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# Irrigation in the Jordan Valley: Are Water Pricing Policies Overly Optimistic?

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## 1 **Abstract**

2

3 Water is very scarce in the Hashemite Kingdom of Jordan. The development of both public  
4 irrigation in the Jordan Valley and private groundwater schemes in the highlands has diverted  
5 a large share of the country's water resources to agriculture. Many policy instruments have  
6 been used in the last ten years to reallocate water to nonagricultural uses and encourage  
7 improvements in efficiency throughout the water sector. Demand management has been  
8 emphasized, with water pricing policies expected to instill conservation and motivate a shift  
9 toward higher-value crops. We examine the rationale for, and potential and current impact of,  
10 pricing policies in the Jordan Valley.

11

12 We describe the likelihood of success of such policies in terms of operation and maintenance  
13 cost recovery, water savings and improved economic efficiency, and we explore some of the  
14 alternatives available for meeting these objectives. We show that while operation and  
15 maintenance (O&M) costs can be recovered higher water prices have limited potential for  
16 achieving gains in irrigation efficiency. The current system of quotas, the lack of storage, and  
17 technical difficulties experienced in the pressurized networks indicate that little water can be  
18 saved. More substantial increases in water prices can be expected to raise overall economic  
19 efficiency by motivating farmers to intensify cultivation, adopt higher-value crops, improve  
20 technology, or rent out their land to investors. Yet such strategies are constrained by lack of  
21 capital and credit, and pervasive risk, notably regarding marketing. Pricing policies, thus, are  
22 best implemented together with positive incentives that reduce capital and risk constraints,  
23 and offer attractive cropping alternatives or exit options with compensation.

## 1 **Keywords**

2 / *economic instruments / demand management / efficiency / quotas / intensification/*

## 3 **Introduction**

4 Water is very scarce in the Hashemite Kingdom of Jordan. Due to both physical water  
5 scarcity and rapid population growth over the second half of the twentieth century the  
6 estimated per capita availability of renewable water is now only 163 m<sup>3</sup>/yr, while the average  
7 domestic consumption is 94 liters per capita per day (34 m<sup>3</sup> per year) nationwide (THKJ,  
8 2004).

9 With the exception of some rain-fed agriculture in the mountains (mostly pasture, wheat and  
10 olive trees), the bulk of commercial agriculture is irrigated and can be found in two  
11 contrasting environments: the Jordan Valley, where a public irrigation scheme supplies  
12 approximately 23,000 ha, and the highlands where private tube-well-based irrigation has been  
13 developed on 14,000 ha during the last 30 years.

14 The Jordan Valley irrigation scheme receives its water from the Yarmouk River, just  
15 upstream of the confluence with the Jordan River, at the northern end of the Valley. Water is  
16 fed into a concrete canal that runs parallel to the river on the eastern bank. Additional inflows  
17 come from several *wadis* (lateral intermittent streams) that cut through the mountain ranges  
18 bordering the Valley. The main water use areas and water flows in Jordan are shown  
19 schematically in Fig. 1.

20 Amman receives water from the Jordan Valley and aquifers, and from southern and eastern  
21 outer basins. Available options to meet the increasing domestic water demand include: a)  
22 improving inflow from the Yarmouk River by construction of a new dam (Al-Jayyousi,  
23 2001); b) transferring more water from the Valley to Amman, which will reduce the supply to

1 agriculture even though treated wastewater will return to the Valley; c) reducing abstraction  
2 from aquifers by highland agriculture in order to preserve water quality, avoid overdraft and  
3 reallocate water to cities (ARD and USAID, 2001a); and d) relying on costly imports (THKJ,  
4 2004).

5 *Insert Figure 1. Main water uses and water flows in the Lower Jordan River Basin.*

6 In the early 1990s, aware of the incipient water crisis, the Jordanian government changed its  
7 policy focus from supply augmentation toward demand management (Al-Jayyousi, 2001).

8 The World Bank and other development agencies were influential in calling for an agenda  
9 that would include demand-management instruments to encourage efficient water use, transfer  
10 water to nonagricultural higher-value uses, and reduce groundwater overdraft (Pitman, 2004).  
11 Pricing of irrigation water was chosen as an instrument to reduce demand for water (World  
12 Bank, 2003a).

13 In the highlands, pricing policies were expected to limit groundwater use with the ambitious  
14 target of reducing abstraction to "close to the annual recharge by the year 2005" and to  
15 promote higher-value agriculture (THKJ and MWI, 1997b, 1998a). The Groundwater Control  
16 Bylaw No. 85, passed in 2002 and further amended in 2004, was designed to regulate  
17 groundwater abstraction through the establishment of a threshold quota and a block-rate tariff  
18 system above it (see Venot et al., 2007).

19 In the Jordan Valley, a block-rate tariff associated with crop-based quotas had been in place  
20 for some time and debate revolved around possible increases in water charges: more  
21 expensive water was expected to bring about improvements in irrigation efficiency and a  
22 switch to less water-intensive crops, thus releasing water for Amman (World Bank, 2003a). It  
23 would also assist in recovering state expenditures in public irrigation schemes: "The water  
24 price shall at least cover the cost of operation and maintenance (O&M) and, subject to some

1 other economic constraints, it should also recover part of the capital cost of the irrigation  
2 water projects. The ultimate objective shall be full cost recovery subject to economic, social  
3 and political constraints" (THKJ and MWI, 1997a; see also THKJ and MWI, 1998b, 2004b;  
4 JRVIP, 2001).

5 Some of these reforms were embedded in the 1994 Agriculture Sector Structural Adjustment  
6 Loan (ASAL), funded jointly by the World Bank and the German KfW, and designed with the  
7 prime objective "to support a transition to an optimal use of water and land resources" and to  
8 address key problems of the sector: "the lack of a national water policy, competing sector  
9 institutions, and insufficient attention to demand management" (World Bank, 2003a; Berkoff,  
10 1994). Implementing these policies proved difficult and generated discord, exemplified by the  
11 occupation of Parliament in opposition to higher water tariffs, requiring further intervention  
12 by His Majesty the King (Pitman, 2004).

13 We examine the rationale for, and potential and current impact of, water pricing policies in  
14 the Jordan Valley. We describe the likelihood of success of such policies in terms of  
15 recovering O&M costs, saving water and raising economic efficiency. Then we explore  
16 alternative options to meet these objectives. The possible impacts and responses to price  
17 increases are analyzed across five types of farming systems derived from a survey of 50 farms  
18 in the spring of 2003.

## 19 **Irrigation management in the Jordan Valley**

### 20 *Irrigation in the Valley*

21 Irrigation has long been developed adjacent to wadis, on their alluvial fans in the Jordan  
22 Valley, and wherever springs are available (Khouri, 1981). Large-scale public irrigation dates  
23 back to the establishment of the Jordan Valley Authority (JVA) and to the construction,

1 between 1958 and 1966, of the 69-km King Abdullah Canal. In 1962, a land reform program  
2 created thousands of small farms (3.5 ha on average) and settled numerous families, including  
3 Palestinian refugees (Khouri, 1981; Van Aken, 2004). Irrigated agriculture thrived in the late  
4 1970s and 1980s.

5 In the Jordan Valley, the government improved and expanded irrigation facilities. Farmers  
6 adopted modern irrigation and cropping techniques, such as greenhouses, drip irrigation,  
7 plastic mulch, fertilizer and new varieties, and they utilized cheap labor from Egypt. During  
8 this period, agricultural revenues increased tenfold for vegetables and more than doubled for  
9 fruits. Irrigated agriculture in Jordan enjoyed a boom in production and profitability,  
10 described by Elmusa (1994) as the “Super Green Revolution.”

11 With increasing competition from neighboring countries (Turkey, Lebanon and Syria) and the  
12 loss of the Gulf export market in the 1990s, this profitability declined, strongly affecting farm  
13 revenues (GTZ, 1995; Fitch, 2001; Jabarin, 2001). The sector's contribution to Jordan's Gross  
14 Domestic Product declined from 8.1% in 1991 to 3.6% in 2003 (Nachbaur, 2004). At the  
15 same time, competition for water also increased as freshwater was progressively transferred to  
16 urban uses in the highlands. As a result, the agriculture sector has become more vulnerable to  
17 droughts, and agriculture in the southern part of the Valley is increasingly supplied with  
18 treated wastewater (see McCornick et al., 2001, 2002; THKJ et al., 2002; THKJ and MWI,  
19 2004a; JICA, 2004).

20 We focus on the northern and middle directorates of the Jordan Valley, where JVA's water  
21 allocation rules apply. The irrigated area is 19,345 ha, with 43% of the area producing  
22 vegetables (both in open fields and under greenhouses), 42% under citrus, and the remaining  
23 area planted to banana and cereals. A conversion from the earlier gravity network to  
24 pressurized systems was completed in the mid-1990s. Irrigation water is now provided to

1 farmers from pumping stations that draw water directly from the King Abdullah Canal,  
2 supplying collective pressurized networks serving areas of approximately 400 to 500 ha.  
3 Farming systems in the Valley are heterogeneous. The survey identified five categories of  
4 farming systems (Table 1), including: 1) family farmers who either own or rent the land and  
5 grow vegetables in open fields; 2) entrepreneurial farmers who use capital, knowledge and  
6 labor-intensive techniques such as greenhouses and earn a high return on investment; 3)  
7 citrus orchards in the north of the Jordan Valley, operated either by owners or by managers  
8 hired by absentee investors; 4) highly profitable banana farms in the north of the Valley; and  
9 5) mixed farms with more extensive vegetable cultivation combined with small orchards (the  
10 poorest category of farmers).

11 The main differences between these farming systems are the degree of capital use and intensity  
12 of production, the type of land tenure, the irrigation technology used, and whether  
13 management is by owners or tenants. Crop budgets and a review of the constraints specific to  
14 each farming system were undertaken and consistency with other studies was checked  
15 (Salman, 2001b; ARD and USAID, 2001b). A detailed description of these farming systems  
16 can be found in Venot et al. (2007).

17 *Insert Table 1. Profile of main farming systems (Jordan Valley, northern and middle directorates).\**

### 18 *Water Allocation*

19 Since the 1960s, water has been allocated through a system of crop-based water quotas,  
20 coupled with volumetric pricing, beginning in 1961 at a cost of \$0.00141 fil/m<sup>3</sup> (Hussein,  
21 2002). The official quota system has undergone several changes since the 1960s and has been  
22 used mainly as a guideline, with adaptations according to circumstances and national  
23 priorities (THKJ and JVA, 1988, 2001). According to quotas defined in 1988 (THKJ and

1 JVA, 1988), each plot of vegetables grown between mid-April and mid-December received 2  
2 mm of water per day. Citrus and bananas were supplied with 4 and 8 mm per day,  
3 respectively, from the beginning of May to the end of October. For all crops, water was  
4 supplied on demand during the rest of the year, when demand is lower.

5 Bananas and citrus are thirsty crops and have been cultivated traditionally in the northern part  
6 of the Jordan Valley (Khoury, 1981; Elmusa, 1994). In 1991, the orchard areas that could  
7 claim larger irrigation quotas were "frozen", institutionalizing inequity in access to water in  
8 the Jordan Valley. In 2004, in contradiction to its policy to reduce demand, the JVA also  
9 legalized citrus orchards planted between 1991 and 2001, granting them the citrus allocation  
10 instead of the vegetable quota they received earlier. All other areas continue to receive the  
11 vegetable allocation, provided that farmers declare to the JVA that they are cultivating their  
12 plots.

13 The 1997-1999 period was marked by a severe drought that forced reduced allocations. In  
14 1999, vegetables and citrus farms received 75% of their allocation, while banana farms  
15 received 85% of their quota. Allocations were reduced by 25% in 2000 and 2003, and by 50%  
16 and 40% during the summers of 2001 and 2002, respectively (MREA and JVA, 2006). Some  
17 areas were left fallow and yields were significantly reduced, notably in citrus and banana  
18 plantations. Lower quotas have been maintained ever since, except in the south of the Valley,  
19 where treated wastewater ensures a more reliable supply.

20 In 2004, the JVA reduced quotas to a level close to the reduced quotas of 1999 to better match  
21 supply and crop water requirements (THKJ and JVA, 2004; Table 2). At a regional scale, this  
22 generated total freshwater savings, in the northern and middle directorates, of about 20.2  
23 Mm<sup>3</sup>/yr between April and October, roughly equivalent to 20% of the pre-1999 average  
24 amount of water delivered. The savings have been reallocated to domestic use in Amman.

1 *Insert Table 2. Current quota system in the Jordan Valley.*

## 2 *Operation and Maintenance Cost Recovery*

3 JVA's revenues from irrigation water have gradually increased with time, as water charges  
4 established at \$0.0014 /m<sup>3</sup> in 1961 later increased to \$0.0042 /m<sup>3</sup>, then to \$0.0084 /m<sup>3</sup> in  
5 1989, and to an average of \$0.021 /m<sup>3</sup> in 1996 (GTZ, 1993; FORWARD, 1998). A planned  
6 increase to \$0.035 /m<sup>3</sup> has been delayed.

7 Revenues from water charges covered one-sixth of O&M costs from 1988 through 1992  
8 (GTZ, 1993; Hussein, 2002), implying an average annual subsidy of \$3.4 million. In 1995,  
9 revenue accounted for less than 25% of O&M costs. Water charges were increased more than  
10 twofold in 1996. In 1997, with a rate of nonpayment of 20%, average revenues were  
11 equivalent to \$0.017 /m<sup>3</sup> compared with \$0.025 /m<sup>3</sup> of O&M costs, implying a recovery rate  
12 of 68% (FORWARD, 1998; World Bank, 2001).

13 Calculations for 1988 through 1992 show that fixed asset depreciation and financing costs  
14 were twice as much as O&M costs (GTZ, 1993). Similarly, the ratio of average capital costs  
15 to O&M costs was 2.07 from 1997 through 2002 (THJK, 2004).

16 Based on the current block tariff system established in 1995 (Table 3) and the latest unit costs,  
17 we have estimated the yearly cost of water for each type of crop, considering that farmers use  
18 their full irrigation quotas (Venot et al., 2007). Total water costs are higher for banana  
19 plantations (\$350/ha/yr) than for citrus orchards (\$138/ha/yr). They are lowest on vegetable  
20 farms, which require less water (\$67/ha/yr). The use of the new quotas led to lower water use  
21 and consequently to a lower recovery of O&M costs, because fixed costs such as salaries do  
22 not vary with actual supply. Water is now charged at an average price of \$0.018 /m<sup>3</sup>,  
23 compared with \$0.021 /m<sup>3</sup> in 1997. Current payments considering a 100% rate of recovery

1 amount to 72% of O&M costs, while full costs are three times higher than O&M costs (THJK,  
2 2004).

3 *Insert Table 3. Current irrigation water tariff structure in the Jordan Valley.*

#### 4 **Analysis of responses and impacts**

##### 5 *Possible responses to increased water prices*

6 Farmers may respond to falling net income resulting from higher water prices in several ways,  
7 including: a) saving water by improving on-farm water management practices, b) adopting  
8 improved irrigation technology, c) shifting cropping patterns, d) renting out land, or  
9 discontinuing agriculture in the case of a tenant, e) other secondary responses (illegal water  
10 use, bribery, and tampering of structures), or f) doing nothing, and just paying the higher  
11 water charges. The response selected depends on the relative costs and benefits of these  
12 options. Beyond their economic impact on crop budgets, the first four options above are also  
13 constrained by the technical, financial and cultural factors reviewed below.

14 a) *On-farm management.* By improving on-farm practices farmers can reduce water losses  
15 and thus possibly decrease farm water requirements and their resulting costs. Yet, there are  
16 several constraints to increasing on-farm irrigation efficiency under current conditions:

- 17 • First, farmers experience many difficulties because of deficiencies in the collective  
18 pressurized networks that result in variable pressure and substantial variation in water  
19 distribution. Deficits are observed in higher locations, on sandy soils, and at the ends  
20 of water distribution lines. Secondary irrigation networks designed for 6 l/s flows were  
21 eventually equipped with 9 l/s or 12 l/s flow limiters after farmers complained that the  
22 pressure was too low. This impeded the proper functioning of the networks. Rotations

1 are difficult to establish and not respected, and water theft and tampering with  
2 equipment are pervasive (GTZ, 2004; MREA and JVA, 2006).

3 The importance of stable pressure is illustrated in the case of farmers in the extreme  
4 north of the Valley, most of whom initially shifted from gravity to micro-irrigation  
5 systems after pressurization of the network by the JVA in 1996. Most farmers reverted  
6 to gravity irrigation, as the delivery service did not match their expectations (Bourdin,  
7 2000).

8 • Farmers also experience many technical problems due to: micro-irrigation systems  
9 that have been installed without technical guidance in 70% of cases; direct connection  
10 of old farm pipe networks to the JVA's pressurized system; poor design of blocks and  
11 rotations; and problems of filtration and clogging (Wolf et al., 1996; Courcier and  
12 Guérin, 2004; Shatanawi et al., 2005).

13 • Unless water can be traded, the economic incentive for a farmer to save water is small  
14 (Development Alternatives Inc., 2004) because: 1) he cannot use the water saved to  
15 expand cultivated land, and 2) the system of monthly quotas limits the abstraction of  
16 canal water at pumping stations. Water savings are not possible during critical periods  
17 in spring and autumn, because demand exceeds supply (Petitguyot, 2003) and the  
18 marginal value of water far exceeds its marginal cost. During the rest of the year,  
19 efficiency is lower because supply exceeds demand, but this occurs at times when  
20 there is no alternative use for water. If water storage facilities are not available, there  
21 is little rationale for saving water.

22 In addition, the desirability of further water savings is not fully established, as it is  
23 feared that reduced salt leaching would increase salinity problems in the Valley  
24 (McCornick et al., 2001). In the early 1990s, for example, the JVA encouraged  
25 farmers to take water free of charge in the winter months for leaching purposes (Wolf

1 et al., 1996). Furthermore, citrus trees can abstract water from as deep as 1.50-2.50 m,  
2 thus tapping part of the “excess” supply that has been stored in the ground during this  
3 surplus period (Arrighi de Casanova, 2007a).

- 4 • In most cases, farmers are billed according to their water quotas and not according to  
5 their effective use, either because the meter has been broken or because the actual use  
6 indicated is suspiciously low. When a meter reading indicates a volume less than 75%  
7 of a quota, the farmer is charged for the full quota.

8 b) *Adoption of technology*. Technological improvements can enhance irrigation efficiency.

9 Better on-farm irrigation is possible if pressures in the main network are stable or if  
10 intermediate storage (farm ponds) and individual pumps are available. Internal rotations can  
11 then be redefined to better balance pressure in the network, but this requires technical  
12 assistance and capital. Existing users of micro-irrigation can improve irrigation uniformity if  
13 they redesign their network, in particular to use larger secondary pipes and better balance  
14 irrigation blocks, but they also need improved filtration, more frequent renewal of drippers,  
15 and more skilled operations.

16 MREA and JVA (2006) have shown that improving existing micro-irrigation systems would,  
17 on average, cost \$1,075, \$1,330, \$970, \$1,435 ha<sup>-1</sup> of citrus, bananas, and vegetables, either in  
18 open fields or under greenhouses, respectively, i.e., annualized investments of about \$205,  
19 \$224, \$147 and \$185 ha<sup>-1</sup>, depending on the average lifetime of the material, corresponding to  
20 added net revenues of \$430, \$1,460, \$820, \$650 ha<sup>-1</sup> yr<sup>-1</sup>. These are average values that vary  
21 with the type of irrigation technology (gravity, open tubes, micro-sprinklers and drippers).  
22 These values were observed in pilot projects under relatively controlled conditions and should  
23 therefore be viewed as upper limits. Redesigning requires technical assistance and computer

1 software to define blocks with a uniform pressure, stressing that improvements in irrigation  
2 are knowledge-intensive.

3 The estimated costs of converting to micro-irrigation are from \$1,400 to \$2,400 ha<sup>-1</sup> for citrus  
4 and \$2,900 ha<sup>-1</sup> for bananas. These costs represent annualized investments of \$263-462 ha<sup>-1</sup>  
5 yr<sup>-1</sup> for citrus and \$615 ha<sup>-1</sup> yr<sup>-1</sup> for bananas, depending on specifications. These investments  
6 might generate additional average net revenues of \$850 ha<sup>-1</sup> yr<sup>-1</sup> for citrus and \$425 ha<sup>-1</sup> yr<sup>-1</sup>  
7 for bananas, after accounting for depreciated investment costs (MREA and JVA, 2006). If  
8 pressure is too low to maintain a desirable supply rate, drippers will clog more easily and  
9 farmers will need to invest an additional \$410 ha<sup>-1</sup> in improved filtration or an intermediary  
10 farm pond and pump. Micro-sprinklers are more susceptible to low pressure, but drippers are  
11 more sensitive to variations in pressure.

12 Three important points can be made. First, the adoption and improvement of micro-irrigation  
13 technologies are, on paper, financially attractive, both before and after an increase in water  
14 costs (and more so before than after). Therefore, increasing water prices can motivate farmers  
15 to invest in technology, with the possibility of increasing income rather than incurring higher  
16 costs. However, adoption is often constrained by lack of capital or credit, as the costs of  
17 investing in technology in citrus farms are higher than the average annual net revenue (Table  
18 5). Smaller, indebted farmers, or ones without collateral, cannot easily access credit and,  
19 therefore, retain older, simpler production methods, or rent out their land to commercial  
20 growers. Some urban absentee owners also have strategies that are inconsistent with  
21 intensification.

22 Second, micro-irrigation increases profitability by improving crop yields and quality, through  
23 better irrigation scheduling and uniformity. In addition, farmers can improve their control of  
24 nutrient status by applying fertilizer through a drip irrigation system (fertigation). Many  
25 farmers justified their investments in micro-irrigation from the 1970s through the 1990s by

1 intensifying production and marketing higher-quality crops. Water savings were not  
2 substantial, as farmers used their full water quotas, regardless of their irrigation technology.

3 Third, field application efficiency is higher when using micro-irrigation, but this results from  
4 an increase in the fraction of water transpired productively by the crop, due to a more uniform  
5 water distribution, rather than from reduced water diversions to farms.

6 c) *Crop choice*. Higher water charges reduce farm-level net revenue and can motivate shifts to  
7 low-water-consuming crops and/or higher-value crops (Pitman, 2004; THKJ, 2004). The net  
8 revenue from citrus production is less than that from production of vegetables, mangoes,  
9 guava, grapes or dates that are becoming popular in some parts of the Valley. Banana  
10 production is a profitable enterprise that can be replaced by crops with lower water  
11 requirements such as grapes or dates. Despite the apparent attractiveness of these newer crops,  
12 many farmers continue to produce citrus and other less-profitable crops.

13 Some farmers do not grow the most profitable crops due to environmental constraints (soil  
14 type, salinity, temperature), lack of skill or capital, indebtedness, alternative income sources,  
15 age, risk aversion and drudgery (Molle and Berkoff, 2007). It is difficult for many farmers to  
16 adopt riskier, more intensive and time-/input-consuming crops, unless relatively stable market  
17 opportunities are available.

18 Jordan's agriculture is notably constrained by difficulties in identifying and adapting to  
19 changes in market demand (Salman, 2001b; DOS and FAO, 2002; Al-Zabet, 2002; Nachbaur,  
20 2004). For example, date production is attractive because palm trees are salt-resistant and  
21 dates attract high prices. However, date production has several drawbacks from the  
22 perspective of small-scale extensive farmers. In particular, date palms require five years to  
23 come into production, post-harvest operations are difficult to master, and only high-quality  
24 products reach the most profitable markets. Farmers facing higher water prices might wish to

1 intensify production, but production and marketing constraints can limit farm-level  
2 responsiveness.

3 Many large citrus groves are owned by absentees whose livelihoods do not depend on  
4 agriculture. Their orchards have value in terms of social prestige and recreational use, and  
5 their production goals are not driven primarily by economic motivations (GTZ, 1995;  
6 Lavergne, 1996; Venot et al., 2007). These owners may not shift to a more intensive and time-  
7 consuming activity to preserve a secondary agricultural income. Some have even declined to  
8 accept highly subsidized equipment and design in pilot areas (Arrighi de Casanova, 2007b).

9 Another disincentive for farmers to shift from producing citrus and bananas to producing  
10 vegetables is the consequent loss of their higher water quota, with little hope of obtaining it  
11 again if they ever would like to revert to producing tree crops.

12 d) *Land rental*. Since 2001, land sales and renting have been allowed in the Jordan Valley,  
13 although renting plots had already become a widespread practice. As land pressure in the  
14 Valley is very high, farmers who practice extensive agriculture may cede their land to other  
15 farmers who achieve higher profitability, either because they have other occupations or  
16 because net revenue falls below land-rent value, estimated at \$570 ha<sup>-1</sup> yr<sup>-1</sup> (Salman, 2001b).  
17 Because 87% of farm managers are tenants (Salman, 2001a) and farm 51% of the total area,  
18 the most vulnerable farmers might retire from agriculture, although it is uncertain whether  
19 economic alternatives will be available to them.

20 e) *Others*. Last, it is worth mentioning that raising water charges much higher or curtailing  
21 quotas further might lead farmers to respond by: tampering with, or destroying, meters;  
22 bribery; or defaulting (Courcier and Guérin, 2004; MREA and JVA, 2006). Indeed a large  
23 number of meters have been broken, in part as a response to the very costly fines imposed on  
24 illegal use of water. Unrest and political interventions are also possible and likely reactions, as

1 when the army recently intervened to quell violent conflicts that erupted in the south of the  
2 Valley after the government attempted to collect unpaid land and water fees (Al-Hanbat,  
3 2007; Al-Dustour, 2007). Such outcomes are not attractive for the government, which has  
4 little incentive to antagonize supportive segments of society unless gains are expected to be  
5 substantial (Richards, 1993).

#### 6 *Economic impacts and adjustments at the farm level*

7 Based on the constraints and economic considerations discussed above we evaluated  
8 responses to increasing water prices in three different scenarios. In scenario A, we consider  
9 that water prices increase to a level where the O&M costs of the JVA are recovered. This is  
10 the primary objective of water pricing policies in Jordan (THKJ and MWI, 1998c, 2002;  
11 FORWARD, 1998; Salman, 2001a; THKJ et al., 2002; THKJ, 2004). In scenario B, we  
12 consider a water price increase allowing the recovery of total costs of irrigation in the Jordan  
13 Valley (O&M plus capital costs). In both scenarios, we retain the block-tariff system (Table  
14 3). Scenario C is based on a recommendation by THKJ (2004) that prices in the Valley should  
15 be raised to 80% of the present average cost of water borne by farmers in the highlands. In  
16 this scenario, water is charged at a flat rate of \$0.116/m<sup>3</sup> (Al-Hadidi, 2002) regardless of the  
17 volume of water used on the farm.

18 We first analyze the financial impact of these scenarios on the different farming systems,  
19 assuming that farmers merely pay for the water fee (situation [f]), *ceteris paribus*, including  
20 crop mix, irrigation efficiency and delivered water. The rate of fee recovery is assumed to be  
21 100%. This provides a benchmark for the relative costs and benefits, and advantages and  
22 drawbacks of other options ([a] to [e]) in order to evaluate farmers' likely strategies.

23 The analysis of farmers' decisions cannot be based on crop budgets only. We must also  
24 consider both the *a priori* positive financial incentives to adopt improved technology or high-

1 value crops, and the factors that impede these changes, such as risk and alternative farmer  
2 strategies. Although such an analysis is contingent by nature, it attempts to capture the  
3 diversity of farming systems, constraints and farmer strategies. Table 4 describes the average  
4 water costs for each crop and scenario (assuming that farmers use their full quota), and Table  
5 5 presents their financial impacts on each farming system.

6 *Insert Table 4. Crop-based water costs according to three different levels of price increase.*

7 Water-cost increases in scenarios A and B are 1.4 and 4.15 times, respectively, of present  
8 values. In scenario C, due to the implementation of a flat charge, water costs increase 8.7  
9 times for vegetables, 8.5 times for citrus and 5 times for bananas. Extensive farming systems  
10 (citrus and mixed farms) would be most impacted because water charges represent a large  
11 portion of total costs (on citrus farms) and because net revenue is very low (Table 5).

12 *Insert Table 5. Impact of different levels of water price increase on farming systems in the*  
13 *Jordan Valley.*

14 Scenario A would have a limited impact on most farming systems in the Jordan Valley. Net  
15 revenues on vegetable and banana farms would decrease by less than 1% and 2%,  
16 respectively. Mixed farms would also be slightly affected by the increase (-2.6%). Finally,  
17 citrus farming systems would be the most affected. Net revenues would decrease by 4.2% to  
18 13.2% on farms with micro-irrigation and gravity irrigation, respectively. In the latter case,  
19 the impact is higher but these absentee owners have other sources of revenue and are therefore  
20 less sensitive to changes in farm revenue. In sum, these impacts are unlikely to modify very  
21 much farmers' perceptions of the constraints to intensification. The motivation provided by  
22 declining revenues seems quite modest.

1 In scenario B, farm net revenues would decline more substantially. Productive systems  
2 (vegetables in open fields or under greenhouses) would again be slightly affected, with net  
3 revenue decreasing by about 2.8% to 5.5% and little change expected in current farming  
4 strategies. Mixed (poorer) farms would be substantially affected (-20.1%). Because net  
5 revenues are nearer to land rental value ( $\$570 \text{ ha}^{-1}$ ), owners will increasingly rent out their  
6 land, while tenants will increasingly seek other jobs, unless better market opportunities and  
7 subsidies for modernization are available (Table 5). Adoption of micro-irrigation ( $\$1,760 \text{ ha}^{-1}$ )  
8 would offset their losses and increase revenue by more than 40% (i.e., by  $\$670 \text{ ha}^{-1} \text{ yr}^{-1}$ ) but  
9 this remains hindered by risk and the need for credit.

10 Net revenues from banana production decrease by 8.8% to 15.8%, so that some farmers will  
11 be motivated to change to more profitable orchard crops that require less water, such as date  
12 palms. Incentives will remain limited unless import tariffs on bananas are lowered. Such  
13 diversification would involve only the best-capitalized and most entrepreneurial farmers, i.e.,  
14 no more than 50% of all banana farmers. As 50% of bananas are still irrigated by gravity  
15 systems, adoption of micro-irrigation might limit financial losses. For such farmers, capital is  
16 less likely a constraint, as the investment cost is  $\$2,900 \text{ ha}^{-1}$  compared with annual revenues  
17 of  $\$7,000 \text{ ha}^{-1}$ . However, the additional maintenance and operation burden of filtering and  
18 cleaning drippers is substantial. Higher water costs of  $\$1,100 \text{ ha}^{-1}$  would be only partly offset  
19 by the  $\$425 \text{ ha}^{-1} \text{ yr}^{-1}$  generated by higher yields.

20 Finally, citrus farms would be greatly affected. The profitability of family farms already using  
21 drip irrigation would decrease by one third. Family farms include many small owners who are  
22 likely to improve design, equipment and management along the lines defined earlier, with  
23 investments of  $\$1,075 \text{ ha}^{-1}$ , but with additional revenue of  $\$430 \text{ ha}^{-1} \text{ yr}^{-1}$  that will almost cover  
24 additional water costs ( $\$435 \text{ ha}^{-1} \text{ yr}^{-1}$ ). Citrus farmers still using gravity irrigation will have a  
25 strong incentive to capture the gains from a shift to micro-irrigation, with net revenues

1 increasing from \$400 ha<sup>-1</sup> to \$815 ha<sup>-1</sup> instead of becoming negative if response [f] is selected  
2 (Table 5). Yet this demands a high initial investment, equivalent to more than three years of  
3 annual revenue, and poses problems for such growers, 70% of whom are family farmers,  
4 including shopkeepers, civil servants, retirees, old farmers, and widows. Financial incentives  
5 will be the same for richer absentee owners, but these owners are more likely to accept losses,  
6 depending on their preferences for leisure and prestige, and for nonlabor-intensive agriculture  
7 (GTZ, 1995; Lavergne, 1996; Venot et al., 2007).

8 All citrus farmers have the same incentive to diversify into other fruit trees, because fruits  
9 such as dates, mangoes, guava and grapes are more profitable than citrus. However, the  
10 adoption of improved technology or higher-value tree crops largely depends on the will and  
11 ability of farmers to intensify and on the availability of stable market opportunities. If their  
12 perceptions of risk, drudgery or capital constraints remain negative, the primary option that  
13 remains will be to rent their land to investors. On farms irrigated with gravity or drip systems,  
14 prices would motivate improvements in economic efficiency.

15 Finally, scenario C would have a dramatic impact on agriculture in the Jordan Valley. Citrus  
16 orchards would no longer be profitable and would be replaced completely in one of the ways  
17 described above. For well-capitalized banana farms, a partial shift to date palm and other  
18 trees, and the use of more efficient drip irrigation systems might be observed, but the  
19 likelihood of losing the higher water quota will dampen farmers' enthusiasm. Mixed farm  
20 operators would see their profitability decrease by one-half and would rent out their land.  
21 Tenants, if they have the financial capacity, will accept the risk of intensifying or will be  
22 replaced by more entrepreneurial farmers. The profitability of greenhouses would decrease by  
23 6.9%, but they would be the only farms to withstand the pressure, for lack of cost-effective  
24 alternatives (MREA and JVA, 2006).

1 Open-field vegetable farms would lose 13.6% and would consider improving water  
2 application (response [a]) or adopting improved irrigation systems. Response [b] would offset  
3 the losses due to higher water costs and increase revenues by 11%. Further intensifying  
4 agriculture by building greenhouses ( $\$25,000 \text{ ha}^{-1}$  for a greenhouse only) is unlikely to be  
5 observed on a large scale due to critical capital and environmental constraints. This third  
6 scenario is very unlikely, as it would disrupt the Valley economy and exacerbate the political  
7 protests that have erupted previously in the wake of less-serious policy changes, as in the case  
8 of groundwater use in the highlands (Pitman, 2004).

9 Changes stimulated by high water prices would, therefore, likely include technological change  
10 and (less so) changes in cropping patterns, and lead to higher water productivity. We have  
11 earlier discarded the possibility of significant water savings under the present monthly quota  
12 system because the marginal productivity of water is too high in the critical period of April  
13 through October, while there is no alternative use for water when supply exceeds demand.  
14 The incremental value of water depends on the crop and its physiological stage, but in this  
15 critical period, which generally includes flowering and/or fruit formation, it is higher than the  
16 average water productivity, which is itself an order of magnitude higher than the marginal  
17 cost of water.

18 This remains true for all crops in scenarios A and B, with one exception: gravity irrigation of  
19 citrus farms in scenario B, in which the average water productivity ( $\$0.0004 / \text{m}^3$ ) is slightly  
20 lower than average water costs ( $\$0.00057 / \text{m}^3$ ). In the critical period, the marginal cost of  
21 water is  $\$0.00071 / \text{m}^3$  for the second tier in the block tariff, while the marginal productivity of  
22 water is much higher than the average.

23 Water stress at flowering and fruit formation stages can substantially reduce yields (Arrighi de  
24 Casanova, 2007b). The value of maintaining water deliveries during those stages is reflected

1 in bribes paid for illegal water at such times, which can be 10 times higher than the marginal  
2 cost of water. During the on-demand period, however, the marginal cost is \$0.00047/m<sup>3</sup> (first  
3 tier), close to the average value, suggesting possible cost-effective water savings over 2,400  
4 hectares of citrus.

## 5 **Discussion and prospects**

6 The sociopolitical and economic contexts in which water policies in general, and pricing  
7 policies in particular, are embedded often determine much of what is eventually possible and  
8 desirable (Dinar and Saleth, 2005; Molle and Berkoff, 2007).

9 Several factors limit the scope for pricing mechanisms to improve irrigation and economic  
10 efficiency. We have stressed that suboptimal irrigation efficiency is due partly to unstable  
11 pressure in collective pressurized networks. These on-farm networks are subject to many  
12 technical problems, such as the clogging of emitters, nonuniformity of water application, and  
13 poorly designed block layouts and rotations. Another source of inefficiency, independent of  
14 farmers, is the lack of storage capacity at the system level. With inadequate storage, water  
15 supply can exceed demand at times. To some extent, excess water can be used for leaching  
16 salts or stored in the soil profile, but these activities are not perfect substitutes for surface  
17 storage facilities. Where excess water cannot be stored and where irrigation deliveries are  
18 controlled by strict quotas when demand exceeds supply, the potential for saving water is  
19 limited.

20 These conditions explain why complete recovery of O&M costs pursued by the Ministry of  
21 Water and Irrigation is unlikely to "increase conveyance system and on-farm water use  
22 efficiency," as anticipated in the 2004 Masterplan (THKJ, 2004). From the correct assumption  
23 that "low prices for irrigation water provide limited incentive to improve on-farm  
24 efficiencies" it is too hastily inferred that raising prices will automatically improve on-farm

1 efficiency and should therefore be "a prime target for implementing improvements" (USAID,  
2 2006). A World Bank (2003a) report acknowledges that "it was anticipated that increased  
3 water tariffs [of 1995] would reduce agricultural water use. This did not happen."  
4 With limited scope for achieving water savings, farmers will potentially respond to increasing  
5 water costs by intensification. In intensive and profitable systems such as vegetable and  
6 greenhouse production, water costs are negligible compared to input and labor costs, and they  
7 will remain so at any politically acceptable level (Wolf et al., 1996). Farms with more  
8 extensive agricultural strategies will be more affected, including: 1) mixed farms and small  
9 orchards of citrus or banana that are prone to indebtedness and vulnerable (Salman, 2001a),  
10 and 2) absentee urban owners with other sources of revenue.

11 Price-induced pressure will have a beneficial impact if these farmers are to adopt improved  
12 technology and higher-value crops. As noted earlier, these options were already available to  
13 these farmers and there are sound reasons why, despite potentially high returns, farmers did  
14 not adopt them earlier. Farmers engaged in extensive agriculture are frequently indebted (Van  
15 Aken, 2004), wary of becoming so, or lack sufficient capital to embrace such risky ventures.  
16 Urban absentee owners have little interest in burdening themselves with intensive  
17 management and value their farms for other reasons.

18 Higher water prices can encourage competition, eliminate underachievers, and select more  
19 efficient farmers. For example, higher water prices might induce changes in citrus and  
20 banana cultivation or displace small farmers who might lease their plots to investors growing  
21 higher-value crops. Higher prices might increase farmers' financial vulnerability, motivating  
22 them to intensify production in ways that might increase the probability of bankruptcy or  
23 retirement from farming.

24 Pricing policies are more appropriate where farmers can easily find alternative occupations or  
25 sources of income. Where this is not the case, policymakers might inadvertently create

1 volatile sociopolitical situations. Helpful remedies include providing farmers with technical  
2 information that enables them to reduce the market and financial risks that are pervasive in the  
3 Jordan River Valley (Doppler et al., 2002). With increasing competition from other countries  
4 in the Middle East, identifying crops with a good return and limited risk is not easy. This goal  
5 has become a policy priority (Montigaud et al., 2006; Nachbaur, 2004; Salman, 2001b).

6 Public officials in Jordan are concerned also with the potential social and political costs of  
7 reforms, particularly with regard to poor farmers. The experience, for example, of the  
8 elimination of all direct subsidies to owners of small livestock herds from 1995 through 1997  
9 was effective in reducing herd sizes by 25% to 50%. This reduced overgrazing, rangeland  
10 degradation and desertification. However, the program reduced revenue and increased poverty  
11 (Pitman, 2004). Earlier consensus that attendant safety nets would be needed seemed to have  
12 been later forgotten (Richards, 1993). The government's reluctance to raise water prices  
13 before treated wastewater or market opportunities are available also indicates concern  
14 regarding potentially negative impacts in the absence of alternative opportunities.

15 Water pricing schemes largely reflect the political economy of a country, and political  
16 counterweights are often raised when prices depress revenues. The recent regularization of  
17 illegal citrus orchards in the Valley suggests that some landowners have enough political  
18 influence to counter the reduction of quotas. The high percentage of broken meters suggests  
19 that quotas which are too low and constrain water use can trigger defaulting, tampering or  
20 destruction of meters, social unrest and political stress, and corruption or collusion involving  
21 officials and farmers (GTZ, 2004; Courcier and Guérin, 2004).

22 The above analysis indicates that the primary objective of financial autonomy of the Jordan  
23 Valley Authority is attainable. Raising prices to recover O&M costs would not dramatically  
24 affect farmers. From the point of view of the state, such recovery is very important in terms of

1 fiscal discipline, but less so in absolute terms, because the current O&M subsidy to the JVA is  
2 worth less than 0.1% of state expenditures of \$3.7 billion (Jreisat, 2005).

3 Yet, despite higher recovery of state-borne O&M costs, water charges do not generate a  
4 virtuous circle of improved management and maintenance by either managers or farmers  
5 (Small and Carruthers, 1991; Easter and Liu, 2005; Molle and Berkoff, 2007). Positive  
6 incentives are lacking if the charges paid by farmers are not reinvested in the irrigation  
7 scheme, managers do not depend on the payments (which are sent to the Ministry of Finance),  
8 farmers control neither part of the revenue nor water deliveries, supply is uncertain, and water  
9 allocations are not transparent. In such situations, water pricing generates revenue, but does  
10 not cause substantial changes in the quality of water delivery.

11 Last, reducing agricultural demand and current diversions in the Valley through pricing alone  
12 is unattainable, as noted by Berkoff (1994), who recognized "that it is inconceivable that  
13 [charges] would be high enough to balance supply and demand." Under such circumstances,  
14 the higher-level objective of regulating intersectoral allocation through prices, expressed in  
15 the Agriculture Sector Structural Adjustment Loan despite considerable doubt from experts  
16 (Pitman, 2004), is also unrealistic, a conclusion now widely recognized as generic (Bosworth  
17 et al., 2002; World Bank, 2003b; Dinar and Saleth, 2005).

18 That "the partial tariff increase [in the Valley] satisfied an immediate objective of maximizing  
19 transfer of water to the highlands" (World Bank, 2003a) is also unfounded because the  
20 transfer is a bureaucratic decision completely independent of prices. Water transfers have  
21 been continuously increasing and effective. In the future most of the Valley might be irrigated  
22 with treated wastewater only (McCornick et al., 2002). Reallocation has been made possible  
23 by curtailing water use through quotas.

24 In water-scarce situations where volumetric control is possible, such as in Iran, Tunisia,  
25 Morocco, France, Italy, Spain, Jordan, and the United States, water quotas are often used

1 (Molle and Berkoff, 2007). Quotas are generally easy to understand, equitable, effective in  
2 reducing diversions, and have less impact on net revenue than price-based regulations. The  
3 primary disadvantage of quotas is their limited capacity to adjust to changes in demand. This  
4 is true in the Jordan Valley, where quotas create a disincentive for citrus and banana growers  
5 to shift to less water-intensive crops. When water users are unable to trade their quotas,  
6 careful downward adjustments of quotas, as made in the Valley since 1999, can motivate  
7 farm-level efforts to save water.

8 While the scope for improving irrigation and economic efficiency through price incentives is  
9 limited, several alternatives have been proposed, along the following lines:

- 10 • Flexibility of water supply at the farm level is obtained not only through exceptional  
11 requests but also through digging farm ponds to buffer irregular supply (Shatanawi et  
12 al., 2005), by using water from wadis and, wherever possible, by pumping  
13 groundwater. Many farmers have already implemented these options.
- 14 • Effective freshwater savings in the Jordan Valley might come from greater use of  
15 treated wastewater blended with freshwater in the north of the Jordan Valley, as  
16 proposed by ARD and USAID (2001b) (see also Al-Jayyousi, 2001; McCornick et al.,  
17 2002; KfW et al., 2006).
- 18 • Significant water savings could be achieved through better in-season distribution of  
19 water in the King Abdullah Canal. With the completion of the Wehdah dam on the  
20 Yarmouk River, it will be possible to provide flexible management of water  
21 allowances and increase economic output (Al-Jayyousi, 2001; Salman et al., 2001;  
22 Shaner, 2001; Courcier and Guérin, 2004). Monthly quotas could be transformed into  
23 yearly quotas, with farmers retaining the right to distribute water throughout the year  
24 according to their needs (Petitguyot, 2003). In the long run, quotas could be made

1 transferable, thus creating opportunities for technical and economic gains

2 (Development Alternatives Inc., 2004).

- 3 • The JVA might adopt bulk water allocation and charging procedures, whereby water  
4 user associations would manage a yearly amount of water and recover charges  
5 (JRVIP, 2001). This approach, however, is hindered by extant cultural and social  
6 structures, and would require significant changes in the agency (JVA)-farmer  
7 relationship (Van Aken, 2004).
  
- 8 • The banana area could be reduced by substantially raising the price of the higher tiers  
9 of the water quota so that revenue would be reduced without affecting other crops.  
10 Banana production could be made less profitable also by removing duties on imported  
11 bananas, in line with World Trade Organization rules (WTO, 1999; Montigaud et al.,  
12 2006). Such economic incentives could be quite efficient in inducing a shift toward  
13 other trees and a full conversion to drip irrigation, but the capital constraint and the  
14 potential loss of higher banana quotas are likely to hinder this shift if no positive  
15 incentives are available. A bonus might be granted to farmers who agree to shift from  
16 a high tree quota to the vegetable quota, providing that proper market opportunities for  
17 vegetables are ensured. This approach might be difficult to justify, however, given the  
18 recent contradictory measure granting new citrus quotas to land with vegetable quotas.
  
- 19 • Last, both irrigation and economic efficiency can be enhanced by conventional  
20 positive incentives that modify the environment in which farmers take decisions to  
21 invest and intensify. Positive incentives include: providing attractive output markets,  
22 crop insurance schemes for farmers tempted to diversify and further subsidies to adopt  
23 drip-irrigation and, gradually, to implement precision irrigation. In practice, because

1 pricing reforms often affect extensive family-based farming, concomitant state support  
2 to intensify or modernize is widely observed (Molle and Berkoff, 2007).

### 3 **Conclusion**

4 We conclude that some, but not all, benefits expected from water pricing policies can be  
5 expected to materialize in the Jordan Valley. On the positive side, a recovery of operation and  
6 maintenance (O&M) costs is achievable without major impact on revenues. The establishment  
7 of a block tariff system and the continued improvement in O&M cost recovery are notable  
8 achievements when compared with the situation worldwide (Bosworth et al., 2005; Molle and  
9 Berkoff, 2007). The relationship between water payment and improved water service should  
10 be enhanced by granting more financial autonomy to the Jordan Valley Authority. More  
11 substantial increases in water prices can also be expected to increase overall economic  
12 efficiency by motivating farmers to intensify and invest in technology, or to lease their land to  
13 investors. For banana farmers, this incentive will be increased if protective import duties are  
14 removed.

15 On the other hand, the current system of quotas, the lack of storage, and the technical  
16 difficulties experienced in the pressurized networks indicate that little water can be saved.  
17 Technical interventions improve irrigation efficiency not because water use is reduced, but  
18 because better uniformity and timing of water application enhance crop ET and yields. Real  
19 water savings may be possible if monthly quotas can be revised to form one annual quota. In  
20 such conditions the possibility of trading water would also enhance both irrigation and  
21 economic efficiency. Other enabling factors would need consideration, such as improving the  
22 control of the water supply.

23 Higher water prices would decrease the net revenue of citrus and banana farmers and motivate  
24 them to reconsider the benefits, risks and constraints of adopting new crops and technologies.

1 Higher water prices also would increase financial vulnerability, thereby increasing the  
2 financial risk of such choices. Positive incentives that reduce capital and risk constraints, and  
3 offer attractive cropping alternatives and exit options with compensation should be  
4 implemented in conjunction with higher prices.

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6

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