export under greenhouses | | |
| | **South of the Valley (30%)** | Bananas with drip irrigation and high level of fertilizer. Very intensive way of cropping | Vegetables for export under greenhouses and in open field | |
| | **Highlands (25%)** | Stone or pipes fruit plantation with drip irrigation and high level of fertilizer | Vegetables for export under greenhouses | |
| | | | | |
| **Absentee entrepreneurial farmers** | **North of the valley** | There is no farmer of this kind in this area | | |
| | **Middle of the valley** | | | |
| | **South of the Valley** | | | |
| | **Highlands (10%)** | **Eastern desert: ½ Stone fruits and ½ of olive trees/loose management** | Renting out or sharecropping | |
| | | **Upper Yarmouk, Transition and Suburban Areas: vegetables under greenhouses/loose management** | | |
| | | | | |
| **Absentee owners** | **North of the valley (40%)** | Citrus with surface irrigation with a low level of fertilizer | Renting out | Wheat and olive orchards |
| | **Middle of the valley (20%)** | Citrus with surface irrigation with a low level of fertilizer | Renting out | Wheat |
| | **South of the Valley (10%)** | Renting out | | |
| | **Highlands (25%)** | ½ Vegetables in open field and 1/2 of olive trees. loose management | Very large plantation of olive trees | Renting out |
| | | | | |
| **Family farmers** | **North of the valley (45%)** | Maximum of bananas trees | Maximum of citrus orchards | A varied production of vegetables in open field |
| | **Middle of the valley (25%)** | Vegetables under greenhouses | Vegetables in open field | |
| | **South of the Valley (45%)** | A maximum of banana trees under drip irrigation/ bananas plantation developed in relation with vegetable crops | Vegetables in open field with a high level of Inputs and work | |
| | **Highlands (25%)** | Stone or pine fruit plantations if the land is in ownership | Vegetables under greenhouses/high level of inputs | Vegetables in open field (+olive tree orchard if land in ownership)/High level of input |
| | | | | |
| **Poor farmers** | **North of the valley (5%)** | Mixed farms (citrus & bananas) | A varied production of vegetables | |
| | **Middle of the valley (15%)** | A varied production of vegetables in open field + wheat +breeding activity. Surface or drip irrigation | | |
| | **South of the Valley (15%)** | Mixed farms bananas-vegetables in open field + breeding activity | A varied production of vegetables in open field + breeding activity | |
| | **Highlands (15%)** | Vegetables in open field + breeding activity | | |

* Widespread strategies are given in red; common strategies in blue and rare strategies in green

*Appendix 10. Different types of spring water management*

Diagram of a cistern (Lancaster and Lancaster, 1999)




Stages of Development of a Spring Aquifer for Irrigation (Ron, 1985:153)

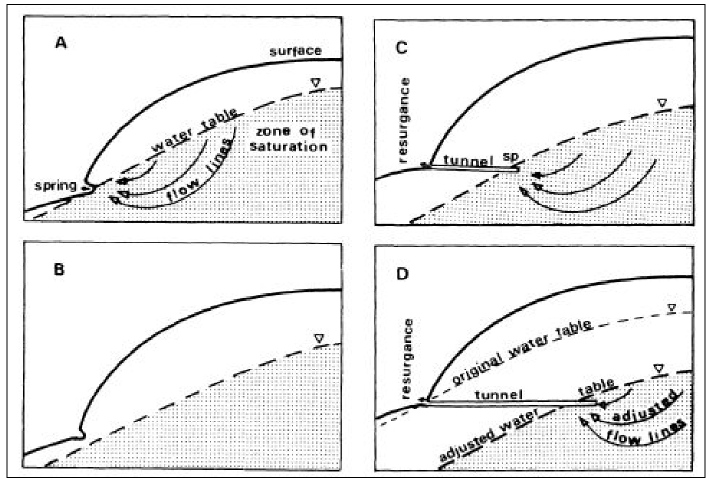



Diagram of a Mahafir (Lancaster and Lancaster, 1999)

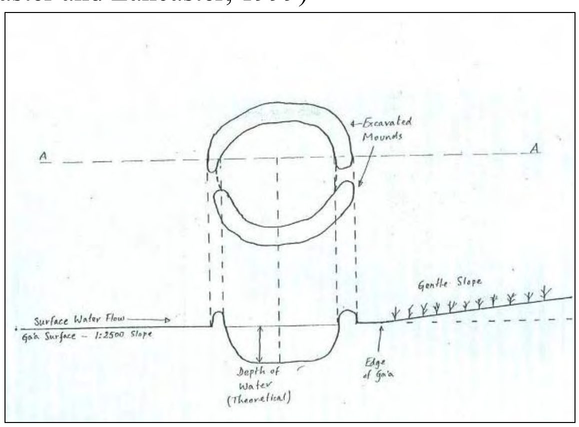
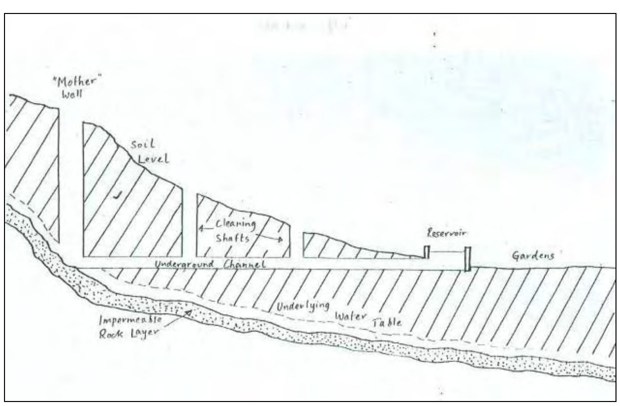



*Diagram of a Fogara (Lancaster and Lancaster, 1999)*



*Appendix 11. Categories of river basin water accounting (Molden et al. 2001)*

* *Gross inflow* is the total amount of water entering into the water balance domain from precipitation, and surface and subsurface sources.

* *Net inflow* is the gross inflow plus any changes in storage.

* *Water depletion* is a use or removal of water from a water basin that renders it unavailable for further use. Water depletion is a key concept for water accounting, as interest is focused mostly on the productivity and the derived benefits per unit of water depleted. It is extremely important to distinguish water depletion from water diverted to a service or use as not all water diverted to a use is depleted. Water is depleted by four generic processes:

* *Evaporation*: water is vaporized from surfaces or transpired by plants.

* *Flows to sinks*: water flows into a sea, saline groundwater, or other location where it is not readily or economically recovered for reuse.

* *Pollution*: water quality gets degraded to an extent that it is unfit for certain uses.

* *Incorporation into a product*: through an industrial or agricultural process, such as bottling water or incorporation of water into plant tissues.

* *Process consumption* is that amount of water diverted and depleted to produce a human intended product.

* *Non-process depletion* occurs when water is depleted, but not by the process for which it was intended. Non-process depletion can be either beneficial, or non-beneficial.

* *Committed water* is that part of outflow from the water balance domain that is committed to other uses, such as downstream environmental requirements or downstream water rights.

* *Uncommitted outflow* is water that is not depleted, nor committed and is, therefore, available for a use within the domain, but flows out of the basin due to lack of storage or sufficient operational measures. Uncommitted outflow can be classified as utilizable or non-utilizable.

Outflow is utilizable if by improved management of existing facilities it could be consumptively used. Non-utilizable uncommitted outflow exists when the facilities are not sufficient to capture the otherwise utilizable outflow.

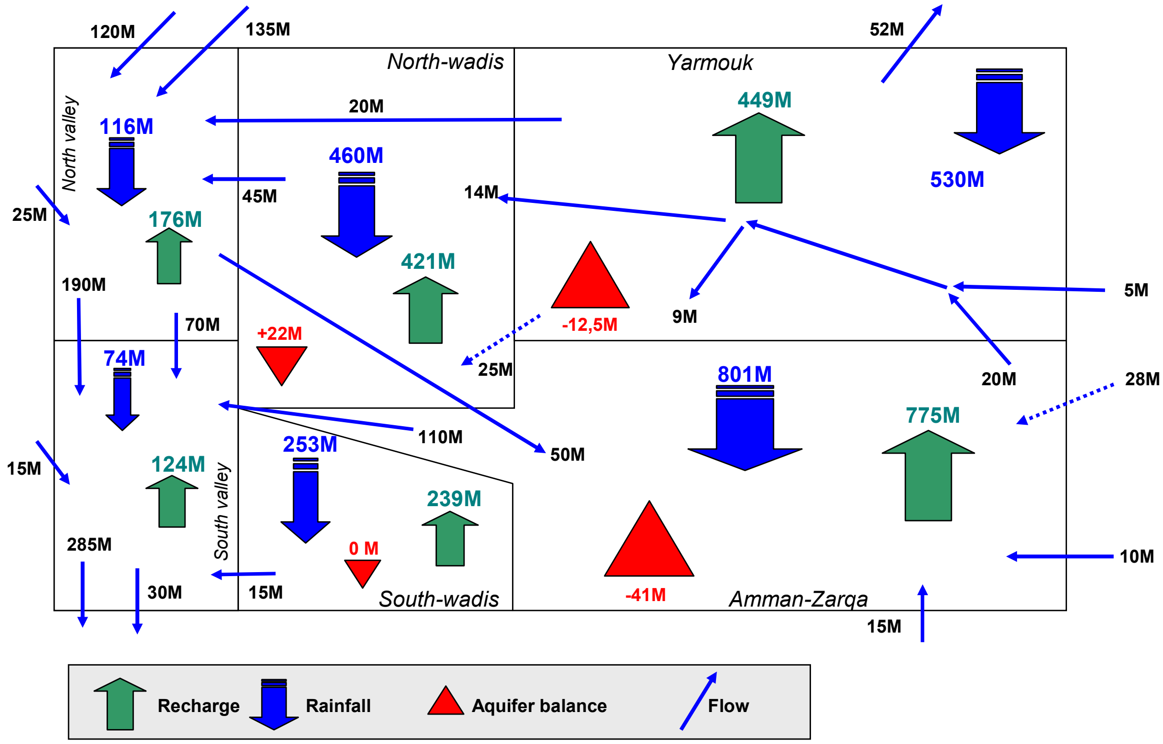
* *Available water* is the net inflow minus both the amount of water set aside for committed uses and the non-utilizable uncommitted outflow. It represents the amount of water available for use at the basin, service, or use levels. Available water includes process and non-process depletion plus utilizable outflows.

* A *closed basin* is one where all available water is depleted.

* An *open basin* is one where there is still some uncommitted utilizable outflow.

* In a *fully committed basin*, there are no uncommitted outflows. All inflowing water is committed to various uses.

*Appendix 12.Inflow and outflows from subbasins considered in the 2000s.*

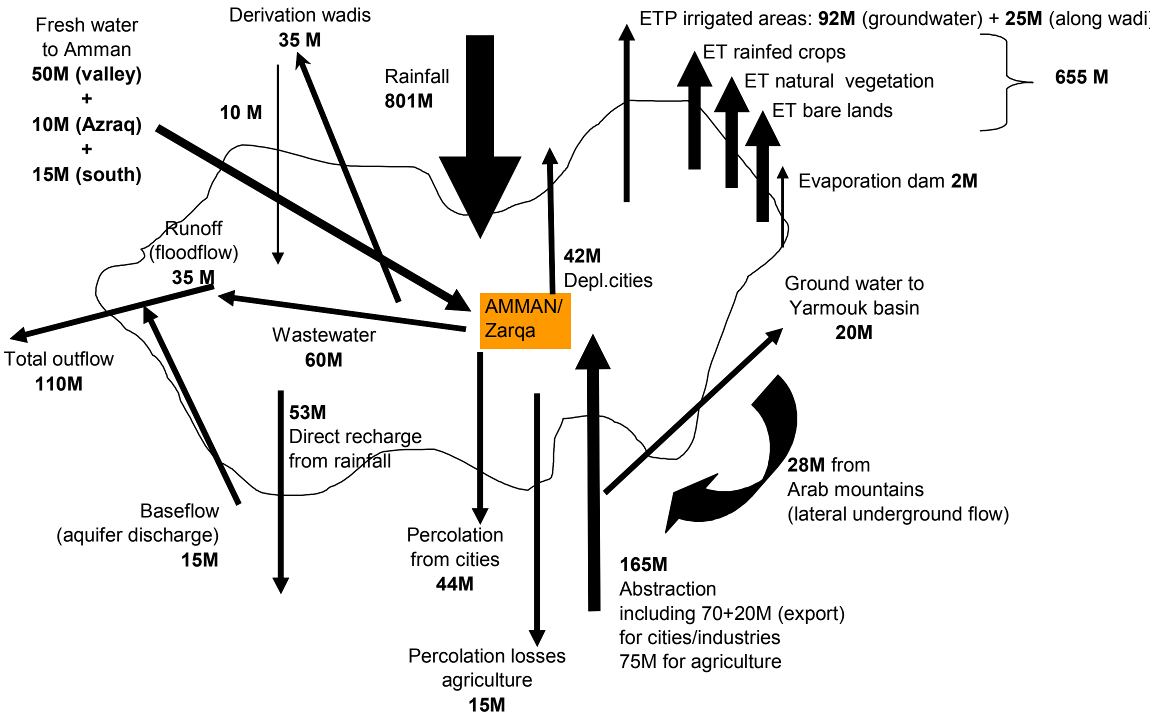



*Appendix 13. Indicators of water mobilization and water use efficiency in the lower Jordan River basin and their evolution on the period 1950-2025.*

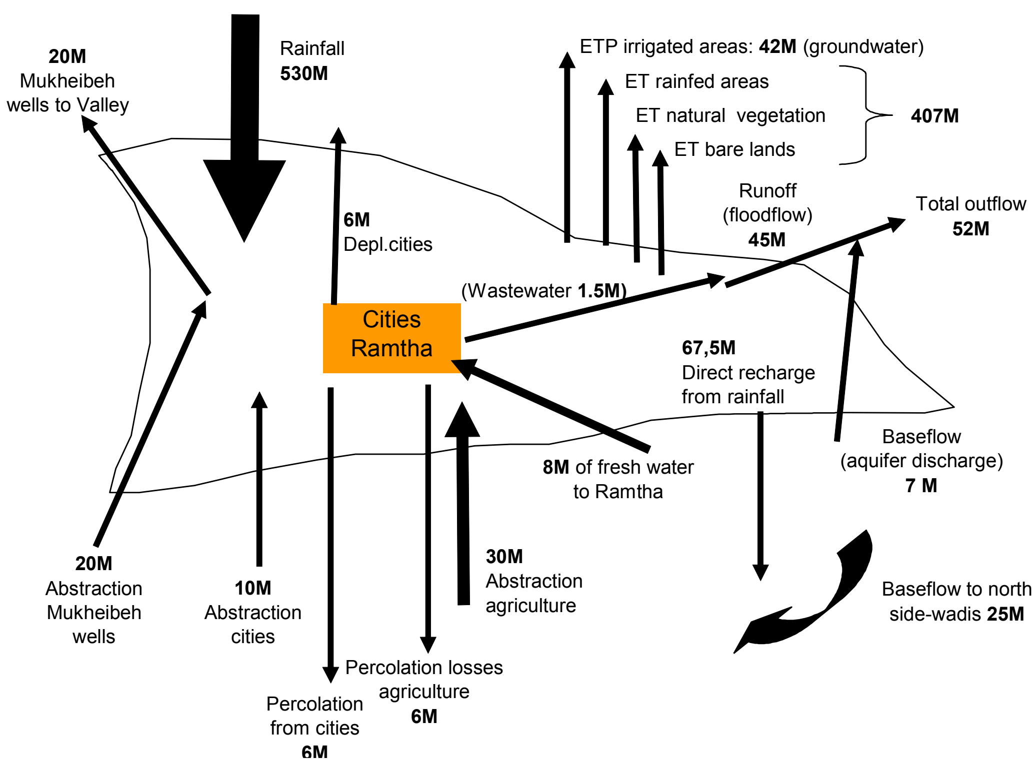
| | 1950 | 1975 | 2000 | 2025 |
|---|---|---|---|---|
| Renewable blue water | 1588 | 833 | 705 | 861 |
| Total uncontrolled Jordan river flow | 1095 | 290 | 160 | 40 |
| Controlled renewable blue water | 493 | 543 | 545 | 821 |
| Controlled surface water | 0 | 15 | 120 | 335 |
| Stream water (uncontrolled diversions) | 95 | 189 | 190 | 125 |
| *Unused stream water* | *1335* | *489* | *252* | *113* |
| Groundwater abstraction | 6 | 110 | 275 | 242 |
| Groundwater imports | 0 | 2 | 30 | 50 |
| Surface surface imports + Red-Dead project | 0 | 0 | 45 | 225 |
| Withdrawals of basin resources | 101 | 314 | 585 | 702 |
| Total withdrawals (with imported water) | 101 | 316 | 660 | 977 |
| Total withdrawals (% of renewable blue water) | 6 | 38 | 94 | 113 |
| Total withdrawals (% of controlled renewable blue water) | 20 | 58 | 121 | 119 |
| | | | | |
| Outflow to the Dead Sea from inner basin (uncontroled Jordan flow excluded) | 190 | 215 | 155 | 125 |
| Total outflow of the basin to the Dead Sea | 1285 | 505 | 315 | 165 |
| | | | | |
| Volume of withdrawals depleted | 54 | 202 | 474 | 717 |
| Groundwater returnflow | 1 | 40 | 89 | 162 |
| Depleted water (% of withdrawals) | 54 | 64 | 72 | 73 |
| Depleted water (% of renewable blue water) | 3 | 24 | 67 | 83 |
| Depleted water (% of controlled renewable blue water) | 11 | 37 | 87 | 87 |

*Appendix 14 Water balances of subbasins in the 2000s.*

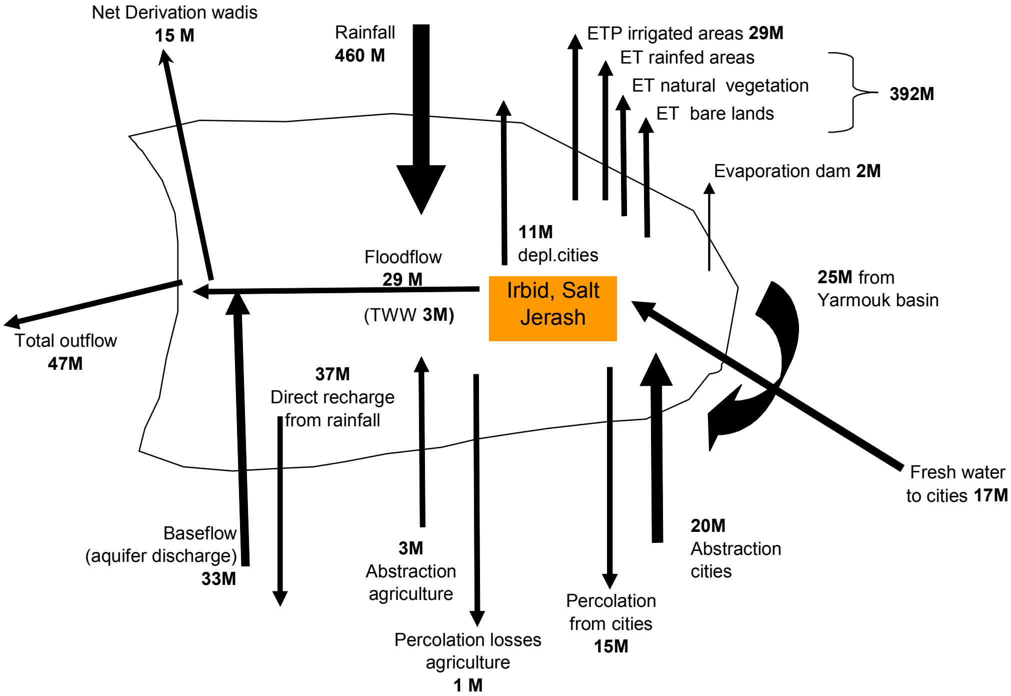
**BALANCE OF ZARQA BASIN**



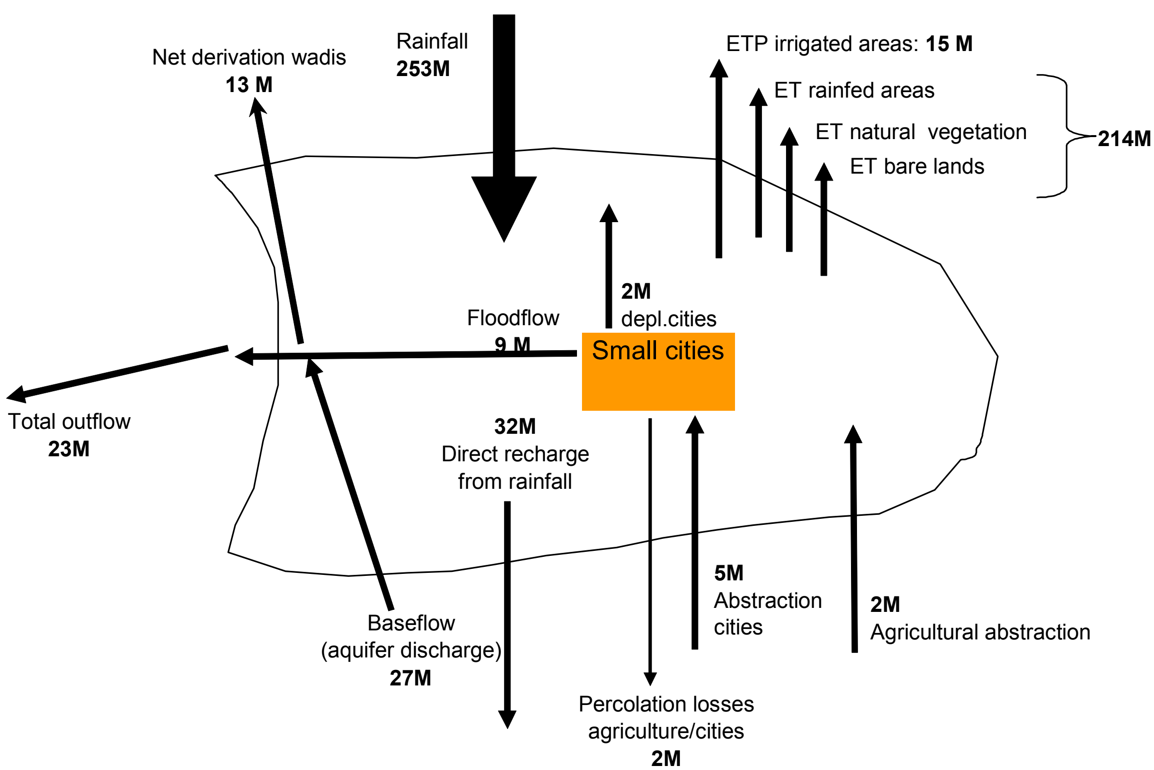

**BALANCE OF YARMOUK BASIN**



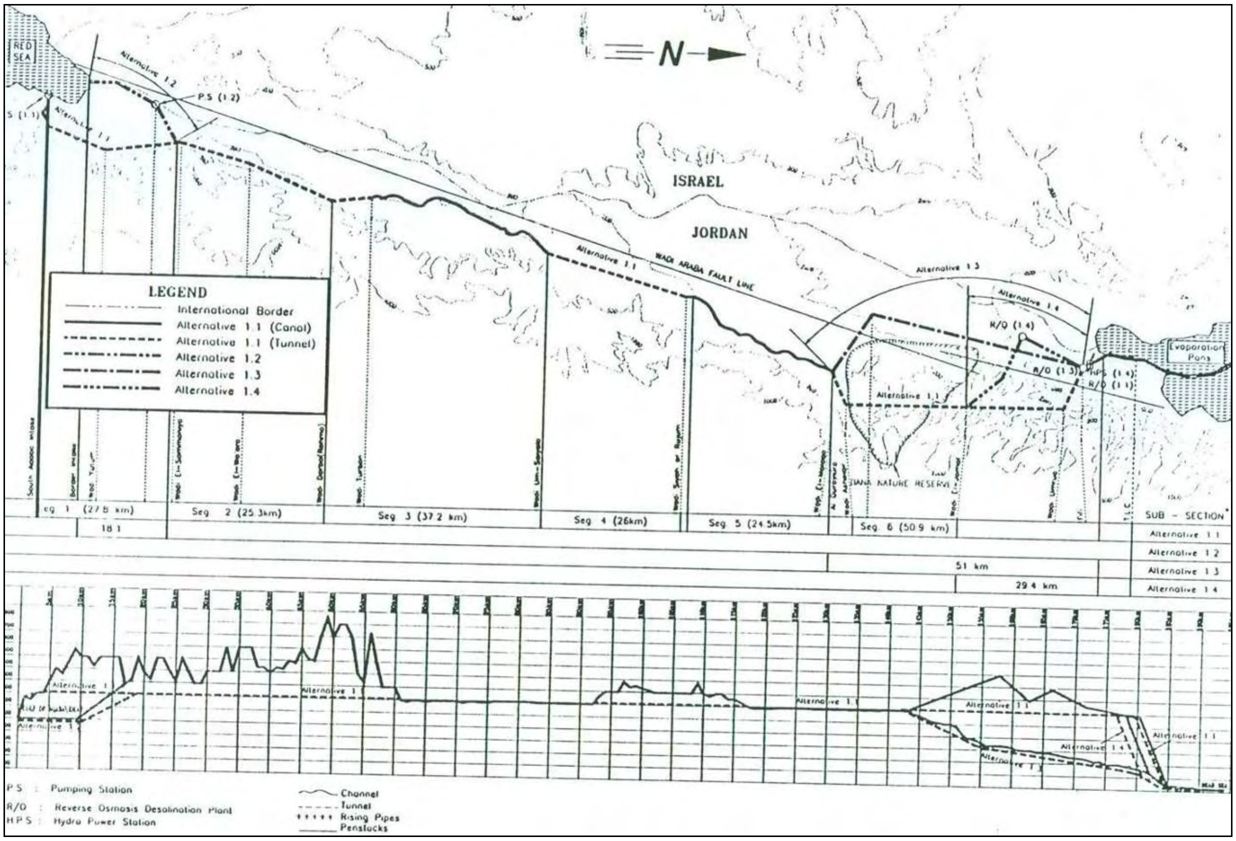
**BALANCE OF NORTH WADIS BASIN**




**BALANCE OFSOUTH WADIS BASIN**



*Appendix 15. Red-Dead Project: one example of alignment of the conveying system (after Harza JRV group, 1998)*




*Appendix 16. Financial impacts of the By-Law No.(85) of 2002 on banana farming systems in the south of the Jordan Valley.*

The Jordan Valley aquifer is brackish with ECw commonly included between 1.5 and 2.5 dS/m (TDS>1,350 ppm) and the by-law rules for brackish water could affect the 350 private wells located in the south of the Jordan Valley. Table 9-1 summarizes water fees for licensed wells, according to different levels of salinity: prices over the 150,000 m$^3$ threshold are homogenous and the highest the salinity, the lowest the fee.

*Table 9-1. Groundwater pricing in brackish aquifers for volumes higher than 150,000 m$^3$/well (bylaw No.85 of 2002; licensed wells)*

| Aquifer salinity | Water costs (\$/m$^3$) |
|---|---|
| TDS<1,350 ppm | Rules for fresh aquifers (chapter 5.3.1) |
| 1,350<TDS<1,500 ppm | 0.02 |
| 1,500<TDS<2,000 ppm | 0.014 |
| TDS>2,000 ppm | 0.007 |

If wells are licensed, most family farmers will not be affected by the by-law (the volumes they pump are lower than 150,000 m$^3$/well if the cropped area is lower or equal to 3.5 ha; and revenues are expected to decrease by a maximum of 2% if cropped area is 5 ha, the maximum observed in the valley). If farmers use a well without license, their revenue could decrease by as much as 11%: they might consider a shift to more intensive techniques or less water consuming crops like date palm trees.

Entrepreneurial farmers often have two wells: impacts of the by law will be negligible to force any adjustments if these wells have a license (farmer's revenue would decrease by a maximum of 3%, depending on the aquifer salinity); but impacts will be much higher (revenues expected to decrease by 14%) if wells have no license and farmers may be willing to intensify their production. In these farms, about three quarters of the area is cultivated in open field vegetables (for soil regeneration purposes between two cycles of banana plantation) that have a very low profitability and are not central for the functioning of the farming system. Entrepreneurial farmers may just let their land fallow between two banana cycles (they would then decrease their water abstraction by 90,000 $m^3$/yr/well and their revenue would decrease by about 3%). Shifting to date palm trees would also be a cost effective strategy (chapter 5.1) but remains contingent to capital availability and farmers' willingness to change. The shift to date palm trees could be progressive and could take place first on fallow (or vegetable) plots, in order to keep the banana plantation profitable until date palm trees reach maturity. Proper market conditions need to be ensured to make a highly demanding production (notably for post harvest activities) profitable and to support farmers who would like to invest in such risky venture.