10 Wells and Canals in Jordan: Can Pricing Policies Regulate Irrigation Water Use?

J.-P. Venot, F. Molle and Y. Hassan

Introduction

The Hashemite Kingdom of Jordan is one of the countries with the scarcest water resources in the world. Due to both physical water scarcity and a high demographic growth during most of the second half of the 20th century it has been estimated that the per capita endowment of renewable blue water (i.e. surface runoff and groundwater recharge) is now only 163 m^3/year, while the average domestic consumption is 94 l/capita/day nationwide (THKJ, 2004).

Most agricultural activities are concentrated in the Lower Jordan River Basin (LJRB) (Fig.10.2), a region of prime importance for the country: it includes 83% of the total population, most of the main industries, and 80% of irrigated agriculture of the country. It is endowed with 80% of the country's water resources and withdrawals in the basin total 75% of those at the national level (Courcier *et al.*, 2005). The bulk of irrigated agriculture is located in two contrasting environments: the Jordan valley, where a public scheme supplies approximately 23,000 ha; and the highlands, which include two groundwater basins of major importance, the Amman-Zarqa and the Yarmouk basins[1] (Fig.10.2), where most of the private tube well-based irrigation that has developed over 14,000 ha in the last 30 years is located.

The main water allocation problems in the LJRB are schematized in Fig. 10.1. Amman receives water from the Jordan valley, local aquifers, and from southern outer basins. To meet its growing water demand, there is a need to: (i) improve inflow from the Yarmouk river (dam); (ii) transfer more water from the valley to Amman (and hence reduce agricultural use, although treated wastewater [TWW] is sent back to the valley); (iii) reduce abstraction from aquifers by highland agriculture in order to preserve water quality, avoid overdraft and reallocate water to cities; and (iv) rely on (costly) imports from southern basins as little as possible.

In the early 1990s, Jordan's officials took the measure of the coming water crisis and policies underwent a paradigm shift from supply augmentation towards demand management. The World Bank and other development agencies were influential in calling for an agenda that

[1] The Amman-Zarqa and Yarmouk groundwater basins are roughly coterminous with the river basins bearing the same names.

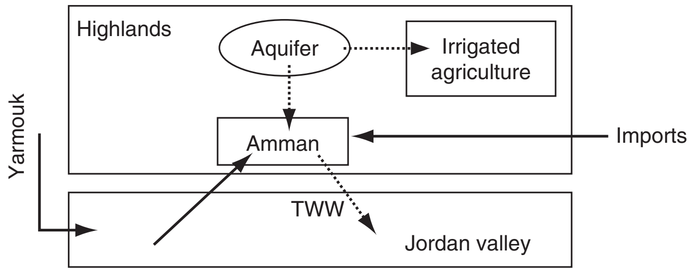

Fig. 10.1. Schematic representation of main water flows in the LJRB.

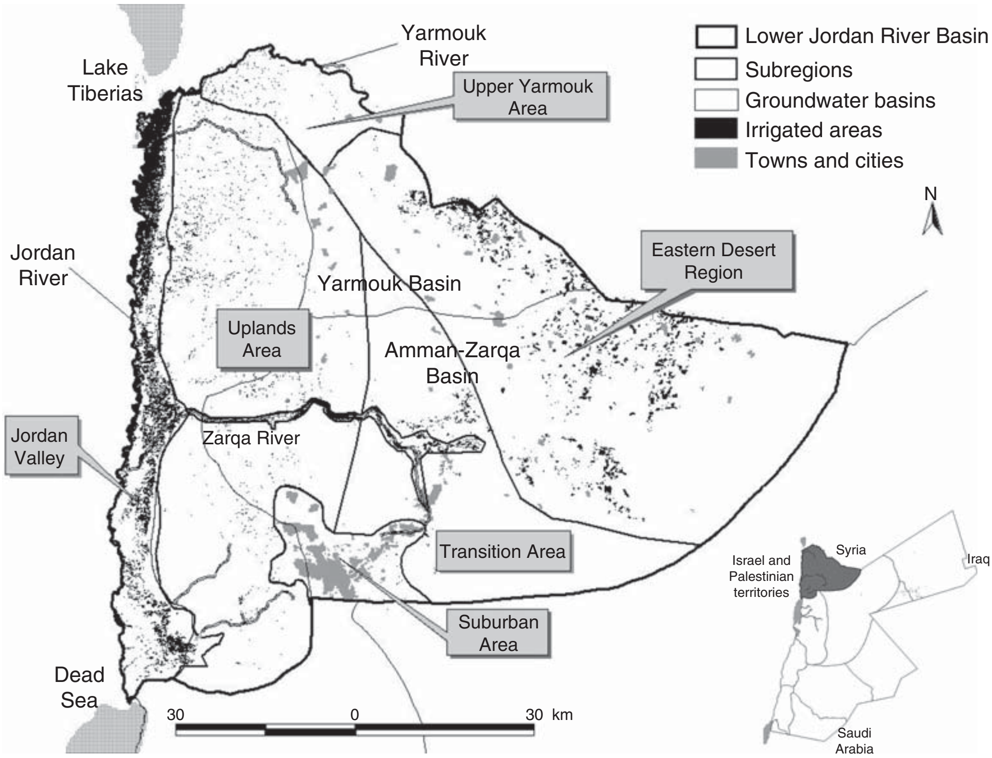

Fig. 10.2. Agricultural zoning of the LJRB (Adapted from Venot, 2004; unpublished land use classification from the Ministry of Water and Irrigation [MWI] and the Deutsche Gesellshaft für Technische Zusammenarbeit [GTZ].)

would include demand management measures and economic instruments to encourage efficient water use, transfer water to non-agricultural 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, 2003).

In the highlands, development of groundwater resources had been 'exacerbated by relaxed controls on drilling operations, and the near absence of controls on licensed abstraction rates' (THKJ and MWI, 1997b, 1998a). High rates of abstraction (up to 215% of the mean annual recharge in the Amman-Zarqa basin) prompted the government to design a new water strategy in 1997. Pricing policies were deemed to assist in controlling groundwater abstraction (with the ambitious task of taking abstraction rates 'close to the annual recharge by the year 2005'[2]) and to elicit shifts towards higher-value crops.

In the Jordan valley, more expensive water was expected to bring about efficiency improvements and a switch to less water-intensive crops, thus releasing water for Amman (World Bank, 2003). 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, 1998b, 2004c; JRVIP, 2001a).

These reforms were to be embedded in the 1994 agriculture sector structural adjustment loan (ASAL) jointly funded by the World Bank and the German KfW and designed with the prime objective 'to support a transition to an optimal use of water and land resources' (ASAL, 1994; World Bank, 2003) and to tackle key problems of the sector: 'the lack of a national water policy, competing sector institutions, and insufficient attention to demand management'. Implementation of these policies proved to be problematic, since part of the government denounced the difficulties that increased agricultural water tariffs would cause and argued that administrative allocation together with efficiency improvement would be more efficient in saving water. Two hot debates arose.[3]

Regarding the highlands, the Groundwater Control By-law No. 85, passed in 2002 and further amended in 2004, was designed to regulate groundwater abstraction through the establishment of a block tariff system, with charging of water use over a threshold of 150,000 m^3/year/well. Regarding the valley, a block tariff system associated with crop-based quotas had been in place for some time and the debate revolved around possible increases in water charges. This chapter examines the rationale, the potential and the current impact of these water pricing policies in these two environments, and attempts to answer the following questions:

- What will be the likely impacts of the application of the by-law in the highlands?
- What will be the financial impact of increasing water prices in the valley, so as to cover O&M or capital costs?
- What is the likelihood of success of such policies in terms of water saving and raising economic efficiency, and what alternatives are available to meet these objectives?

In both the highlands and the valley, a typology of farming systems was established with the intent to discriminate the impact of policies on different types of farms and to assess what could be farmers' adjustments and responses in each case. Regional data aggregation then provided a wider picture of the water savings to be achieved, and of the financial impact on both farmers and the state. These results are developed in the final section, which discusses the disjuncture between expected and actual or estimated outcomes, points to commonalities and discrepancies between the two regions, and identifies measures which can improve the regulation of the water sector in Jordan.

Farming Systems in the Two Study Areas

Context

With the outflow of the Jordan river from Lake Tiberias virtually blocked by Israel, the lower Jordan river chiefly receives the water from its main tributary, the Yarmouk river. Several temporary streams of lesser importance named 'side-wadis', as well as the larger Zarqa

[2]This target was revised in 2004 and shifted to 2020 (Pitman, 2004).

[3]Opposition to higher water tariffs led to the occupation of the Parliament floor and further intervention by His Majesty the King (Pitman, 2004).

river, also incise the two mountainous banks and feed the valley: the valley is a 115 km long fertile plain located 300 m below sea level and where irrigation schemes have been built.

The highlands are composed of a mountain range running alongside the Jordan valley and of a desert plateau extending easterly to Syria and Iraq. While rain-fed cereals are grown near the mountains, precipitations become scarcer more to the east where only nomadic Bedouin livestock farming can be found, with a few localized plots of groundwater-based irrigated agriculture. The eastern desert region overlaps the Amman-Zarqa and the Yarmouk groundwater basins (cf. Fig. 10.2).

Irrigation is traditional in Jordan along the side-wadi valleys and on their alluvial fans spread in the Jordan valley itself, or wherever springs are available. Large-scale public irrigation dates back to the establishment of the Jordan Valley Authority (JVA) and to the construction, between 1958 and 1966, of the main 69 km long concrete canal – the King Abdullah Canal (KAC) – which parallels the river on its eastern bank. In 1962, a land reform led to the formation of thousands of small intensive farms (3.5 ha on average), and the settlement of numerous families, including Palestinian refugees (Khouri, 1981; van Aken, 2004). During the same period, several governmental projects aiming at settling Bedouins were implemented in the highlands and later gave way to a modern market-oriented agriculture developed by small to medium entrepreneurial farmers supplying growing cities and exporting their surplus around the Middle East (Elmusa, 1994; Nachbaur, 2004; Venot, 2004).

The heyday of irrigated agriculture was observed in the 1980s and early 1990s. In the Jordan valley, irrigation facilities were expanded and improved by the government, and modern irrigation and cropping techniques (greenhouses, drip irrigation, plastic mulch, fertilizer, new varieties, etc.), together with cheap labour from Egypt, became widely available. In the highlands, energy costs decreased and well-drilling techniques improved while land was cheap, fertile and not prone to diseases. During this period, agricultural revenues increased tenfold for vegetables and more than doubled for fruits: irrigated agriculture in Jordan enjoyed a boom in production and economic profitability that was described by Elmusa (1994) as the ‘Super Green Revolution’.

With the growing competition from surrounding countries in the 1990s (Turkey, Lebanon and Syria) and the loss of the Gulf export market, the profitability of Jordanian agriculture decreased, strongly affecting farmers’ revenue (Fitch, 2001; Jabarin, 2001) and taking the sector’s contribution to the country’s GDP down to 3.6%. Freshwater is increasingly transferred from irrigated agriculture (in the valley) to urban uses (in the highlands), affecting the agriculture sector which receives ever-decreasing quantities of water and becomes more vulnerable to droughts (Courcier *et al.*, 2005). In exchange, agriculture in the southern part of the valley is increasingly supplied with treated wastewater (McCornick *et al.*, 2001, 2002; THKJ *et al.*, 2002; JICA, 2004; THKJ and MWI, 2004b).

This chapter focuses on two main regions of the LJRB: (i) the eastern desert area (the only region of the LJRB highlands to be concerned by the by-law); and (ii) the northern and middle directorates of the Jordan valley (where JVA management rules apply). The total irrigated area in the eastern desert region totals 11,835 ha; 50% of this area is planted with olive trees, 34% with stone fruit trees (peach and nectarine trees essentially) and 16% with vegetables. In the northern and middle directorates of the Jordan valley, the irrigated area totals 19,345 ha, with 43% of vegetables, 42% of citrus, and the remainder of banana and cereals.

Farming system characterization

Farming systems were analysed in order to identify the different types of farms found in the valley and in the highlands. Understanding the socio-economic processes occurring at this microscale will allow us to better foresee the adjustments and the strategies developed by farmers in a changing context and the impact of water pricing policies on farmers. By complementing this microlevel analysis with regional data (statistic data, satellite image analysis) we can assess the possible evolution of regional irrigated agriculture as a whole.

Extensive farm surveys were carried out in the highlands by USAID/ARD in 2000/2001 (Fitch, 2001), but economic analyses were based on cropping patterns. This makes it difficult to discriminate responses by type of farmer. In order to sketch out farming systems that combine typical cropping patterns with socio-economic characterization (profile of the farmer, land tenure, labour use, costs, etc.), 30 in-depth farm surveys were carried out during the spring of 2003. Farming systems were then modelled in economic terms based on crop budgets whose consistency with USAID/ARD data was checked. Likewise, the main farming systems in the Jordan valley were identified and their economics modelled based on 50 farm surveys carried out also during the spring of 2003, and on other studies (ARD and USAID, 2001b; JRVIP, 2001c).

The highland surveys led to the identification of three main categories of farming systems (Table 10.1; a detailed description can be found in Venot *et al.*, 2007). 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. The main differences between these farming systems are the degree of capital use and intensification, and the direct/indirect type of management.

Generally speaking, farming systems in the Jordan valley are more intensive than in the highlands: farms are smaller (3.5 ha on average against 20–25 ha in the highlands) and net benefit per hectare (for similar crops and/or farming systems) is generally higher. The survey identified five main categories of farming systems (Table 10.2). They include family farmers who either own or rent the land and grow vegetables in open fields; entrepreneurial farmers who adopt capital- and labour-intensive techniques like greenhouses with a high return on investments; 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 economic value of their farm; highly profitable bananas grown in the extreme north of the valley; and, finally, some poorer farmers with more extensive vegetable cultivation, associated with small orchards.

Control of Groundwater Overabstraction in the Highlands

The problem of groundwater overdraft

Since the 1930s, when the first wells were dug in the Azraq oasis, to the present, groundwater abstraction in the highlands has increased to meet the needs of agriculture, industries and cities, although the part of agriculture has decreased in both absolute and relative terms in the last decade. According to the official figures of the MWI for 2004, total groundwater abstraction in the LJRB reached 248 Mm^3, of which about half was used in agriculture (THKJ, 2004). In the highlands, in the Amman-Zarqa and Yarmouk groundwater basins, local groundwater abstraction reached 215% and 125% of the annual recharge, respectively. Taking return flows from municipal/industrial and irrigation uses into account, the overall net depletion of these aquifers comes down to 159% and 98% of their annual recharge, respectively.

The resulting drawdown of the aquifer is paralleled with a decline in water quality (due to increasing salinity and use of fertilizers and pesticides) 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; JICA, 2004). 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).

Groundwater policies and by-law No. 85 of 2002

Faced with such problems the Government of Jordan has tried to reorient its water policy through the Water Strategy Policy of 1997.

Table 10.1. Profile of main farming systems (highlands, eastern desert region).

	Settled Bedouins			Stone fruit tree entrepreneurs		Absentee owners	
	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
Land tenure/ water access	Rent	Ownership	Ownership	Ownership	Ownership	Ownership	Ownership/ Rent
Farm area range (ha)	20–25	(20–25+10–15)	10–20	25–35	40–80	15–35	20–25
Net benefit (US$/ha/yr)	1,100	621	6,900	16,000	14,850	300	600
Net benefit (US$/farm/year)	24,750	21,750	103,500	480,000	891,000	7,500	13,500
Number of wells	1	1	1	1	2	1	1

Table 10.2. Profile of main farming systems (Jordan valley, northern and middle directorates).

Farming systems	Open-field vegetable family farms	Entrepreneurial greenhouse farms	Citrus farms		Banana farms		Poor farmers
			Family farms	Absentee owners' farms	Family farms	Entrepreneurial farms	Mixed farms
Land tenure	Rent/ Ownership	Rent/ Ownership	Ownership	Ownership	Ownership	Ownership/ Rent	Rent/ Sharecropping
Farm area range (ha)	3–6	6–10	3–6	1–20	1–5	1–5	1–3
Number of family workers	2–5	1–2	3–5	1	3–5	1–2	4–10
Net benefit (US$/ha/year)	3,800	7,500	1,250	400	7,000	12,500	1,050
Net benefit (US$/farm/year)	17,100	60,000	5,625	4,000	21,000	37,500	2,100

Table 10.3. Water prices according to the volume abstracted in private agricultural wells. (From THKJ and MWI, 2002b, 2004a as mentioned in by-law No. 85 of 2002.)

Quantity of water pumped	Water prices in wells with former abstraction license – 2002 by-law	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	JD0.025/m^3 ($0.035)
101,000 to 150,000 m^3	Free	Free	JD0.030/m^3 ($0.042)
151,000 to 200,000 m^3	JD0.025/m^3 ($0.035)	JD0.005/m^3 ($0.007)	JD0.035/m^3 ($0.050)
More than 200,000 m^3	JD0.060 /m^3 ($0.085)	JD0.060/m^3 ($0.085)	JD0.070/m^3 ($0.098)

Several measures have been taken to decrease groundwater abstraction, including: (i) freezing of well-drilling authorizations in 1992; (ii) implementation of a tax of $0.35/$m^3$ for any water pumped and sold/used for industrial or aesthetic purposes (since 1994) as well as for domestic purposes (since 2002); (iii) a campaign to equip private wells with water meters; (iv) reduction of losses in urban networks; (v) promotion of less water-intensive/high-value crops; and finally (vi) promulgation of the groundwater by-law No. 85 of 2002 (Chebaane *et al.*, 2004). Government policies called for a massive reduction in abstractions by highland pumpers by 86 Mm^3/year until 2010, and by a further 36 Mm^3/year until 2020 (World Bank, 2001b). Water savings elicited by the new water charges were expected to reach about 40–50 Mm^3 over the next 3–5 years (Checchi and Devtech, 2003).

From 1962 to 1992[4] 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/year, and sometimes 100,000 m^3/year after 1990; Fitch, 2001) but these limits were never enforced (THKJ and MWI, 1997b, 1998a). In 2002, the groundwater by-law introduced a system of quotas combined with taxation of any use exceeding the quota. However, instead of endorsing previous license quotas, the by-law allowed uncontrolled abstraction up to a limit of 150,000 m^3/year/well, a volume much larger than the limits mentioned in the licences. Rules for the taxation of the water pumped above this limit are detailed in Table 10.3.

It has been reported that farmer interest groups have got the authorities to cancel the former licenses 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.

In April 2004, the first bills, corresponding to water consumption between 1 April 2003 and 31 March 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.

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/year. Volumes will be charged at Jordanian dinar (JD) 0.005/m^3 instead of JD0.025/m^3 (cf. Table 10.3). The second amendment concerns abstraction from brackish aquifers: the higher the water salinity, the lower the fee; it will have an impact in the south of the Jordan valley and in the Azraq basin (east of the country) but not in the LJRB highlands.

Implementing the by-law 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 only 61% of the meters were functioning properly (Fitch, 2001) and, although major replacement campaigns have been conducted, this problem is likely to recur.

[4]No drilling license has been delivered after 1992. However, the number of operating wells is continuously increasing as illustrated by the records of the Water Authority of Jordan for 2004. This may be due to the development of well metering.

Moreover, there is an important lack of material and human resources since controls are handled by only a few employees of the Water Authority of Jordan (WAJ). Another problem arises because 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). In the highlands, the risks of deterioration are reduced because the meter is paid for by the farmer but, on the other hand, tampering is quite easy and could become common.[5]

Financial impacts and expected adjustments in eastern desert's farming systems

Based on the description of farming systems presented earlier, this section explores the financial impact of the by-law on each type of farming system and how this impact could be mitigated by possible farmers' strategies.

Financial impacts of the by-law on farming systems

Table 10.4 summarizes financial impacts (before and after the 2004 amendment, Scenario A and Scenario B, respectively) on farms with licensed wells, assuming that actual withdrawals remain unchanged.[6]

Settled Bedouins with fruit tree farms and absentee owners with prestige olive trees will not be affected by the by-law since their current annual water consumption is less than 150,000 m^3/well. Fruit tree farmers will be very slightly affected by the by-law. Table 10.4 illustrates that the amendment considerably softened the financial impact of the by-law on settled Bedouins with vegetables or mixed farms and absentee owners with vegetables.[7]

To assess possible farmers' responses it is necessary to know what the present irrigation efficiency in the eastern desert is and to what extent the quantity of water supplied to crops matches their water requirements. Surveys have shown that orchards (especially olive trees)[8] are underirrigated with regard to full agronomic requirements: further water savings are thus unlikely. On the other hand, vegetable farmers abstract nearly 160% of the net crop water requirements, as evaluated by Fitch (2001). In this condition, the overall efficiency of water use in vegetable farms only reaches 62% and can be improved without affecting production. If we assume that on-farm irrigation efficiency can reach a maximum of 75%, vegetable farmers could decrease the amount they pump from 216,000 m^3 down to 179,760 m^3 while still meeting net crop water requirements.

The financial impacts at the farm level of four different scenarios are presented below: (A) the first scenario assumes a maximization of water savings by a decrease of water use down to 150,000 m^3/well/year (so that no fee needs to be paid), and a proportional reduction in the cultivated area (water use efficiency remains constant); (B) the second scenario assumes that farmers pay their water bills without changing their water consumption; (C) in the third scenario farmers increase irrigation efficiency up to 75% (still meeting crop water requirements) and reduce water abstraction; and (D) the fourth scenario is like Scenario C, but farmers do not reduce abstraction and use

[5]Anecdotal observations during our surveys showed that tampering and 'compromising' with WAJ employees did exist.

[6]Unlicensed wells in Jordan are mainly located near the Azraq oasis (east of the LJRB) and in the south of the Jordan Valley where they tap the brackish aquifer. For the sake of simplification, the following quantification assumes that all wells in the highlands of the LJRB have a license.

[7]For mixed farms, we have presented a case where farmers have only one well. In these conditions, impacts of the by-law are expected to be high. However, many of these farmers have two separate wells that they use indifferently to irrigate two different plots. In the latter situation, the by-law will not have any impact on them and no changes are expected to occur.

[8]Only 56% of olive-orchard requirements are met: this very low satisfaction (also observed by Hanson, 2000) illustrates their drought-tolerance quality and also their very low profitability. Deficit irrigation highlights that these orchards have a high social value but that their conventional economic profitability is not of prime importance to farmers. Farmer strategies do not boil down here to profit maximization.

Table 10.4. By-law impact on farm income in the eastern desert.

		Settled Bedouins			Stone fruit tree entrepreneurs		Absentee owners	
		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
Net benefit (US$/ha)		1,100	621	6,900	16,000	14,850	300	600
Water use (m^3/farm/year)		216,000	284,750	150,000	300,000	435,000	137,500	216,000
Actual abstraction costs	US$/ha	2,181	1513	1,373	1,310	1,310	432	1,875
	US$/farm	49,072	52,955	20,595	39,300	78,600	10,800	42,187
	% of current revenue	198	243	19.3	8.2	8.8	144	312
A – Extra water costs by-law	US$/ha	138	259	–	342	108	–	138
	US$/farm	3,110	9,050	–	10,250	6,475	–	3,110
B – Extra water costs by-law and amendment	US$/ha	76	217	–	295	61	–	76
	US$/farm	1,710	7,621	–	8,850	3,675	–	1,710
Revenue decrease	Scenario A	12.6	41.6	–	2.1	0.7	–	23.0
(% of current revenue)	Scenario B	6.9	35	–	1.8	0.4	–	12.7

Table 10.5. Financial impacts of the by-law (with amendment) on settled Bedouins farms and absentee owner vegetable farms according to the four response scenarios.

		Settled Bedouins		Absentee owner
Farming system category		Open-field vegetable family farm	Mixed farm vegetables and olive trees	Open-field farm
Scenario A	Volume abstracted (m^3/well)	150,000	150,000	150,000
	Change in revenue – US$/ha and % of current revenue	– 341 (–31%)	– 264 (–43%)	– 186 (–31%)
Scenario B	Volume abstracted (m^3/well)	216,000	284,750	216,000
	Change in revenue – US$/ha and % of current revenue	– 76 (–6.9%)	– 217 (–35%)	– 76 (–12.7%)
Scenario C	Volume abstracted (m^3/well)	179,760	218,760	179,760
	Change in revenue – US$/ha and % of current revenue	– 379 (–34%)	– 426 (–68%)	– 379 (–63%)
Scenario D	Volume abstracted (m^3/well)	216,000	284,750	216,000
	Change in revenue – US$/ha and % of current revenue	+ 129 (+12%)	+ 35 (+5%)	+ 46 (+8%)

the water saved to increase the cultivated area. We hypothesize that irrigation efficiency can be improved up to a maximum of 75% through a better design of the farm network, the use of higher-quality emitters, better on-farm operations, and a better monitoring of soil water reserves that would allow fine-tuning of irrigation, thanks to the involvement of more specialized technicians. The cost of such changes can be estimated at about $370/ha/year (Courcier, 2006, personal communication [by e-mail 20 May 2006]).[9] Contrary to common assumptions that farmers can easily save substantial amounts of water by just being 'more careful', improvements demand better knowledge and material and thus have a cost, especially in a situation where microirrigation is already in use. Assessing such costs is a difficult task, and the willingness/ability of farmers to achieve these improvements will depend on these costs.

Adjustments to be observed in open-field vegetable and mixed farms

Table 10.5 summarizes the impacts of the four scenarios on extensive vegetable farms run by settled Bedouins or absentee owners.

[9]This cost can be broken down into: $90/ha/year of incremental wage and $280/ha/year for dripper lines as well as for primary and secondary pipes, filters and tensiometers. To increase efficiency above 75%, there is an additional need for skilled engineers as well as for computerized systems that would cost about $1400/ha/year, with an initial investment of $1100/farm (Courcier, 2006, personal communication [by e-mail 20 May 2006]). The incremental cost to increase efficiency up to 75% is lower than the extra revenue that the farmer would derive from expanding his field and using saved water, but other constraints can explain why a 'farmer-maximizer' has not yet increased his irrigation system efficiency. These include aversion to risk or to incremental labour and time to be spent on the farm, as well as a low investment capacity, especially in a situation where most Bedouin farmers are indebted (Cheebane *et al*., 2004). The relative high costs (compared to farmers' revenue) of increasing efficiency above 75% make such an evolution unlikely.

For settled Bedouins with vegetables in open fields, reducing the land area until water abstraction is curtailed down to 150,000 m^3/well/year (Scenario A) entails a decrease in income of 31%. Paying the water fee (B) is a much better strategy (–6.9%), even though farmers already face water costs which are higher than their net income (cf. Table 10.4). Improving efficiency without increasing cropping area (C) entails a 34% decrease in farm revenue. If actual costs of improving efficiency are lower than $76/ha, (a rather low value compared with our estimate of $370/ha), then strategy C is cost-effective. Strategy D seems a better option with a 12% increase in farm revenue, due to the expansion of the irrigated area. Conclusions for absentee owners are similar: Scenario D is the best option but another possible strategy for well owners would be to rent out their wells to large entrepreneurial fruit tree farmers or to cities (cf. below). It is noteworthy that these conclusions would not have been significantly different with the pre-amendment price of water.

These results confirm the fact that technology costs are in general much higher than corresponding savings in the water bill, unless prices are taken at very high levels. In other words, even in the present case where water costs are very high, saving water is rarely cost-effective for farmers, and price incentives alone are unlikely to reverse this situation. However, in regions with abundant land, savings derived from improved irrigation efficiency can be used to expand the cropping area in a cost-effective way (Scenario D). Since, under conditions of high water costs, higher water costs deplete incomes, they may also trigger adoption of higher-value crops.

To avoid paying any water fee (A), settled Bedouins with mixed farms would have to decrease their current abstraction of 284,750 m^3/year by 47%, incurring a drop in income of 43% (the farmer would first abandon his olive orchard and then shrink its [more profitable] vegetable area). The average income is so low that paying the fees (B) would entail a 35% decrease in revenue (pre-amendment water prices would have sent a stronger signal but at the cost of more than half the current income). Strategy C would be even worse with an expected decrease in revenue of about 68%. Finally, as in the case of vegetables, improving efficiency and increasing the cropping area (D) would offset the financial loss due to the by-law and increase farmers' revenue by 5%.

Adjustments to be observed in entrepreneurial fruit tree farms

Intensive stone fruit tree entrepreneurs will be slightly affected by the by-law. In line with their large water abstraction, farmers will have to pay high water fees (between $3675 and $8850/farm according to the farming system; cf. Table 10.4). However, due to the high profitability of these farming systems, this increase in water prices will have a negligible impact on farmers' revenue (~2%).

In all likelihood, Scenario B will prevail, that is, farmers will squarely foot the bill. In systems where trees are underirrigated and efficiency already high, Scenarios C and D are very unlikely. Scenario A, however, might also be an option if there is a possibility for farmers to rent an additional nearby well: this new well would provide both the shortfall of water needed for the old orchard and additional water for expansion. The availability of large flat desert areas would make this option quite easy (although it is illegal because areas attached to a particular well are normally specified) and economic calculations show that such an expansion would be profitable, even with the cost of well renting (about $18,000/well). This rent is also higher than the total revenue generated at present by extensive open-field farms managed by absentee owners and would also make this option attractive to them. This could accentuate the current increase in stone fruit production by entrepreneurial farmers in the highlands. In such a case, there will not be any water savings but higher productivity will be achieved through the shift from vegetables to fruit trees.

Water savings at a regional scale

A land-use mapping carried out by the MWI and the GTZ based on two mosaics of

LandSat images dated August 1999 and May 2000 was used to estimate irrigated areas within the Amman-Zarqa and Yarmouk groundwater basins, giving a total of 14,460 ha with a breakdown between olive trees, fruit trees and vegetables. Based on these estimates of irrigated areas and on crop water use data, we can approximate groundwater abstraction in the Amman-Zarqa and the Yarmouk basins and compare these values with earlier estimates from other sources, and with annual recharge values given by THKJ (2004).

Results show that gross agricultural abstraction records of the MWI are 20% 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% of the annual recharge in the Amman-Zarqa and Yarmouk basins (or 179% and 168% if return flows of irrigation and municipal/industrial uses are considered, i.e. net abstractions of 121 and 63 Mm^3/year). These estimates will be used as a baseline situation in the following sections to assess possible water savings in the two groundwater basins considered.

Information on the different classes of agricultural wells according to their yearly production in the two groundwater basins of Amman-Zarqa and Yarmouk shows that out of the 606 wells located in these two basins, only 182 yield more than 150,000 m^3/year and will thus be concerned by the by-law (MWI records for 2004). Discounting government wells producing more than 500,000 m^3/year, this figure drops down to 166 wells that represent 38% of water abstracted in these two basins. Finally, as shown above, since only settled Bedouins with vegetables or mixed farms and absentee owners with vegetables are likely to respond to the by-law, only 83 wells in the eastern desert (90% of these in the Amman-Zarqa basin) will eventually be affected by the by-law.

Regional water savings can be assessed based on the four scenarios considered earlier by aggregating responses expected for each type of farm. Table 10.6 shows that the maximum gross water savings to be expected in vegetable plots in the eastern deserts are about 5.5 Mm^3/year (90% of these in the Amman-Zarqa basin). These savings would be obtained if all vegetable farmers decreased their water application and irrigated area by one-third on average, while maintaining their actual water use efficiency (Scenario A). This would lead to high agricultural losses ($2.5 million, not shown). This response, however, is not the one that the incentives in place are likely to prompt.

In Scenario B, 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 payments of all farms are considered. Improving efficiency without increasing cropping area (Scenario C) would reduce abstracted volumes to around 179,760 m^3/well/year in vegetable farms. In such conditions, gross water savings would reach 3.0 Mm^3/year and the regional gross overdraft would be decreased by about 2.2%. The net abstraction would not be affected by this change.

Finally, Scenario D would lead to increasing the depleted fraction by about 2.3 Mm^3/year (as cropping area and efficiency increase, and return flows are reduced), which would defeat the objective of the by-law. 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 fact, however, that expanding cultivation by using saved water is – on paper – financially profitable but not observed strongly suggests that the real costs of increasing efficiency may be higher than what has been considered here.

In conclusion, we can say that the implementation of the by-law in its current form will not lead to significant water savings. Because of the threshold of 150,000 m^3 and the weight of the public wells, 72% of the wells in the Amman-Zarqa and Yarmouk basins will not be affected by the by-law (a threshold of 100,000 m^3 would take this proportion down to 53%). Olive orchards, for example, which represent 32% of the total agricultural water abstraction in the highlands and qualify as the

Table 10.6. Impact of the by-law on vegetable farms at the basin level (eastern desert zone).[a]

	Abstraction (m^3 per year and per well)	Gross water savings (Mm^3/year)		Net water savings (Mm^3/year)		Depleted fraction in vegetables (Mm^3/year)	Government revenue from vegetable 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	–	–
Scenario A: maximizing water savings	150,000	5.5	4.0	3.4	4.2	7.7	–	–
Scenario B: payment of water fees	216,000	–	–	–	–	11.1	0.21	0.84
Scenario C: improving efficiency area constant	179,760	3.0	2.2	–	–	11.1	0.012	0.63
Scenario D: improving efficiency increased area	216,000	–	–	–2.3	–2.9	13.4	0.21	0.84

[a]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.

prime target of policies because of their low water productivity (WP) (WP = \$0.05/m^3) will not be affected. If we add to this the facts that high-value crops such as fruit trees (WP = \$1.1/m^3) will be financially little affected and that farmers' behaviour is unlikely to change, then the 83 wells concerned correspond to only 18% of the total water abstraction (16.1 and 1.8 Mm^3/year in the Amman-Zarqa and Yarmouk basins, respectively).

Vegetable and mixed farms are most vulnerable to hikes in water charges: this is because their income is so low that any additional production cost will depress them further. However, it is unlikely that such pressure would result in significant water savings, since improving efficiency would require investment in technology and qualified labour that are: (i) higher than gains resulting from a reduced water bill; and (ii) beyond the capacity of most of these farmers, many of whom are indebted.

Upper (optimistic) estimates of reduction in gross water abstraction (Scenario A for vegetable and mixed farms) point to a decrease by 4%, that is, 5.5 Mm^3/year, a drop in an ocean of overabstraction, and quite short of the 40–50 Mm^3 hoped for.[10] Revenue to the government is expected to vary between \$0.63 and \$0.84 million/year, not considering the costs of collection and enforcement.

With higher charges (like in the pre-amendment price table, for example), 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 (nor would economies in the water bill ever offset the costs of doing so). 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.

But they might as well sell their water to neighbouring 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: (i) benefits would accrue to wealthier entrepreneurs; (ii) this would defeat earlier social policies aimed at settling Bedouins by providing them opportunities in the agriculture sector (Chebaane *et al.*, 2004), unless they are able to find equivalent or better job opportunities; (iii) the amount of water used would not be radically altered; and (iv) 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.

Because of the large share of unaffected farmers and likely impacts in terms of crop shifts rather than of improvements in efficiency, 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/renting out of wells, but 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, 2001b) are more promising. Additional measures include reduction of losses in urban networks, educational and public awareness programmes for water users, allowing transfer of water to neighbouring orchards and the possibility of renting out wells (which 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

[10] If abstraction of all private wells was to be reduced to 150,000 m^3/year, total gross water savings would reach 12.5 Mm^3/year.

alternatives to people moving out of low-value agriculture, such as subsidies or secure market opportunities to help viable farms to intensify production.

Water Pricing in The Jordan Valley

Water allocation

From the beginning of large-scale irrigation in the Jordan valley, in the 1960s, a crop-based system of water allocation by quota has been used to supply water to irrigated schemes. Volumetric pricing was also initiated in 1961, with a cost of fils1/m^3 (Hussein, 2002; one fils is equivalent to JD0.001 or \$0.0014). 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, 2001). According to quotas defined in 1988 (THKJ and JVA, 1988), each plot of vegetable grown between mid-April and mid-December received 2 mm of water/day (during the rest of the year water was allocated on demand). Citrus and bananas were supplied with 4 and 8 mm/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). Historical large landowners (mainly citrus owners) as well as entrepreneurial farmers growing bananas are the main beneficiaries of these quotas.

Bananas and citrus are highly water-consuming crops and were traditionally cultivated in the northern part of the Jordan valley (Khouri, 1981; Elmusa, 1994): their higher quotas have now been frozen resulting in the institutionalization of some inequity in the access to water in the Jordan valley. Only the plots planted with bananas before 1991 are eligible to a 'banana allotment'. 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 allotment instead of the vegetable allotment they were receiving before. All other areas receive the vegetable allotment if the farmer declares to the JVA that he is cultivating his plot.

The 1997–1999 period was marked by a severe drought which, in 1999, made ad hoc reductions in farm allotments necessary. While some areas had to be left fallow, it is not clear whether impacts on yields were observed, but these reduced quotas have been maintained ever since (except in the south of the valley, where treated wastewater is used). In 1999, vegetables and citrus were allocated 75% of their allocation while bananas received 85% of their quotas. Allocations were reduced by 25% in 2000 and 2003, and by 50% and 40% during the summer 2001 and 2002, respectively.

In 2004, the JVA proposed new quotas expected to better match supply and crop water requirements (THKJ and JVA, 2004). These recommendations are close to the reduced quotas of 1999. On a regional scale, changing from the previous allocation system (2, 4, 8 mm/day) to the new recommended values yielded total water savings in the northern and middle directorates (where the rules apply) of about 20.2 Mm^3/year (between April and November), which were reallocated to domestic use in Amman.

O&M costs recovery

Revenues from irrigation water have gradually increased with time, as water charges established at fils1/m^3 in 1961 later increased to fils3/m^3, then to fils6/m^3 in 1989, and to an average of fils15/m^3 in 1996 (GTZ, 1993; FORWARD, 1998; the planned increase up to fils25/m^3 has been delayed).

Revenues from charges covered one sixth of O&M costs during the 1988–1992 period (GTZ, 1993; Hussein, 2002), which meant a corresponding average annual subsidy of \$3.4 million. In 1995, less than a quarter of O&M costs was recovered. Charges were then increased more than twofold and data for 1997 point to a rate of recovery of O&M costs of two-thirds, with an average charge of fils15/m^3 (against fils18/m^3 of O&M costs) and a rate of defaulting of 20% reducing actual revenues down to fils12/m^3 (FORWARD, 1998; World Bank, 2001b).

Calculations for 1988–1992 showed that fixed asset depreciation and financing costs were twice higher than O&M costs proper (total costs were thus three times higher than O&M costs) (GTZ, 1993). THJK (2004) indicated that the ratio of average

Table 10.7. Crop-based water costs according to three different levels of price increase.

Cost of water ($/ha/year)	Vegetables	Citrus	Bananas
Current water costs	67	138	350
A. O&M costs recovery-block tariff system	94	191	485
B. Total costs recovery (O&M + capital costs)	278	573	1454
C. 80% of water costs borne by farmers in the highlands	586	1172	1740

capital costs to O&M costs was 2.07 for the 1997–2002 period.

Based on the actual block tariff system (FORWARD, 2000; cf. Appendix) we have estimated average costs per m^3 and per year for each type of crop according to the recent JVA recommendations (see details in Venot *et al.*, 2007). Total water costs for the farmers are higher in banana plantations ($350/ha/year) than in citrus orchards ($138/ha/year). They are lowest in vegetable farms which consume less water ($67/ha/year). Differences in water charges for each crop are lower than previously, since uses have been capped. The main beneficiaries of this evolution are banana farmers whose consumption rarely reaches expensive tariff blocks. The new JVA recommendations lead to lower water use and consequently to a lower overall level of O&M cost recovery, with an average charge of about fils13/m^3.[11]

In line with these recent evolutions, despite substantial differences between sources, we will consider here that current charges cover 72% of O&M costs and that full costs are three times higher than O&M costs.[12]

Economic impacts and adjustments at the farm level

This section provides financial evaluations of a rise in water prices according to three different scenarios. First, we will consider that water prices will increase up to a level where O&M costs of the JVA are recovered; this is the main objective of water pricing policies in Jordan (FORWARD, 1998; THKJ and MWI, 1998c, 2002a; Salman, 2001; THKJ *et al.*, 2002; THKJ, 2004). Second, we will consider a water price increase allowing the recovery of total costs of irrigation in the Jordan valley (O&M and capital costs). In these two scenarios, we consider that the actual block tariff system is maintained (cf. Appendix). Finally, based on a recommendation of THKJ (2004),[13] we will assess the impact of a hypothetical increase of up to 80% of the present average cost of water borne by farmers in the highlands, that is, about $0.116/$m^3$ (Al-Hadidi, 2002). In this third scenario, water is charged at a flat rate regardless of the total water used in the farm. (In the three scenarios, the rate of bill recovery is assumed to be 100%.) Table 10.7 specifies water costs for each crop and scenario and Table 10.8 for each farming system.

In Scenarios A and B, water prices are multiplied by a factor of 1.4 and 4.1, respectively, regardless of the crop planted. In Scenario C, and because of the implementation of a flat charge, water prices are multiplied by 8.5 for vegetables and citrus and by 5 for bananas. Table 10.8 shows that extensive farming systems (citrus and mixed farms) would be most impacted since water costs represent an important percentage of total costs (in citrus farms) and because their income is very low. On the other hand, intensive systems (greenhouse farms, for example) are not responsive to such policies since water costs are negligible compared to

[11] The JVA's revenue has decreased in line with declining allotments from 1999 onwards. This may have prompted the proposal to establish a monthly flat charge of JD2 ($2.8) on each water bill.

[12] In fact, since 2005, O&M costs are totally covered by the sale of water from the Mujib Southern Carrier to the Dead Sea industries. This recent change is not considered here in order to keep conservative estimates.

[13] 'The water production cost from private wells borne by the farmers (at present about fils100/m^3) should be taken as a guideline for adjusting the water tariffs charged by the JVA (at present fils10–12/m^3). The tariff for 'public' water of the JVA should not be lower than 80% of the average cost of the water produced from private wells' (THKJ, 2004).

Table 10.8. Impact of different levels of water price increase on farming systems in the Jordan valley.

Farming systems		Open-field vegetable family farms	Entrepreneurial greenhouse farms	Citrus farms		Banana farms		Poor farmers
				Family farms	Absentee owners' farms	Family farms	Entrepreneurial farms	Mixed farms
Allocation type		Vegetables	Vegetables	Citrus	Citrus	Bananas	Bananas	Vegetables
Net income (US$/ha/year)		3800	7500	1250	400	7000	12,500	1050
Total costs (US$/ha/year)		8150	21,000	1550	1200	8200	8600	2400
Actual water costs (% of income)		1.8	<1	11	34.5	5	2.8	6.4
Actual water costs (% of total costs)		<1	<1	8.9	11.5	4.3	4.1	2.8
Revenue decrease (% of the actual income) according to three different water prices	A. O&M costs recovery	<1	<1	4.2	13.2	1.9	1.1	2.6
	B. Total costs recovery (O&M + capital costs)	5.5	2.8	34.8	negative revenue	15.8	8.8	20.1
	C. 80% of water costs borne by farmers in the highlands	13.6	6.9	82.7	negative revenue	19.8	11.1	49.4

input and labour costs, and they will remain so at any politically acceptable price level (Wolf *et al.*, 1996).

Scenario A would have a limited impact on most farming systems in the Jordan valley. Revenues in vegetable and banana farms would decrease by less than 1% and 2%, respectively. Poor farmers would also be slightly affected by the increase (2.6%). Finally, citrus farming systems would be the most affected: revenues would decrease by 4.2% to 13.2%. In the latter case, most absentee owners would probably retain their orchard because it is not central to their livelihood, or would adopt other trees.

In Scenario B, farmers' revenues would decline more substantially. Productive systems (vegetables in open fields or under greenhouses) would again be slightly affected (revenue is expected to decrease by about 2.8–5.5%). These farmers would probably cope with this loss or seek (limited) on-farm water savings through better management, in a bid to decrease overall water costs (see below). Mixed farms developed by poorer farmers would be substantially affected (–20.1%): some farmers might be driven out of agriculture, looking for jobs in other economic sectors, while their plots could be rented to and cultivated by more entrepreneurial farmers.[14] Profitability of banana orchards would be moderately affected (revenues decrease by 8.8–15.8%). Despite their high revenues, some farmers might shift to other very profitable orchards such as date palm trees that are less water-consuming, especially if import tariffs on banana are lowered. Finally, citrus farms would be greatly affected: profitability of family farms would decrease by one-third, while absentee owners' farms would no longer be profitable: citrus areas would be expected to decrease substantially with many small owners (shopkeepers, civil servants, retirees, old farmers, widows, etc.) renting out their land or shifting to higher-value trees, and only a small fraction of rich absentee owners retaining their orchards.

Finally, Scenario C would have a dramatic impact on the Jordan valley agriculture. As in the two previous scenarios, citrus orchards would hardly be profitable anymore and would basically disappear, with the same replacement options as above. In banana farms, a partial shift to date palm trees and generalization of drip irrigation systems might be observed. Mixed farm operators would see their profitability decrease by one-half and would tend to be replaced by more entrepreneurial farmers. In the end, profitability of vegetables planted in open fields or under greenhouses would decrease by nearly 13.6% or 6.9%. This third option is hardly imaginable politically and would disrupt the valley economy.

Are improvements in irrigation and economic efficiency possible at the regional scale?

Whether substantial water savings are possible is highly variable and depends on what the actual irrigation efficiency is and, if any low value is observed, on the causes of such a state of affairs.[15] Improvement of efficiency is hindered by several constraints, both technical and socio-economic.

[14]Since 2001, land market transactions have been allowed in the Jordan valley. Renting plots is also a widespread practice. As land pressure in this valley is very high, any plot left fallow by a farmer is expected to be taken up by another farmer with a more intensive management and higher profitability. The irrigated area in this valley is unlikely to decrease, whatever water prices are.

[15]Because of the high diversity of situations, available data on efficiency are rather inconsistent (Al-Zabet, 2002; World Bank, 2002; Petitguyot, 2003; etc.). This is due to the extreme complexity and variability of use efficiency, and to what is considered: which crop and what type of farm; the plot, pumping unit or the valley level; the water-short period or the whole year; which ET and Kc values; total or effective rainfall; special water requirements for specific operations such as 'solarization' and in occasional periods of deficit irrigation. All these factors combined explain why the literature is not fully consistent (Ghezawi and Dajani, 1995; World Bank, 2001a; World Bank, 2002; Shatanawi *et al.*, 2005; USAID, 2006; etc.). Our estimates of annual irrigation efficiencies give 64%, 62% and 82% for vegetables, citrus and bananas, respectively.

- First, farmers experience many technical problems at the farm level that come from drip irrigation systems which have been installed without technical guidance (in 70% of the cases), direct connection of old dripper lines to the JVA's pressurized network,[16] problems of filtration and clogging, etc. (Wolf *et al.*, 1996; Courcier and Guérin, 2004; Shatanawi *et al.*, 2005).
- Second, whether much water can be saved just by farmers being more 'careful' and with limited additional costs is doubtful in non-gravity irrigation. Experiments by USAID/JVA and MREA/JVA suggest that with precision irrigation it might be possible to save around 25% of water applied. This is easier to achieve in citrus farms irrigated by open microtubes. Achieving better irrigation efficiency requires computerized monitoring, use of tensiometers, improved filtration, frequent renewal of drippers, qualified staff, etc., and is therefore very costly. With the impossibility to expand cultivated land, the incentive for the farmer to achieve such gains is low, since corresponding costs are too high, regardless of the price of water. If we keep the estimates used for the highlands ($370/ha/year for achieving an efficiency of 75%, and an additional $1130/ha/year for reaching 85%) we can see that economies in the water bill will never come close to improvement costs, even for Scenario B.
- Only very high-tech and capitalized farmers linked to high-value markets demanding high quality of products can adopt and master such practices. It is important to note that, historically, drip irrigation was developed in the early 1980s as a technical response to the need to produce high-value products (along with the adoption of mulch, fertigation, labour-saving technology, control of doses, homogeneity and quality of products, etc.) rather than to a lack of water per se.[17]
- Third, farmers also experience many difficulties because of deficiencies in collective pressurized networks which result in a high heterogeneity of water distribution (with deficits observed in higher parts, sandy soils or at the end of the lines); rotations are difficult to establish; water theft, rent-seeking and tampering of equipment are pervasive (GTZ, 2004).
- Fourth, despite being conceived as a demand-based system, subject to the limitation of quotas, the actual mode of operation of the JVA and the uncontrolled nature of the inflow from the Yarmouk river do not ensure enough reliability in water provision (Courcier and Guérin, 2004). Overirrigation can also be considered as a safeguard against uncertainty in supply.
- Fifth, the system of monthly quotas defines a ceiling to the abstraction of pumping stations from the main canal (KAC): demand may be higher than the quota during a few critical periods in spring and autumn (Petitguyot, 2003), when no savings are possible. Conversely, efficiency is often lowest when supply exceeds demand, with no alternative use for water and therefore little rationale for saving water.
- Last, the desirability of further water savings is not fully established, as it is feared that lower salt lixiviation would raise salinity problems in the valley (McCornick *et al.*, 2001). (In the early 1990s, the JVA encouraged farmers to take water free of charge in the winter months for leaching purposes; Wolf *et al.*, 1996).

The idea that farmers are wasting water only because its price is relatively low is therefore simplistic and mistaken; so is its corol-

[16]Irrigation water is provided to farmers through several pressurized networks serving areas of approximately 400 ha and pumping stations which draw water directly from the KAC.

[17]After the conversion of the open channel irrigation networks to pressurized systems (completed in the mid-1990s), which caused the reduction of the flow at the farm turnout from 20 l/s to 6–9 l/s, most farmers were obliged to shift to localized irrigation.

lary that raising prices will necessarily improve efficiency. A World Bank (2003) report indeed acknowledges that '[I]t was anticipated that increased water tariffs [of 1995] would reduce agricultural water use. This did not happen.'

Higher water charges also deplete incomes and, at least for low-value crops, tend to motivate shifts towards higher-value crops (Pitman, 2004; THKJ, 2004). Economic data in Table 10.8 suggests that, prima facie and as far as revenue per hectare is concerned, farmers would have an interest in shifting to vegetables or to high-value trees. Several points must be emphasized:

- First, although citrus (low productivity) and banana (water-intensive) may appear as undesirable there is little incentive for farmers to shift to vegetables (or to rent out their land to vegetable farmers) since they would then lose their higher quota with little hope of getting it back if they ever would like to revert to trees.
- Second, even if water prices were increased to cover all costs (Scenario B), banana farming would remain highly profitable and the shift to date palm trees (or other trees) not warranted (non-elasticity).
- Third, citrus would be made less attractive but large areas are owned by absentee owners whose livelihoods do not depend on their agricultural activity. Their orchards are linked to social prestige and recreational use and are not driven by economic motives. These owners may not shift to a more intensive and time-consuming activity for the sake of preserving their secondary agricultural revenue.
- Citruses in family farms are more likely to be replaced by more profitable trees (mangoes, guava, grapes, dates), or by vegetables, sometimes with the land being rented out to entrepreneurs. Yet these farmers have chosen to develop relatively extensive systems for a reason (lack of skill, capital, or alternative activities; ageing of farm-holder, etc.) and it will be difficult for them to shift to riskier, more intensive, and time-/input-consuming crops, unless market opportunities are identified.
- Last, it is worth mentioning that overestimating the capacity or willingness of farmers to adopt new crops or technologies and pushing for much higher water charges (Scenarios B or C) might lead to farmers responding to higher water tariffs by tampering with or destroying meters, bribery or defaulting. Unrest and political intervention would also be likely reactions. Such outcomes are not attractive for the government, which has little incentive to antagonize supportive segments of the society if gains are not expected to be substantial (Richards, 1993).

In conclusion it can be stated that all these elements strongly limit the scope for pricing mechanisms to achieve improvements in both irrigation and economic efficiency. Gains are possible but their magnitude and realization depend on the type of farm, and they cannot be obtained without support, including technical assistance, predictable water supply, secure markets, and subsidies to shift to drip irrigation (where this has not yet happened) and, gradually, to precision irrigation. Several alternative options have been proposed, along the following lines:

- Flexibility of water supply at the farm level is obtained not only through exceptional requests but also by digging farm ponds to buffer irregular supply (Shatanawi *et al.*, 2005), by using water from side-wadis and, wherever possible, by pumping groundwater. Many farmers already have implemented these options.
- Effective freshwater savings in the Jordan valley may come from the generalization of the use of treated wastewater blended with freshwater in the north of the Jordan valley, as proposed by ARD and USAID (2001b) (see also JRVIP, 2001b; McCornick *et al.*, 2002; and KfW *et al.*, 2006).
- Significant water savings could be achieved through a better in-season distribution of water in the KAC. With the

completion of the Wehdah dam on the Yarmouk river, it will be possible to have a more flexible management of water allotments (JRVIP, 2001b; Courcier and Guérin, 2004). Monthly quotas could be transformed into yearly quotas, with farmers keeping the latitude to distribute water along the year according to their needs (Petitguyot, 2003).

- With a more controlled water regime, it might be possible to adopt bulk allocation and bulk charging procedures, whereby water user associations would be in charge of managing a yearly amount of water and recovering charges (JRVIP, 2001a). This, however, is hindered by extant cultural and social structures and would require significant institutional transformations and changes in the agency(JVA)–farmer relationship (van Aken, 2004).
- The banana area could be reduced by substantially raising the price of the higher tiers of the quota so that revenue would be reduced without affecting other crops; it could also be made less profitable by removing duties on imported bananas, in line with WTO rules. Such economic incentives could contribute to inducing a shift towards other trees, but the potential loss of high banana allotments is likely to hinder this shift if no positive incentives are available.
- The most efficient way to reduce diversions to the valley (and to free more water for Amman) would be to gradually reduce quotas – as observed since 1999 – in order to force adjustments (high-tech management, change in crops, etc.). Additionally, a bonus might be granted to those who accept to shift from a high quota to the vegetable quota; of course, this would be hard to justify in the face of the recent contradictory measure of recognizing more citrus allotments.

The last point concerns cost recovery objectives: the analysis indicated that the prime objective of financial autonomy of the JVA is within reach. Charges could be slightly raised to ensure revenue, while defaulting should be controlled by stricter enforcement. Raising prices to full O&M costs would not dramatically affect farmers. It must be noted however that the ‘fiscal drain’ argument commonly raised to justify increased cost recovery is hardly convincing since the present O&M subsidy to the JVA is worth less than 0.1% of state expenditures at $3.7 billion.

Despite higher coverage of state-borne O&M costs, water charges do not instil any virtuous circle towards improved management and maintenance on both the manager and the farmer sides (Small and Carruthers, 1991). There is a lack of positive incentive stemming from the fact that charges paid by farmers do not benefit the scheme, managers do not depend on these payments (which are sent to the Ministry of Finance), farmers control neither part of the revenue nor water deliveries, supply is uncertain, and allocation not transparent enough. Under such conditions water pricing merely boils down to a taxation instrument. Bulk charging at the pumping station level and transferring responsibility for charging farmers individually to water user associations might be a way forward.

It is unlikely that raising fees much beyond O&M cost recovery can be tenable because of the limited effect on water use and the difficulty to justify charges higher than the JVA’s expenditures, which would look like a transfer of wealth to the state. These factors and the fact that there is hardly any example of full cost recovery of public schemes in the world make Scenario B highly unlikely (not to mention Scenario C).

Discussion and conclusions

The results obtained in both the highlands and the valley have both similarities and discrepancies, and also bring out lessons that have wider validity.

**Limited effectiveness of increased prices in instilling higher efficiency.* Several modelling studies (Doppler *et al.*, 2002; Salman *et al.*, 2002; Shatanawi and Salman, 2002; Salman *et al.*, 2005 for the valley; Salman and Al-Karablieh, 2004 for the highlands) have shown that demand is only responsive to prices at levels which are in general not compatible with sustained farm incomes and equity. However, we have shown that the causes of efficiency losses are not all at the farm level and that further improvements require significant technological improvements which are costly and offset any gain derived from a reduced water bill (Pitman, 2004).

Consequently, the claim by the 2004 master plan (THKJ, 2004) that the full cost recovery for irrigation O&M pursued by the Ministry of Water and Irrigation will, among four objectives, 'increase conveyance system and on-farm water use efficiency' is not valid. From the correct assumption that 'low prices for irrigation water provide limited incentive to improve on-farm efficiencies' it is mistakenly inferred that raising prices will automatically improve on-farm efficiency and should therefore be 'a prime target for implementing improvements' (USAID, 2006). Despite evidence to the contrary, these claims are still pervasive among donors, development banks and some green NGOs (FOE, 2002). Removing public subsidies may have other virtues but should not be expected to bring about improvements in irrigation efficiency (or be justified by this).

**Intensifying agriculture: at what cost?* Consequently, the principal impact of higher charges would be to reduce the income of two categories of farmers: poor and often indebted farmers with more extensive agriculture, on the one hand, and absentee urban owners and rentiers with other income sources, on the other. Such a pressure would have a beneficial impact if these farmers were encouraged to adopt more intensive farming. One should note, however, that these higher-value cropping systems were already available to these farmers and there are good reasons why – despite their high return – they did not adopt them earlier. Farmers engaged in extensive agriculture lack capital to embrace such ventures, which incur considerable risk; rentiers lack the interest to burden themselves with intensive management and value their farm for reasons other than their profitability. Intensification must be driven by market opportunities and not forced by circumstances which would drag de-capitalized farmers into risky ventures with a high probability of going bankrupt. It is doubtful whether the benefits of pushing the more vulnerable farmers out of business would be higher than the social costs incurred.

Most countries are confronted with this necessity of balancing family farming and agrobusiness, and social stability and economic efficiency (the case of Spain in Arrojo, 2001; Berbel *et al.*, 2005). As a rule, state policies include investments/subsidies to allow modernization of family farms in order to better compete with highly capitalized operators.

**High-value crops: for which market?* The move towards a more intensive and higher-value agriculture is critically dependent on the availability of a market for it. With growing competition from other countries in the Middle East it is not easy to identify crops with a good return: farmers are neither immune to drops in prices following a too widespread adoption of promising crops nor all ready for, or capable of, handling the complexity of certain productions. Palm trees, for example, are salt-resistant and dates (so far) fetch high prices, but they have several drawbacks which make them largely unfit for small extensive farmers: they 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 best market niches.

**The politics of water management and policy*. The negotiations around the by-law and the amendment, carried out with a fair degree of participation of stakeholders (Chebaane *et al.*, 2004), showed that agricultural interests retain significant political and bargaining power; the government is unwilling to alienate the support of Bedouin tribes or part of the Palestinian population, and to prompt claims from Islamist radicals that Islamic law is violated (Richards, 1993). The teeth of the by-law were removed through the implicit abolition of former abstraction limits (which were lower than the 150,000 m^3 threshold adopted) and through the recent amendment which abated the already low water fees. Some groups of influential farmers, with strong political linkages and opposed to a control of water abstraction, have tried to stop the process and have managed to slow it down thanks to support in the parliament.

The fact that illegal citrus orchards in the valley have recently been regularized – quite contradictory to policy objectives – also suggests that the populations concerned have enough political clout to counter the reduction of quotas. All this confirms that water pricing schemes largely reflect the political economy of a country and that political counterweights are often raised when prices depress incomes. This does not mean that reforms are not desirable or should not be attempted; but this cautions us against simple-minded decisions and forces decision makers to weigh benefits against all costs.

**Improving allocation of water resources.* With such a minimal expected impact of price increases on efficiency, the objective of reducing demand to sustainable levels in the highlands and to volumes lower than current diversions in the valley through pricing measures is clearly unattainable and must be dismissed, in line with Berkoff (1994), who recognized 'that it is inconceivable that [charges] would be high enough to balance supply and demand'. Under such circumstances, the higher-level objective of regulating intersectoral allocation through prices, expressed in the ASAL despite considerable doubt from experts (Pitman, 2004), is quixotic.[18]

**State and donors: conflicting viewpoints.* Opposition to pricing by most quarters in the government is based on three considerations (Pitman, 2004): (i) social concerns and the view that farmers' access to groundwater is already too costly; (ii) the view that administrative allocation of surface water and technical/institutional improvements in management are more efficient and equitable than pricing in achieving sound management; and (iii) the understanding that alternative markets must be ensured before pushing farmers to abandon lower-value crops. With some caveats this study tends to confirm these misgivings.

Pitman (2004) notes that the 'social-welfare dimension of water was the largest divergence of views between the Bank and government over the agricultural sector' and critically soured relationships. A possible source of misunderstanding is that affected people include both poor farmers and rentiers, and that the former might be used to unduly shelter the latter from adverse policy measures.

**Safety nets.* Policy makers' misgivings may be well founded if one judges from experience in other domains where planned safety nets have been neglected, equity impaired and social objectives defeated. For example, the elimination of all direct subsidies to owners of small livestock herds over the period 1995–1997 has proven to be very effective in reducing herd sizes by 25% to 50%, overgrazing, and thus rangeland degradation and desertification. However, an official evaluation found that 'the poorest group – nomadic pastoralists – in the driest areas have fared worst as they do not have the income to buy even subsidized concentrates. All farmers monitored, with the exception of the medium-sized agro-pastoral farmers in the wettest areas in 1997/1998, had negative profits since 1996' (Pitman, 2004). Earlier consensus that attendant measures would be needed seems to have been later forgotten (Richards, 1993).

This suggests that too little attention is given to safety nets and the assumption that people can be reabsorbed by the labour market without much hardship is often not valid. Clearly, linkages to the macroeco-

[18]The claim by the World Bank (2003) that 'the partial tariff increase [in the valley] satisfied an immediate objective of maximizing transfer of water to the highlands' has no basis since this transfer is a bureaucratic decision completely independent of prices.

nomic framework must be strengthened if social objectives are to be fulfilled.

**From negative to positive incentives.* Negative incentives through prices that deplete incomes or force costly/risky adjustments generally raise considerable opposition which may express itself through political channels or in the streets. Such (stick) measures must be accompanied with positive incentives (carrot) (Al-Weshah, 2000). Positive incentives include a bonus for uprooting olive trees in the highlands or for accepting vegetable allotments in the valley (or tree allotments for banana growers), attractive buyout schemes of wells in the highlands, aid or crop insurance schemes for farmers tempted to diversify, etc. The government's refusal to raise prices before treated wastewater or market opportunities are available also indicates the fear of negative impacts in the absence of clear alternative opportunities and 'pull' factors.

**Enforcement and monitoring.* It is clear in both situations that individual metering is extremely demanding and hard to administrate. The percentage of broken meters both in the highlands and in the valley is likely to rise again after replacement campaigns. If fees significantly affect the economic situation of farms they will also probably trigger defaulting, tampering or destruction of meters, social unrest and political stress at unprecedented levels, and corruption or collusion between officials and farmers (GTZ, 2004). This does not mean that metering should not be attempted but reminds us of the costs involved and of the possibility that other approaches could be adapted more (e. g. charges based on crop and area in the highlands, or defined and recovered at the level of the pumping station in the valley).

**Quotas and regulation.* As shown from other situations where scarcity is high and volumetric control possible (Iran, Tunisia, Morocco, south of France, Italy, Spain, etc.), quotas are invariably selected as the main regulation instrument. This is because quotas are generally transparent, equitable, easy to understand, and effective in reducing demand without impacting incomes. Their implementation on wells, however, requires a major enforcement capacity. Their main drawback is their limited capacity to adjust to changes in demand. The present case provides such an example, where inefficiencies arise from the disincentive they generate for citrus and banana growers to adopt less water-intensive crops. A careful downward adjustment of quotas, as implemented since 1999, is, however, effective in skimming off the 'slack'.

Although the two situations show many commonalities, the comparison also evidenced a few meaningful discrepancies. The first difference is the possibility offered to highlanders to expand their plots. This allows them to capitalize on possible water savings and to increase cultivated areas (and benefits) in proportion. Since they may benefit directly from their financial or managerial efforts it is more interesting for them to improve efficiency than in the valley, where the sole reduction in the water bill (sometimes complemented by gains in yields) offers a limited incentive, while benefits go to Amman in the form of increased supply. Second, quotas in the highlands are merely thresholds which can be exceeded at limited cost, while those in the valley are rigid and cap diversions (although informal arrangements may offer some way out). Third, water supply in the highland is very reliable because it depends on individual wells and compact networks; in contrast, allocation and distribution in the valley are much more complex both technically (regulation of the KAC, rotation between farmers within pressurized networks, etc.) and socially (practices are embedded in complex social and political contexts). This difference explains why efficiencies are higher in the highlands (with the additional benefit that return flows tend to return to the aquifer while in the valley they mostly go to a sink: the Dead Sea). In sum, water management is technically simpler in the highlands but enforcement and control are problematic, while the opposite is true in the valley, where quotas are effective in controlling water use but management is heterogeneous and a uniform efficiency hard to achieve.

APPENDIX. Current and proposed irrigation water tariff structure in the Jordan valley. (From FORWARD, 2000.)

Water quality	Usage block (m^3/month/3.5 ha maximum)	Irrigation tariff (per 1000 m^3) Current	Proposed
Freshwater	0–2500	JD8 ($11.5)	JD15 ($21.6)
	2501–3500	JD12 ($17.3)	JD30 ($43.2)
	3501–4500	JD20 ($28.8)	JD45 ($64.8)
	Over 4500	JD35 ($50.4)	JD55 ($79.2)
Low-quality water (freshwater mixed with treated effluents or highly saline water)	0–2500	JD8 ($11.5)	JD8 ($11.5)
	2501–3500	JD12 ($17.3)	JD12 ($17.3)
	3501–4500	JD20 ($28.8)	JD20 ($28.8)
	Over 4500	JD35 ($50.4)	JD35 ($50.4)

In conclusion, we can observe that there is pervasive overenthusiasm about what can be achieved through pricing policies, and that policy objectives are often listed without due attention to the contradictions they entail and the trade-offs they imply. Expectations of the ASAL, for example, were high but the goals of economic efficiency, equity and environmental sustainability central to the definition of Integrated Water Resource Management are not easily reconciled. In both, the highlands and the valley, substantial increases in volumetric charges would not elicit major water savings but would further depress the income from low-value or extensive crops. A shift towards high-value crops would not only raise water productivity but also entail a transfer of wealth to the government and to wealthier entrepreneurs, an evolution which is so far not considered desirable or politically palatable by Jordanian decision makers. It is therefore essential that negative incentives be accompanied by positive measures offering attractive alternatives (market options, subsidies for modernization, technical advice, etc.) and exit options with compensation.

Acknowledgements

This research has been supported by the Comprehensive Assessment of Water Management in Agriculture, the International Water Management Institute, the Ministry of Foreign Affairs, Government of France and the Institut de Recherche pour le Développement, France.

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