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Viability of increasing the tariff of freshwater for irrigation as a tool to stimulate wastewater reuse in the MENA region

M. Abu-Madi, R. Al-Sa'ed, O. Braadbaart and G. Alaerts

ABSTRACT

Despite water scarcity and high agricultural water demand in the Middle East and North Africa region, substantial proportions of treated wastewater are discharged into the environment and seas without proper utilization. All countries of the region, low pricing of reclaimed wastewater is a common tool to make reuse attractive. However, low pricing of reclaimed wastewater is ineffectual due to farmers' access to freshwater for irrigation at low tariff. Therefore, increasing the prices of freshwater in such a way that does not jeopardize feasibility of agriculture would promote irrigation with reclaimed wastewater even at increased prices. On one hand, it increases the gap between the price of freshwater and that of reclaimed wastewater, making the later more attractive. On the other hand, it would be used as a financial resource for funding the investment costs of the infrastructure needed for conveyance and distribution of reclaimed wastewater. This paper studies the viability of increasing the prices of freshwater and reclaimed wastewater. The results show that irrigation with reclaimed wastewater even for restricted irrigation can be as profitable as, and sometimes better than, freshwater irrigation. Some of the permitted crops such as fruit trees can be more profitable than vegetables. Thus, it appears that the level of knowledge farmers and others on the benefits of reclaimed wastewater is still limited.

Key words | irrigation, profit, reuse, tariffs, wastewater

M. Abu-Madi
Water Studies Institute, Birzeit University,
P.O. Box 14, Birzeit, West Bank,
Palestine
E-mail: *abumadi@birzeit.edu*

R. Al-Sa'ed
Water Studies Institute, Birzeit University,
P.O. Box 14, Birzeit, West Bank,
Palestine
E-mail: *rsaed@birzeit.edu*

O. Braadbaart
Wageningen University and Research Center,
Wageningen,
The Netherlands
E-mail: *okke.braadbaart@wur.nl*

G. Alaerts
UNESCO-IHE Institute for Water Education,
Delft,
The Netherlands
E-mail: *g.alaerts@unesco-ihe.org*

INTRODUCTION AND BACKGROUND

Across the world, the water policies and management practices in the last decades were often based on considering water as a free and renewable resource. As a result, water resources of many countries nowadays are under increasing pressure and suffer from scarcity. Countries started to (re)consider mechanisms to improve water use efficiency (Abu Qdais & Al Nassay 2001). This is especially true for agricultural irrigation, which consumes more than 89% of MENA's total water consumption. Irrigation water has long been considered a public good, which is provided to the public for free or at a nominal price. Only in recent years, the charging of a fee for irrigation water is receiving some attention aiming at covering system operation and maintenance cost, or recovering a portion of the initial investment. Also, only recently, the basic concept emerged that water is to be treated as an economic good (UNICWE 1992), and is being introduced in various countries. By treating water as an economic good, users can be given signals regarding the value of water to society through a variety of incentives, including pricing. Water pricing, in other words setting prices closer to their economic (or at least, financial true value), has been a relatively reliable tool to reduce freshwater consumption, ensure more efficient allocation and productive use, and simultaneously raise revenues for maintaining the infrastructure (Perry 2001; Johansson *et al.* 2002).

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Economic theory has long ago explained how correct pricing of private and public goods can lead to gains in economic efficiency. However, the extent to which these principles should be implemented remains a topic for debate. On one hand, it is argued that increased water tariff is regressive and reduces equity since it could have a negative impact on smallholder farmers and those practicing subsistence agriculture (Yoduleman 1989). Likewise, during periods of drought or scarcity, if tariff increases to the level correctly reflecting this scarcity, lower income groups may be disproportionally negatively affected (Dinar & Subramanian 1998). On the other hand, Rogers *et al.* (2002) argue that increasing the water tariff can improve equity. Higher water rates and, thus, higher income allow utilities to extend services to those currently not served and those currently forced to purchase water from vendors at very high prices. Besides, the price policy can help maintain the sustainability of the resource itself. When the tariff of water reflects its true cost, the resource will be put to its most valuable uses. In addition, Rogers *et al.* (2002) argue that if water resources are managed in an integrated manner where the economic, legal, and environmental aspects complement each other, increased prices do improve equity, managerial efficiency, and sustainability of the resource ("water resources" meant to include surface water, groundwater, and reclaimed wastewater).

Several cases of increasing the tariff of water have demonstrated a fall in consumption. In Israel, for example, a gradual 50% drop in freshwater use was reported after a series of tariff increases. Freshwater use in agriculture declined from 74 to 62% between 1986 and the early 1990 s whilst use of reclaimed wastewater proportionally increased, and overall productivity per unit land doubled (Sanz 1999; Ahmad 2000). In Metropolitan Barcelona (Spain), the introduction of the metering system and change of the pricing system to three consumption bands that charged at a progressively higher rate, resulted in a reduction of consumption by 16.9% in 75% of the cases (Mayers 1996). A similar experience occurred in Malvern (UK), after domestic supplies were metered. It is estimated that metering reduced the consumption by 6% (Twort *et al.* 1994). In Athens (Greece), raising the tariff of water on an increasing-block basis resulted in a monthly water consumption decline by 17–25% in 3–4 months following the introduction of the new pricing (Briassoulis 1995). Agthe & Billings (1996) showed that an increase in the marginal price of water by one US$/m^3 increases the probability of using low-flow faucets in Tucson (USA) by 46% and low-flow showerheads by 31%. All these cases are consistent and show that consumers are usually price-responsive in their use of water, and an increase in price could lead to the use of less water and adoption of more water-conserving or efficient technologies (Rosegrant & Ringler 1998).

Generally, the MENA countries adopt low pricing of reclaimed wastewater as a means to make its use attractive (Bahri & Brissaud 1996; MWI 2003; ONAS 2003). Inconsistently, the tariffs of freshwater for irrigation are kept relatively low, which makes the tariff of reclaimed wastewater less competitive. In all MENA countries, effective pricing of freshwater and reclaimed wastewater as well as agricultural-urban water transfers is very uncommon (Saghir *et al.* 2000). The average share of the water bill in income is around two percent and the urban water supply and sanitation are subsidized. In the MENA region in general, freshwater tariffs for irrigation are about 10 times lower than those for domestic and industrial consumption (Faruqui 2000). According to the World Bank (1996), the urban water tariffs in Morocco range from US$ 0.44 to 1.35/m^3, while the average tariff of water for irrigation is about US$cent 2.0/m^3. In Tunisia, farmers pay about US$cent 5.0/m^3 for irrigation water, whereas the total cost for production and distribution is about seven times higher. In the Jordan Valley where surface water is the major resource, the total estimated cost of irrigation water is about US$cent 5.2/m^3 of which about US$cent 2.9/m^3 as O&M costs. The tariff is about US$cent 1.6/m^3 while about US$cent 3.8/m^3 is a subsidy from the government.

In Jordan and Tunisia, agricultural irrigation consumes about 0.75 and 2.4 billion m^3/year, respectively (World Bank 1996; Hamdane 2002; Shatanawi & Salman 2002). The existing tariffs of irrigation water in Jordan and Tunisia vary from one scheme to another even for the same type of water. Increasing the tariff of freshwater by US$cent 5.0/m^3 would secure extra revenues of about US$ 37.5 and 120 million/year for Jordan and Tunisia, respectively. These figures would double if tariffs were increased by US$cent 10.0/m^3. The extra revenues are capable of improving the agricultural infrastructure, especially for use of reclaimed wastewater.

However, the consequences of this tariff increase on farming profitability are questionable.

In the MENA countries, it is not always the public authorities that supply irrigation water. Many farmers have their own facilities for meeting their water needs from surface as well as ground resources. For instance, many farmers in Jordan have their own groundwater wells where they do not pay any tariff for water, but they pay for energy (electricity and diesel) and for O&M of their pumps. In the same way, in the Jordan Valley, many farmers install their pumps on the banks of the King Abdullah Canal. In such instances, increasing the tariffs of water will have no influence on those farmers' behavior. However, another approach that has been applied in many parts of the world is increasing the energy prices and reducing subsidies. According to Al-Hamdi (2000), previous research on the effects of rising energy prices on groundwater abstraction is inconclusive. He argues that while some studies indicate a strong direct correlation between rising energy prices and water use, others have concluded that other factors play a more significant role than energy prices in determining the level of water use in agriculture. In the region in general, the water tariffs are comparatively small and thus other factors are likely to influence groundwater use more strongly. Schiffler (1998) concluded that any realistic increase in energy tariffs will simply reduce farmers' profit, but will not have a significant impact on groundwater abstraction. In areas under severe water stress, the social value of water may be higher than that incurred by the marginal cost of energy and consequently, even marginal cost pricing of energy may not create a strong disincentive for groundwater use (Al-Hamdi 2000). In this case, additional approaches might be needed through regulations and enforcement that restrict freshwater pumping.

OBJECTIVE AND METHODOLOGY

It is hypothesized that increasing the tariffs of freshwater for irrigation might make reclaimed wastewater competitive and increase revenues as well as resource sustainability without jeopardizing farming feasibility. In this scenario, even the tariffs of reclaimed wastewater could be comparatively raised. Accordingly, the objective of this study is to understand the effect of increasing the tariffs of freshwater and reclaimed wastewater for irrigation on agricultural profitability or profit.

This study depends mainly on the data collected in year 2003 through a field survey in 96 farms in Jordan and Tunisia. Simple algebraic spreadsheet calculations are applied for analysis of farmers' profit at different incremental increases to the existing water tariffs. The spreadsheet calculates the farmers' profit for a set of incremental increases of US$cent 5.0/$m^3$ to the existing tariffs of irrigation water (groundwater, surface water, blended water, and reclaimed wastewater).

In this study, agricultural profitability is analyzed from two different perspectives: (1) from economic standpoint, profitability is the balance between gross income and total agricultural expenditures including unpaid labor; input of farmers and their kin, and (2) from farmers' standpoint, their own labor value and its opportunity cost are barely considered, therefore usually not included. The total farming expenses are the sum of annual expenditures on (i) water, (ii) fertilizer, (iii) paid and unpaid labor wages, (iv) land preparation, and (v) use of pesticides and other inputs. The unit US$/ha/year is used for comparison of agricultural profitability.

RESULTS AND DISCUSSION

Effect of existing water tariffs on agricultural profitability

Results of this study show that agricultural profitability at existing water tariffs varies substantially from one farm to another (Tables 1–4). Certain crops are more profitable than others. However, the farm's profitability, however, does not only depend on crop type but also on: (i) soil fertility, (ii) effectiveness of irrigation, (iii) effective use of fertilizers and pesticides, (iv) farmer's technical and managerial skills, (v) crop marketing (vi) climate, (vii) availability and price or water, (viii) land size (economies of scale), and (ix) labor input and cost. In other words, each of these factors affects agricultural profitability. Profitability of using secondary treated wastewater for irrigation of fodder and cereal crops averages about US$ −160 and 970/ha/year when including, and excluding the unpaid labor, respectively. Profitability

Table 1 | Agricultural profitability of the surveyed farms at existing water tariffs

Water type	Existing water tariffs (US$cent/m^3)				Profit incl. farmers' own labor (US$/ha/year)				Profit excl. farmers' own labor (US$/ha/year)			
	Min.	Max.	Avg.	STD.	Min.	Max.	Avg.	STD.	Min.	Max.	Avg.	STD.
GW (n = 15)	1.0	57.1	29.3	24.7	−3,030	5,070	1,440	2,240	570	6,190	3,230	1,850
SW (n = 20)	5.0	26.2	10.0	4.7	−8,710	6,950	−826	3,750	1570	10,760	3,880	2,270
BW (n = 10)	3.3	8.6	6.1	2.03	−1,060	6,950	2,550	2,570	333	9,140	4,770	3,120
RW (n = 51)	0.1	5.7	1.4	0.7	−3,570	9,430	394	2,140	81	10,860	2,300	2,290

WW: Reclaimed Wastewater; GW: Fresh Groundwater; SW: Fresh Surface water; BW: Blended Water.

of using secondary treated wastewater for irrigation of fruit trees averages about US$ 800 and 3,430/ha/year, respectively, compared with that irrigated with fresh groundwater that averages about US$ 2,710 and 3,230/ha/year, respectively. Profitability of using reclaimed wastewater that is blended with fresh surface water for irrigation of vegetables averages about US$ 2,550 and 4,770/ha/year, respectively, compared with that irrigated with fresh groundwater that averages about US$ 370 and 3,160/ha/year, respectively, and that irrigated with fresh surface water that averages about US$ -910 and 3,950/ha/year, respectively. These results show that irrigation with reclaimed wastewater, especially when blended with fresh surface water, can be as profitable as, if not better than, irrigation with only freshwater. This is mainly due to the low water tariff and less use of expensive fertilizers.

Results also show that about 39% of the surveyed freshwater farms and 57% of the reclaimed wastewater farms are running in loss (negative profit) when recognizing the economic value of farmers' own labor. The difference between these two percentages is due to the high dependency of reclaimed wastewater farmers on paid labor, which might be attributed to the fact that farmers may not like their kin to work in farms irrigated with reclaimed wastewater. The question that arises at this point is, what makes such farmers persist despite their loss? Apparently, farmers conceive profit differently; for them, profit calculations do not necessarily include the unpaid labor that is provided locally. They do not recognize any opportunity cost of their kin's labor, most likely because opportunity itself does not exist, especially for wives,

Table 2 | Gross income of the surveyed farms in Jordan and Tunisia

Crops*	Income (US$/ha/year)			
	Min.	Max.	Avg.	STD.
Fodders and cereals (WW) (n = 23)	480	6,700	1,870	1,360
Fruit trees (WW) (n = 28)	2,380	12,500	5,460	2,460
Fruit trees (GW) (n = 6)	4,290	11,430	6,960	2,500
Vegetables (GW) (n = 9)	8,790	17,860	13,960	3,210
Vegetables (SW) (n = 20)	3,570	19,050	9,390	3,680
Vegetables (BW) (n = 10)	5,560	17,140	10,420	4,190

*Fodders include berseem, alfalfa, and sorghum. Fruit trees include apples, peaches, apricots, pears, and citrus. Vegetables include squash, tomatoes, potatoes, cucumber, cupflowers, and cabbages.

Table 3 | Net agricultural profit of the surveyed farms including farmers' input

Crops	Profit incl. farmers' own labor (US$/ha/year)			
	Min.	Max.	Avg.	STD.
Fodders and cereals (WW)	−3,570	1,930	−160	1,310
Fruit trees (WW)	−3,040	9,430	800	2,530
Fruit trees (GW)	740	5,070	2,710	1,710
Vegetables (GW)	−3,040	3,200	370	1,980
Vegetables (SW)	−8,710	6,950	−910	3,840
Vegetables (BW)	−1,060	6,930	2,550	2,570

Table 4 | Net agricultural profit of the surveyed farms excluding farmers' input

Crops	Profit excl. farmers' own labor (US$/ha/year)			
	Min.	Max.	Avg.	STD.
Fodders and cereals (WW)	80	3,030	970	790
Fruit trees (WW)	270	10,860	3,430	2,460
Fruit trees (GW)	1,170	5,430	3,230	1,520
Vegetables (GW)	570	6,190	3,160	2,070
Vegetables (SW)	1,570	10,760	3,950	2,310
Vegetables (BW)	330	9,140	4,770	3,120

daughters, and children. Consequently, agriculture performs as an employer to the whole farmer's family at provisional salaries. It has to be mentioned that the number of workers from farmers' family members is usually large while labor productivity is low, which is a major cause of loss when recognizing the economic value of farmers' own labor.

Effect of increased irrigation water tariffs on agricultural profitability

In addition to its cultural value, agriculture contributes to the national economy and food security. Besides, farmers are mostly poor. This partly justifies the large subsidy given by governments to the agricultural sector in all countries of the region. However, this contradicts the efforts that aim at stimulating the use of reclaimed wastewater. If the existing tariffs of freshwater remain unchanged, reclaimed wastewater can be attractive only if given to farmers at a very low tariff or free of charge. The benefits of a rational increase of freshwater tariffs are threefold. First, it would increase the gap between the tariffs of freshwater and reclaimed wastewater making the latter more attractive. Second, it might help in water saving and release pressure on the groundwater resource. Third, it could be used as a financial resource to recover the investment costs of conveyance and distribution for reclaimed wastewater. The first and second objectives might be viable at scheme level, while the third might be viable at national level. This is because the number of farmers using freshwater is much higher than that of farmers using reclaimed wastewater. As previously mentioned, many farmers control their own water resources through direct pumping of groundwater or surface water. In those cases, farmers do pay the full cost of water used since they have to pay for installing pumps and pipes as well as for energy and maintenance.

Based on the discussion in the previous section, the existing water tariffs have minor influence on agricultural profitability, mainly because these tariffs are very low. Increasing these tariffs by US$cent 5.0/m^3 reduces farmers' profit by US$ 250-700/ha/year (Figures 1–4). Increasing the existing water tariffs by US$cent 10.0/m^3 would double the aforementioned reduction in farmers' profit. Such a reduction in agricultural profitability is crucial for some farmers and trivial for others. Increasing the reclaimed

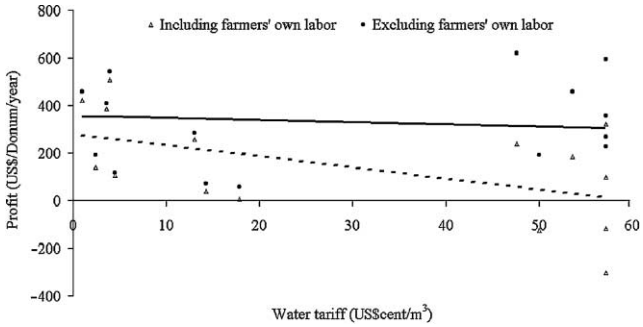

Figure 1 | Agricultural profitability vs. existing tariff of groundwater.

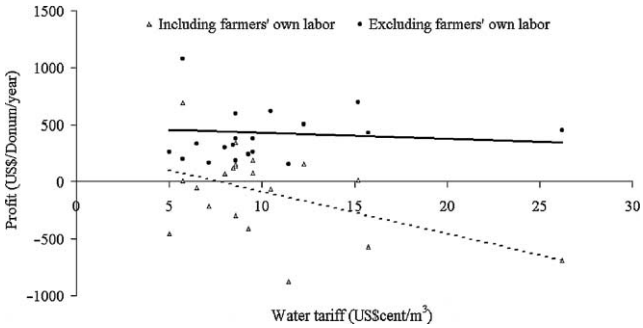

Figure 2 | Agricultural profitability vs. existing tariff of surface water.

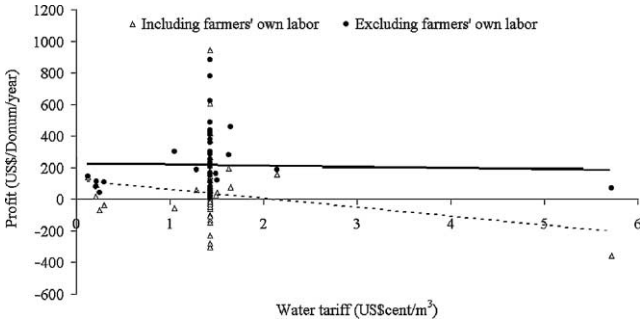

Figure 3 | Agricultural profitability vs. existing tariff of reclaimed wastewater.

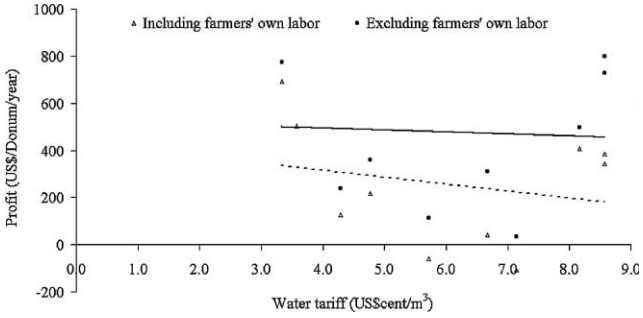

Figure 4 | Agricultural profitability vs. existing tariff of blended water.

wastewater tariffs by US$cent 5.0/$m^3$ makes irrigation of fodders and cereals unfeasible, even when excluding farmers' own labor. On contrary, farmers of fruit trees irrigated with reclaimed wastewater and farmers of vegetables irrigated with blended water as well as freshwater are tolerable to tariff increase by US$ 5.0-10.0/m^3. Profitability becomes intolerable when water tariffs are increased by US$cent 15.0/$m^3$ or higher.

In conclusion, the existing water tariffs are too low. Increasing these tariffs by US$cent 5.0 – 10.0/$m^3$ is not likely to jeopardize farming feasibility. Increasing tariffs beyond this limit would make agricultural irrigation unfeasible and might enforce farmers to shift to using reclaimed wastewater if tariffs are maintained low and if its supply and quality are reliable.

CONCLUSIONS AND RECOMMENDATIONS

Water pricing is a major factor in the incentive system that might make or break the proposition of agricultural irrigation with reclaimed wastewater. The existing tariffs of freshwater for irrigation are too low, which makes reclaimed wastewater uncompetitive. Increasing the tariffs of freshwater for irrigation would increase the gap between freshwater and reclaimed wastewater, on one hand, and increase revenues that could be employed for subsidizing reclaimed wastewater on the other hand. Results of this study show that water tariffs have a significant influence on farmers' profit. The MENA countries are recommended to review their water pricing policies and increase the tariffs of freshwater for irrigation. Wherever reclaimed wastewater exists, irrigation with freshwater has to be abandoned if the supplies of reclaimed wastewater can meet the agricultural demand. Where no reclaimed wastewater is available or where its supplies are not sufficient, access to freshwater can be unrestricted but tariffs have to be increased.

Results show that irrigation with reclaimed wastewater even for restricted irrigation can be as profitable as, and sometimes better than, freshwater irrigation. Some of the permitted crops such as fruit trees can be more profitable than vegetables. Thus, it appears that the level of knowledge farmers and others on the benefits of reclaimed wastewater is still limited. Awareness, education, and dissemination of results from other experiences are needed to help change attitudes. However, improving the quality of reclaimed wastewater in compliance with the standards for unrestricted irrigation improves the receptive market for this water.

At existing water tariffs, about 39% of the farms irrigated with freshwater and 57% of the farms irrigated with reclaimed wastewater are running a loss if the value of unpaid labor (farmers' input) is monetarized in the profit analysis. Apparently, farmers conceive profit differently, which contradicts with the economic theory. They neglect the opportunity cost or the economic value of their own labor. The only justification is that opportunity does not exist for farmers' wives, daughters, and children. Freshwater farmers are tolerable to increasing the present water tariffs by US$cent 5.0 – 10.0/$m^3$. Increase of freshwater tariffs by more than US$cent 10.0/$m^3$ makes irrigation unfeasible, which would force farmers to shift from use of freshwater to reclaimed wastewater, where available. However, imposing restrictions on the use of freshwater would be unjustified where the supply and quality of the reclaimed wastewater do not meet the agricultural demand within a specific irrigation scheme.

Farmers that irrigate fruit trees (especially apricots and peaches) with secondary treated wastewater and farmers that irrigate vegetables with blended water gain more profit than farmers that irrigate fodder crops and cereals. Farmers of fruits and vegetables are tolerable to increasing the tariffs of reclaimed wastewater to a level close to freshwater tariffs. Farmers of fodders and cereals can barely withstand the existing water tariffs.

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