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Perceptions of Farmers and Public Towards Irrigation with Reclaimed Wastewater in Jordan and Tunisia

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Abstract

Despite the high demand and severe shortage of water in Jordan and Tunisia, substantial amounts of treated wastewater are discharged into seas and valleys. This paper studies the perceptions of Jordanian and Tunisian farmers' and public towards reuse of reclaimed wastewater in irrigated agriculture. A field survey was conducted in both countries employing two sets of questionnaires and targeting 96 farmers and 326 households. The results reveal reasonably high levels of farmers' acceptance to use reclaimed wastewater and public acceptance to consume crops irrigated with this water. The study analyzes the factors that influence decisions of farmers and public to accept or reject irrigation with the reclaimed wastewater and related crops, respectively. The results also identify the major factors that might be influential in changing the perceptions and attitudes farmers' and public.

Key words: Farmers; public; perception; reuse; wastewater; Palestine.

Introduction

Jordan and Tunisia are among those Middle Eastern countries that suffer from severe water shortages against a growing demand. Long time ago, both countries were among few that realized the importance of utilizing reclaimed wastewater as a non-conventional resource of water. Therefore, a large number of wastewater treatment plants and storage facilities for reclaimed water were constructed in both countries. Reviewing the experience of both countries shows that wastewater reclamation and reuse is still very low when compared to the potential. Substantial amounts of treated wastewater are discharged into seas and valleys. Technically, the performance of the wastewater treatment technologies that are commonly applied is satisfactory to provide a water quality that is suitable for restricted irrigation. Besides, both governments provided all necessary facilities and infrastructure to convey the reclaimed water from the treatment plants to the storage and reuse sites. Financially, in order to encourage farmer to irrigate with reclaimed wastewater, both countries decided at high levels to provide this water at a very low tariff.

Wastewater reuse projects are too often planned and implemented based upon only technical and financial feasibility studies. Planners tend to discard the relevance of the beliefs and values of a culture that basically determine the perceived need for reclaimed wastewater and the degree of acceptability of reuse by the people who will be affected by the project; farmers and crop consumer (Bahri and Brissaud, 1996). Many studies that apply the contingent valuation survey technique have identified the following important factors that influence public perceptions with regard to wastewater reuse (Brouvold, 1988 and Khouri *et al.*, 1994) (i) degree of body contact, (ii) water conservation and environmental benefits, (iii), health effects, (iv) treatment and distribution costs, (ii) educational and awareness level, (iii) age, (iv) income, (v) religious prohibition, and (vi) opinion of reference or peer group. These factors are among the most decisive factors that determine success or failure of reuse projects, and vary widely from one part of the world to another. Thus, it may not be possible to generalize conclusions related to socio-cultural aspects in the context of wastewater

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reuse. Therefore, a thorough assessment of the local socio-cultural aspects is always necessary before promulgating general guidelines. Unfortunately, there are few in-depth studies of the socio-cultural aspects of reuse projects in the developing countries; thus, more research is needed (Al-Hamdi, 2000).

Khouri *et al.* (1994) attributed farmers' acceptance or rejection to use reclaimed wastewater to personal, rather than a cultural, bias. They reported that although in certain areas some farmers have rejected to substitute treated wastewater for available freshwater, other farmers of similar background in the same area have readily accepted wastewater irrigation. Mills and Asano (Mills and Asano, 1996) emphasize that only identifying the potential water users for planning purposes is not enough, but there must be some assurance before embarking on design and construction of reuse projects that the intended users (farmers) will use and pay for reclaimed wastewater. Planners of the eighties have rarely recognized the necessity for assessing the potential market for the reclaimed wastewater, which explains in part the existing gap between the planned and practiced reuse (Bahrl and Brissaud, 1996).

The main objectives of this study are to (i) assess the perception of farmers towards irrigation with reclaimed wastewater, (ii) assess the perception of common public to consume/buy crops watered with reclaimed wastewater, and (iii) better understand the factors that might change attitudes of farmers and public (crop consumers).

Methodology

A field survey was conducted in Jordan and Tunisia using two sets of questionnaires that targeted 96 farmers and 326 crop consumers in Jordan and Tunisia. The interviewed farmers were asked to rate their acceptance to use reclaimed wastewater for both restricted and unrestricted irrigation as "accept", "uncertain", or "reject". The unwilling and uncertain farmers were asked dichotomous (yes/no) questions for the reasons behind their decisions. The interviewed public were asked to rate their acceptance to buy crops as "accept" or "reject". Those who gave "reject" responses were asked dichotomous questions for the reasons behind their decisions. For both groups, these reasons were pre-identified based on the pilot-testing of the questionnaires. Both sets of questionnaires also presented a list of factors that might change current attitudes of farmers and crop consumers. This question was presented to all respondents irrespective of their acceptance to use reclaimed water and buy related crops.

A descriptive statistics are employed for analysis of the survey data since attempts to build significant regression models between perceptions and other variables did not succeed.

Results and Discussion

Acceptance of farmers to use reclaimed wastewater

The results of this study show that the percentages of Jordanian farmers that accept to use the reclaimed wastewater for restricted and unrestricted irrigation are about 30% and 80%, respectively, compared with about 67% and 82%, respectively, in Tunisia (Table 1). The percentages of farmers who are uncertain are about 28% and 18%, respectively. Farmers clearly prefer to use wastewater in an unrestricted fashion rather than for restricted irrigation only as they correlate the cropping freedom with increased profit. On the other hand, only about 22% and 7% of the Jordanian farmers were found to reject reclaimed wastewater for restricted and unrestricted irrigation, respectively, compared with about 10% and 8% of that in Tunisia; these appear to be mainly farmers who have access to freshwater (surface water, and owners of groundwater wells).

Table 1: Acceptance of the Jordanian and Tunisian farmers to use reclaimed wastewater

Country	For restricted irrigation						For unrestricted irrigation					
	Accept		Uncertain		Reject		Accept		Uncertain		Reject	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Jordan (n=46)	14	30.4	22	47.8	10	21.7	31	67.4	12	26.1	3	6.5
Tunisia (n=50)	40	80.0	5	10.0	5	10.0	41	82.0	5	10.0	4	8.0

These optimistic results demonstrate that farmers' acceptance has improved over the last 10 years. Thus, the results suggest a more promising era for reclaimed wastewater use for both restricted and unrestricted irrigation. However, more effort is still needed in order to improve the farmers' acceptance level through addressing the various factors that influence their perceptions and attitudes. The field survey (Tables 2, 3 and Fig. 1 and 2) identified some prominent factors that fuel the farmers' rejection and hesitation in these two countries: (i) availability of or accessibility to freshwater, (ii) distrusted water quality, and (iii) farmers' worries about crop marketing and acceptance of public to buy crops irrigated with wastewater. In addition to these, the survey identified other factors of less influence: (i) concern for public criticism, (ii) concern for health impacts, (iii) religious prohibition, and (iv) psychological aversion. These factors are discussed in the forthcoming sections.

Table 2: Reasons for farmers' rejection and hesitation to use reclaimed wastewater for restricted irrigation

Factors	Jordan				Tunisia			
	Uncertain (n=22)	Reject (n=10)	Total (n=32)		Uncertain (n=5)	Reject (n=5)	Total (n=10)	
	Count	Count	Count	%	Count	Count	Count	%
Availability/accessibility of freshwater	22	10	32	100	5	5	10	100
Distrusted water quality	21	9	30	94	3	5	8	80
Concern for public criticism	8	2	10	31	2	1	3	30
Worries about crop marketing	4	6	10	31	8	1	9	90
Concern for health impacts	2	4	6	19	1	3	4	40
Religious prohibition	5	1	6	19	1	1	2	20
Psychological aversion	2	3	5	16	1	4	5	50

Table 3: Reasons for farmers' rejection and hesitation to use reclaimed wastewater for unrestricted irrigation

Factors	Jordan				Tunisia			
	Uncertain (n=12)	Reject (n=3)	Total (n=15)		Uncertain (n=5)	Reject (n=4)	Total (n=9)	
	Count	Count	Count	%	Count	Count	Count	%
Availability/accessibility of freshwater	12	3	15	100	5	4	9	100
Distrusted water quality	11	3	14	93	4	4	8	89
Worries about crop marketing	8	2	10	67	5	2	7	78
Concern for public criticism	6	2	8	53	4	2	6	67
Concern for health impacts	4	2	6	40	3	1	4	44
Religious prohibition	3	1	4	27	1	0	1	11
Psychological aversion	1	2	3	20	1	3	4	44

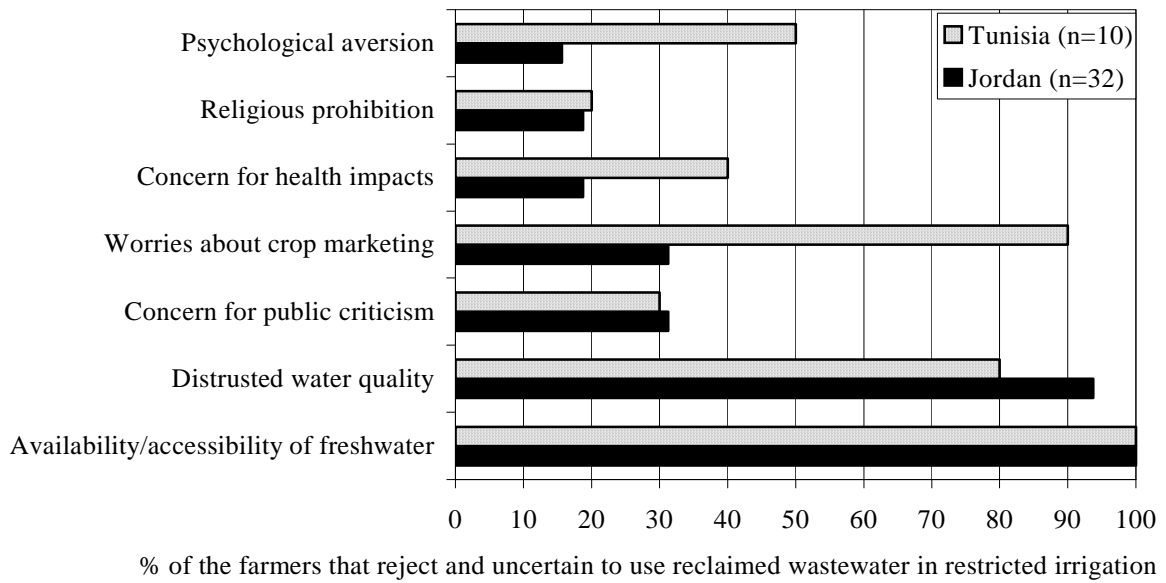


Figure 1. Reasons for farmers' rejection and hesitation to use reclaimed wastewater for restricted irrigation

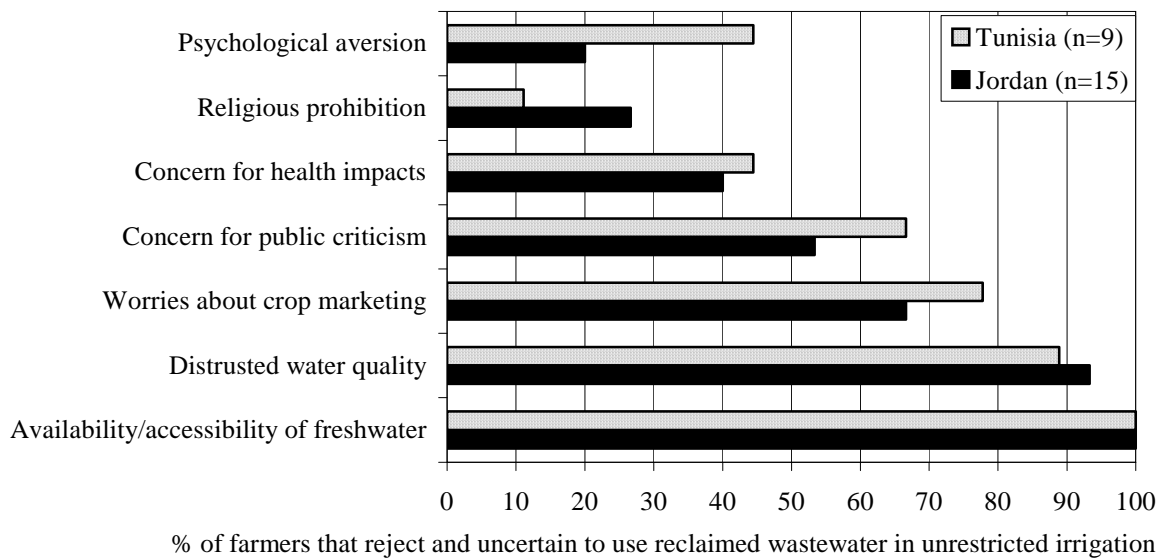


Figure 2. Reasons for farmers' rejection and hesitation to use reclaimed wastewater for unrestricted irrigation

1. Availability of or accessibility to freshwater

Availability/scarcity of freshwater, next to the reclaimable wastewater is a major factor that influences the decision to opt for wastewater irrigation. Because water availability varies from one place to another, within the same country, four possible scenarios have been recognized: (i) where water is abundant enough to meet the entire agricultural demand

and/or where sufficient rainfall makes irrigation itself unattractive, (ii) where freshwater is naturally very scarce, (iii) where freshwater is available but cannot meet the agricultural water demand, and (iv) where there is an enforced restriction on use of freshwater. These scenarios can be explained as follows:

- i) *Where freshwater is abundant enough to cover the entire agricultural demand and/or where sufficient rainfall makes irrigation itself unattractive.* Where the availability of freshwater is sufficient to meet the full irrigation water needs, wastewater irrigation becomes more controversial and unattractive. From one viewpoint, availability of freshwater makes reclaimed wastewater redundant. From another, reclaimed wastewater may compete with freshwater due to the nutrient contents and the extra low price. For example, in Jordan the irrigation scheme of Baq'a, where expensive groundwater from deep wells is the main source of irrigation water. Farmers that are able to cover their entire water need from their own groundwater wells would in principle not welcome the idea of using reclaimed wastewater, if it were available. In contrast, farmers that have to buy the groundwater from their neighbours at high price would prefer to have access to reclaimed wastewater, provided it is suitable for their crops and available at a lower price than that for the groundwater. Likewise, sufficient rainfall makes wastewater irrigation less financially attractive, because the marginal increase in productivity would have to offset the entire (high) cost of the irrigation system (Khouri, *et al.*, 1994). In addition, any low price that a farmer will have to pay for reclamation of wastewater can never compete with rainwater that is of good quality and free of charge.
- ii) *Where freshwater is naturally very scarce.* In those cases where freshwater is scarce, there is a high potential for introducing reclaimed wastewater, depending upon availability of land and farmers who are willing to use and pay for such water. For instance, in the Soukra scheme of Tunisia, reclaimed wastewater irrigates about 600 hectares of citrus orchards and fodder because no other water is available: the groundwater is saline, surface water does not exist, and rainfall is insufficient. Nonetheless, the area equipped for wastewater irrigation is not fully utilized (about 50% only is irrigated). This means that water shortage alone is not a sufficient incentive and other considerations play a role.
- iii) *Where freshwater is available but cannot meet the agricultural water demand.* In such cases, irrigation with reclaimed wastewater becomes controversial. On one hand, the need for supplementary water supplies increases the opportunities for use of reclaimed wastewater. On the other hand, health risks and cropping restriction curtail these opportunities, and render such water disproportionately unattractive. For example, in the Jordan Valley, freshwater from the King Abdullah Canal is used at low price for unrestricted irrigation. But since the demand for water exceeds the available supplies, especially in summer (dry season), the Jordanian government makes indirect use of the reclaimed wastewater by using it to augment freshwater supply. Direct irrigation with this water was not applied because (i) farmers have access to freshwater at too low price, (ii) certain profitable crops would have been banned from such irrigation, and (iii) wastewater treatment/reclamation plants exist at faraway distance only. However, the government utilizes the existing King Talal Dam to augment the freshwater supply by mixing it with secondary treated effluents that flow by gravity from a number of plants. The blended water flows also by gravity to reach downstream farmers who use this water for unrestricted cropping. Therefore, wastewater has indirectly increased the availability of water in a place that fully relies on agriculture for living, without influencing its agricultural traditions or changing the water price.
- iv) *Where there is an enforced restriction on the use of freshwater.* The rapid population increase in the region and the scarcity of the water resource fuel the debate about reallocation of freshwater supplies from the agricultural to the domestic and industrial uses. This means that another form of water shortage may occur as a result of

enforced restriction on the use of freshwater for irrigation. In such cases, reclaimed wastewater could be the substitute if the major obstacles are mitigated. First, the supplies of reclaimed wastewater must be sufficient and reliable, to offset the quantities of freshwater that are taken out. Second, the lower quality of the reclaimed wastewater may force farmers to change their cropping choices by shifting from high value crops to lower value crops. Obviously, this reduction in income would have to be factored in. Thus, improving the quality of the treated effluents by adding tertiary treatment facilities may be required to permit unrestricted cropping and control at least the potential health impacts.

2. Distrusted water quality

As mentioned before, most of the direct reasons for the farmers' unwillingness to irrigate with reclaimed wastewater stem from quality concerns, especially the possible impacts on health, cropping restrictions (with the associated reduced income), psychological aversion, religious prohibition, and public criticism. Moreover, farmers perceive the degree of cropping restriction as an indicator of the quality of the reclaimed wastewater. For about 96% of the surveyed farmers in each country (Figure 5), improving the quality of treated wastewater and allowing unrestricted irrigation have the power to change the negative attitudes of farmers with respect to reuse. This suggests the need for raising the technical understanding of farmers.

3. Crop marketing and acceptance of public to buy reuse-crops

Crop marketing is the last link in the sequence of wastewater reuse decisions. It is determined by public acceptance to buy the crops irrigated with reclaimed wastewater, which consecutively influences the farmers' decision to "accept" or "reject" using the reclaimed water. The crop marketing system need to be analyzed before assessing the perceptions of crop consumers.

Crop sales in the region are conducted through either wholesale or retail marketing. Under the wholesale marketing system, the farmer sells the harvest right to another farmer or merchant for a lump sum price that is determined by the quantity and quality of the harvest as well as by the demand in the market. Farmers prefer this system since it lowers their marketing risks, saves labour and time, and more importantly, provides financial liquidity. Under the retail marketing system, on the other hand, farmers themselves pack, transport, and sell the produce (Al-Hamdi, 2000). Wholesale and retail marketing systems imply one or more of the following:

- i) *Farmers' use of agricultural produce for grazing their own cattle.* As a result of cropping restriction, irrigation with reclaimed wastewater is widely applied for production of fodders and cereals that are used for feeding the farmers' cattle. Most of the interviewed farmers recognize the value of the nutritional value of such crops.
- ii) *Central markets through middlemen.* In central crop markets in general, middlemen or merchants are the key players; and the role of farmers is secondary. Two types of middlemen can be identified (Type A and Type B). Type A middlemen transport the harvest from a number of farms and sell it in the central markets on behalf of the farmers. The farmers are charged a commission and a transport cost. Type B is a distributor, and buys the crops in the central markets and sells them to small merchants and groceries after which they reach the consumer. This is applicable for freshwater crops as well as blended-water crops. Formally, the central markets do not visibly separate crops that are irrigated with freshwater from those irrigated with reclaimed water. However, in practice Type B middlemen are experienced enough to recognize Type A middlemen since both are frequent customers in the market, thus, they are

knowledgeable about the origin of the crops and take advantage to pay lower prices for these crops.

- iii) *Central markets without middlemen.* Some farmers take their crops to the central markets and sell it to the Type B middlemen, thus, avoiding Type A middlemen and saving on the transport costs and commission. In general, central crop marketing does satisfy neither farmers nor crop consumers. Freshwater farmers complain that reclaimed-wastewater crops compete with their crops and lower prices. Reclaimed-water farmers, claim that the availability of subsidized freshwater crops lowers the market prices of all crops. Farmers who illegally irrigate vegetables and cash crops with raw wastewater abuse this system and sell their crops as freshwater crops, which causes inconvenience to crop consumers and make them suspicious about all crops.
- iv) *On-farm crop marketing.* It is very common that farmers sell part of their produce on the farm. Crop merchants prefer this system because they can choose the best quality of crops at low price. Farmers also prefer it since it avoids the considerable transport cost in addition to taxes and middlemen's commission.
- v) *Roaming marketing.* Some farmers and merchants avoid selling crops in the central markets searching for better prices. Therefore, a variety of crops are taken in small lorries to the urban and peri-urban localities where they directly sell crops to the citizens. Consumers of fruits and vegetables often inquire about the source of crops, but purveyors promote all crops as freshwater crops, which is sometimes not true.
- vi) *Export.* Both countries have not yet reached a stage where the crops irrigated with reclaimed wastewater can be exported. This is mainly because the quality of reclaimed wastewater does not comply with the standards and regulations for unrestricted cropping and because of the stringent export requirements.

The existing system for crop marketing in which reclaimed-water crops are on offer together with freshwater crops is an incentive to farmers to use reclaimed wastewater. Unfortunately, such marketing systems might tempt farmers to irrigate with raw sewage. Therefore, the crop marketing has to be monitored to safeguard public health.

The field survey results revealed that 81.7% and 71.5% of the interviewed public in Jordan and Tunisia, respectively, are willing to buy crops irrigated with treated wastewater, which is a high level of acceptance (Table 4). In contrast, the willingness of the same respondents to buy crops irrigated with raw (untreated) sewage dropped significantly to 2.9% and 0.7% in these two countries, respectively. The unwilling respondents were asked for the reasons that drive their decisions (Table 5 and Figure 3 and 4). The most prominent disincentive was the availability of freshwater crops. There are other disincentives, but they are more pronounced for use of raw-sewage crops than that of treated-sewage crops: (i) concern for health impact, (ii) psychological aversion, (iii) affordable prices of freshwater crops, (iv) religious prohibition, and (v) concern for public criticism. These results allow for drawing generalized conclusions since there is no significant difference between responses in Jordan and that in Tunisia. These factors are discussed within the context of this paper.

Table 4: Acceptance of the Jordanian and Tunisian public to use crops (n=326)

Country	Crops irrigated with raw sewage				Crops irrigated with treated sewage			
	Accept		Reject		Accept		Reject	
	Count	%	Count	%	Count	%	Count	%
Jordan (n=175)	5	2.9	170	97.1	143	81.7	32	18.3
Tunisia (n=151)	1	0.7	150	99.3	108	71.5	43	28.5

Table 5: Reasons for public reluctance to buy crops irrigated with raw and treated wastewater

Factors	Crops irrigated with raw sewage				Crops irrigated with Treated sewage			
	Jordan (n=170)		Tunisia (n=150)		Jordan (n=32)		Tunisia (n=43)	
	Count	%	Count	%	Count	%	Count	%
Availability of freshwater crops	166	98	150	100	32	100	42	98
Concern for health impacts	152	89	150	100	14	44	26	60
Psychological aversion	137	81	146	97	7	22	15	35
Affordable prices of freshwater crops	129	76	40	27	22	69	40	93
Religious prohibition	42	25	25	17	6	19	2	5
Concern for public criticism	32	19	11	7	9	28	4	9

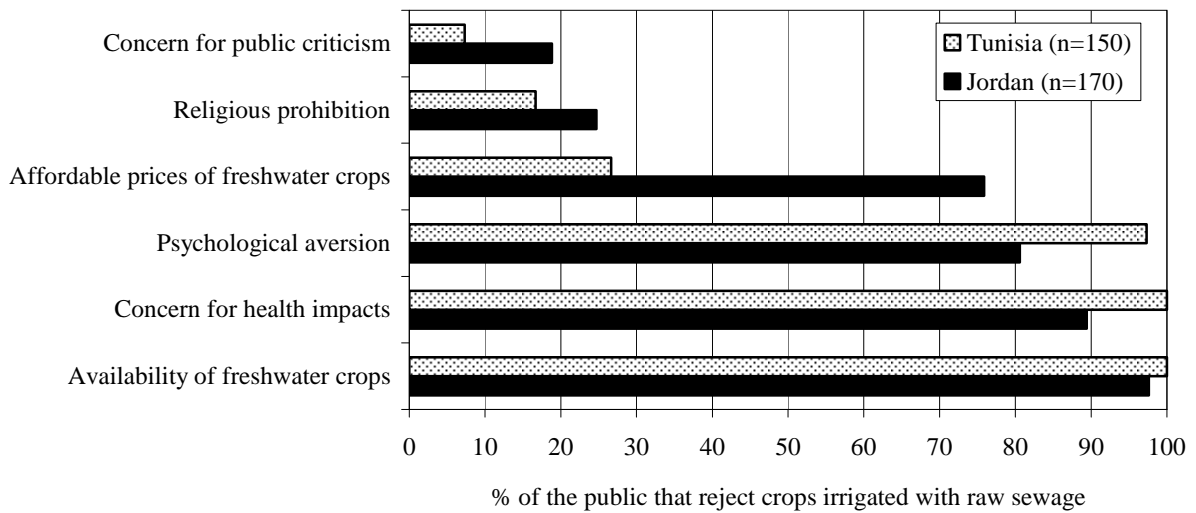


Figure 3. Reasons for public reluctance to buy crops irrigated with raw sewage

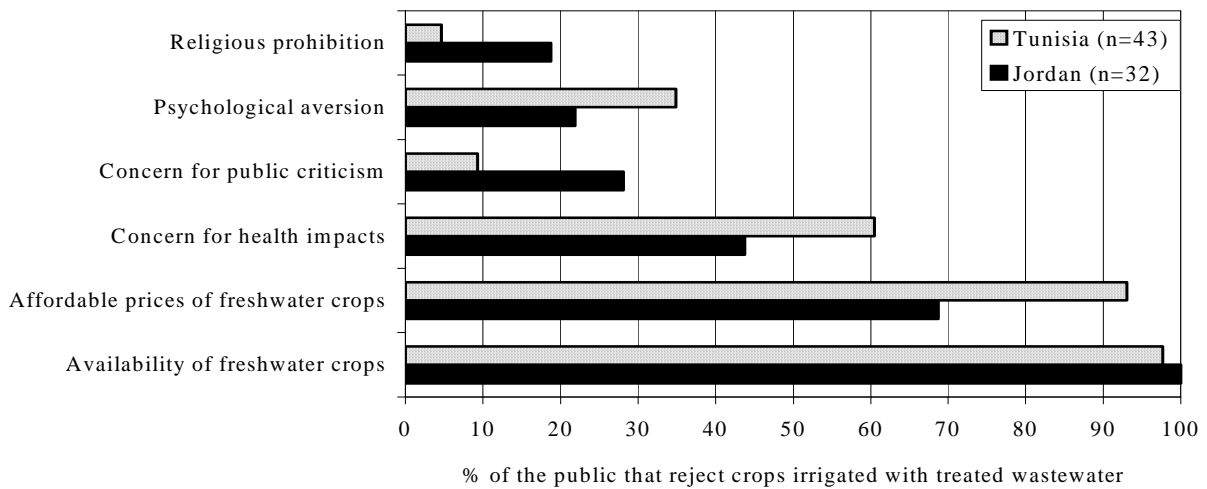


Figure 4. Reasons for public reluctance to buy crops irrigated with treated wastewater

4. Opinion of reference/peer groups and concern for public criticism

The majority of people in both countries are Muslims. Farmers are mostly located in rural and peri-urban areas where the social and traditional ties are stronger than in urban areas. Therefore, farmers' attitudes and perceptions, and any changes thereof, tend to be strongly influenced by religion, culture, politics, and influential reference groups within the society. There is no specific classification of these reference/peer groups since they vary from one society to another, and one individual may feel guided by other reference groups than another individual. However, our study could tentatively identify three categories of reference groups to farmers and crop consumers: (i) community leaders that include religious preachers, clan leaders (*Hamolah Sheiks*), and local politicians, (ii) relatives, and (iii) friends. The results of the field survey show that in Jordan, about 31% and 53% of the farmers that are unwilling and uncertain to irrigate with reclaimed wastewater for restricted and unrestricted irrigation, respectively, attribute their decisions to concern for public criticism; in Tunisia, it is 30% and 67%, respectively (Figure 5 and 6). The results also show that the percentages of farmers who feel concern for the opinions of community leaders, relatives, and friends in Jordan are about 93%, 46%, and 17%, respectively, and in Tunisia are about 42%, 28%, and 28%, respectively (Figure 5). For crop consumers, they are about 51%, 43%, and 34%, respectively in Jordan and 45%, 29%, and 17%, respectively, in Tunisia (Figure 6). There is no significant difference between the two countries, except for more tribute to community leaders by the Jordanian farmers than the Tunisians, which may be attributed to the strong tribal ties in the Jordanian rural communities. The significant difference between the responses of farmers and crop consumers with respect to opinions of community leaders can be attributed to the fact that all the surveyed farmers were located in rural and peri-urban areas while the surveyed crop consumers were from rural, peri-urban, and urban areas. Results also show that concern for public criticism is a strong disincentive to some users of reclaimed wastewater and related crops. Although the influence of this factor is diminishing, it still exists and has to be taken into account. These results suggest that involving the reference groups in decision-making and planning of a reuse project as well as in awareness campaigns might mitigate the socio-cultural influences.

5. Concern for health impacts

Despite numerous epidemiological studies on raw wastewater reuse in both developed and developing countries, direct correlations between incidence of infectious diseases and the reuse are hard to find. Nonetheless, evidence suggests that agricultural farmers who are exposed to untreated or insufficiently treated wastewater risk enteric infections, particularly from *Ascaris lumbricoides* and *Trichuris trichiura*. The risk of cholera and typhoid in consumers of uncooked vegetables irrigated with wastewater is based on circumstantial evidence, however (Shuval *et al.*, 1986).. Studies from Mexico City's reuse scheme show strong evidence that a higher level of risk exists of transmission of various diseases associated with helminth eggs (nematodes or worms), among farm workers exposed to wastewater, especially children Blumenthal *et al.*, 2000)

Jordan and Tunisia took preventive public health measures by prohibiting reclaimed-wastewater irrigation of crops that can be eaten raw or uncooked (unrestricted). Nonetheless, reclaimed wastewater in Tunisia, which is permitted only for restricted irrigation, is frequently used to irrigate green belts, public yards, and golf courses, where in theory chances exist that people can come into contact with the irrigated lawn. Also, during the farm-surveys in Jordan and Tunisia many workers were observed to have direct contact with such water. In the Jordan Valley, where blended water from the King Talal Dam (KTD) is used, some farmers confirm that they use this water even for *Wodoo'* (ritual cleansing prior to Muslim prayers) although they are aware of the presence of the traces of wastewater. Finally, irrigation of fruit trees in Tunisia does not cease two weeks before fruit is picked, and fruits are picked up from the ground, which violates the WHO health guidelines. In all

instances, no health impacts were claimed, which may be attributed to continuing improvement of the water quality after irrigation, and rapid dye-off of pathogens in the storage reservoirs in these hot climates. The retention times in practice exceeds the survival times Feachem *et al.*, 1983), impoundment time or the time effluent in blended conditions spends travelling in the canal, then being sprayed on the crop exposed to sunlight. However, survival time is not necessarily a good indicator but the way how farmers “manipulate” the water increase or lower the risk to ingest the active contaminant or expose skin or open wounds to it.

In both countries, farmers that have experienced reclaimed-wastewater irrigation seem to be more realistic than freshwater farmers. Most of the interviewed administrators in both countries believe that wastewater reuse poses health risks to farmers and crop consumers. The conservative opinions of the administrators do not necessarily reflect a high level of knowledge about the actual health impacts associated with wastewater irrigation. Interestingly, farmers have significantly less conservative opinions; 61% and 20% of the surveyed farmers in Jordan and Tunisia, respectively. The freshwater farmers that have not experienced irrigation with reclaimed wastewater also have conservative opinions; the aforementioned 61% and 20% of farmers in Jordan and Tunisia are mostly freshwater farmers. Apparently, the administrators in both countries are cautious about public health, therefore they adopt more conservative opinions than farmers. This, in effect, imposes a financial penalty on the country because (i) the overly restrictive standards require expensive wastewater treatment, and (ii) farmers are forced to use more expensive freshwater. However, the knowledge of administrators and farmers is often narrow since they mostly recognize the short-term impacts related to some types of infectious diseases, while few recognize the possible long-term impacts associated with the various constituents in reclaimed wastewater. For instance, the health impacts also have important economic consequences. The heavy parasitic burden caused by helminthes can cause digestive and nutritional disturbances, abdominal pain, vomiting, diarrhea, and loss of weight eventually leading to anemia. The anemic condition further prevents victims from developing, both physically and intellectually. This raises costs associated with medical treatment and the loss of the ability to generate revenue as an adult (Shuval *et al.*, 1986).

The household-surveys show that, respectively, 89% and 100% of the Jordanian and Tunisian public that reject raw-sewage crops (97.1% and 99.3% of the total, respectively) attribute their decision to potential health impacts. On the other hand, respectively, 44% and 60% of the Jordanian and Tunisian public that reject treated-sewage crops (18.3% and 28.5% of the total, respectively) attribute their decisions to potential health impacts.

6. Religious prohibition

The effect of religion on the feasibility of reuse in Islamic countries is frequently cited as an example of socio-cultural factors that can limit the application of wastewater reuse in these countries. The farm-surveys show that religious prohibition is a reason for about 19% and 20% of the farmers that are unwilling and uncertain to use reclaimed wastewater for restricted irrigation in Jordan and Tunisia, respectively, against 27% and 11% for unrestricted irrigation, respectively. The percentages of consumers who reject crops irrigated with raw sewage due to the same reason are about 25% and 17% in the two countries, respectively, against 19% and 5%, respectively, for treated wastewater. These results, even though small, are unrealistic since the Islamic religion does not, in principle, forbid wastewater reuse. The Organization of the Eminent Scholars of Saudi Arabia has approved the reuse of wastewater, after adequate treatment, for all purposes including *Wadoo'* for Islamic prayers (Farooq and Ansari, 1983 and Wilkinson, 1978) . However, untreated wastewater is used in many Islamic countries where extreme water scarcity conditions prevail, such as Palestine and Yemen.

It can be concluded that the attitude of Islam towards reuse of wastewater should not be considered an impediment for acceptance of farmers and crop consumers.

7. Psychological aversion

Some of the interviewed farmers and crop consumers expressed psychological aversion towards reclaimed wastewater and crops irrigated with this water, respectively. This aversion is a resultant of (i) the questionable origin of the reclaimed wastewater, (ii) health concerns, (iii) religious beliefs, and (iv) cultural values and traditions. The results of this study show that psychological aversion is a reason for about 16% and 50% of the farmers that are unwilling and uncertain to use reclaimed wastewater for restricted irrigation in Jordan and Tunisia, respectively, against 20% and 44% for unrestricted irrigation, respectively (Tables 2 and 3 and Figure 1 and 2). However, this is particularly observed among freshwater farmers who did not yet experience irrigation with reclaimed wastewater; i.e., those who don't know are most likely to have negative prejudice. Thus, education and awareness are capable of mitigating this disincentive. Likewise, in the two countries, the percentages of public that reject raw-sewage crops due to psychological considerations are about 81% and 97%, respectively, against 22% and 35%, respectively, for treated-wastewater crops (Table 5 and Figure 3 and 4). These results reveal that psychological aversion to wastewater-irrigated crops stems from concerns for quality of the irrigation water. Thus, improving the quality of treated wastewater together with public awareness might overturn this disincentive.

Public awareness and attitude change

Often, public knowledge is very limited about the risks and benefits of wastewater reuse. Therefore, raising public awareness and changing public attitudes on wastewater reuse are common objectives worldwide, even though it is recognized that there is no straightforward relationship between awareness and attitude change; e.g., the attempts to have people quit smoking (Nexus, 1999).

Two main approaches are distinguished for attitude change: spontaneous learning and premeditated awareness. Spontaneous learning, which is very common in the developing countries, would commence in the case of a wastewater reuse scheme after the project is implemented, when first the practitioners' knowledge develops mainly based on "learning by trial and error", supported by occasional awareness or training programs for the practitioners. Thus, as the practitioners try to operate the scheme properly, the public starts experiencing the risks and benefits, and new (positive or negative) perceptions develop. If operation and regulation are not properly implemented from the beginning, the public may be confronted with more negative than positive experiences, which can seriously undermine the reuse's credibility, especially if public health is jeopardized. In the premeditated approach on the other hand, the knowledge of concerned public develops based on better guided awareness development and systematic education.

The results of this study show that perceptions and attitudes towards irrigation with reclaimed wastewater are not rigid but subject to conditional change except for some fundamental postulates and taboos. An attempt was made to understand what might change the perceptions and attitudes of farmers and crop consumers, besides the direct disincentives that have been identified in the previous sections. A list of potential factors was presented to all interviewed individuals in the sample (farmers and crop consumers) in the form of dichotomous questions since respondents were not able to scale these factors. Results suggest a number of factors that might be capable of improving perceptions as discussed below (Figure 5 and 6). Most of these factors are applicable to both farmers and crop consumers, but some are group-specific.

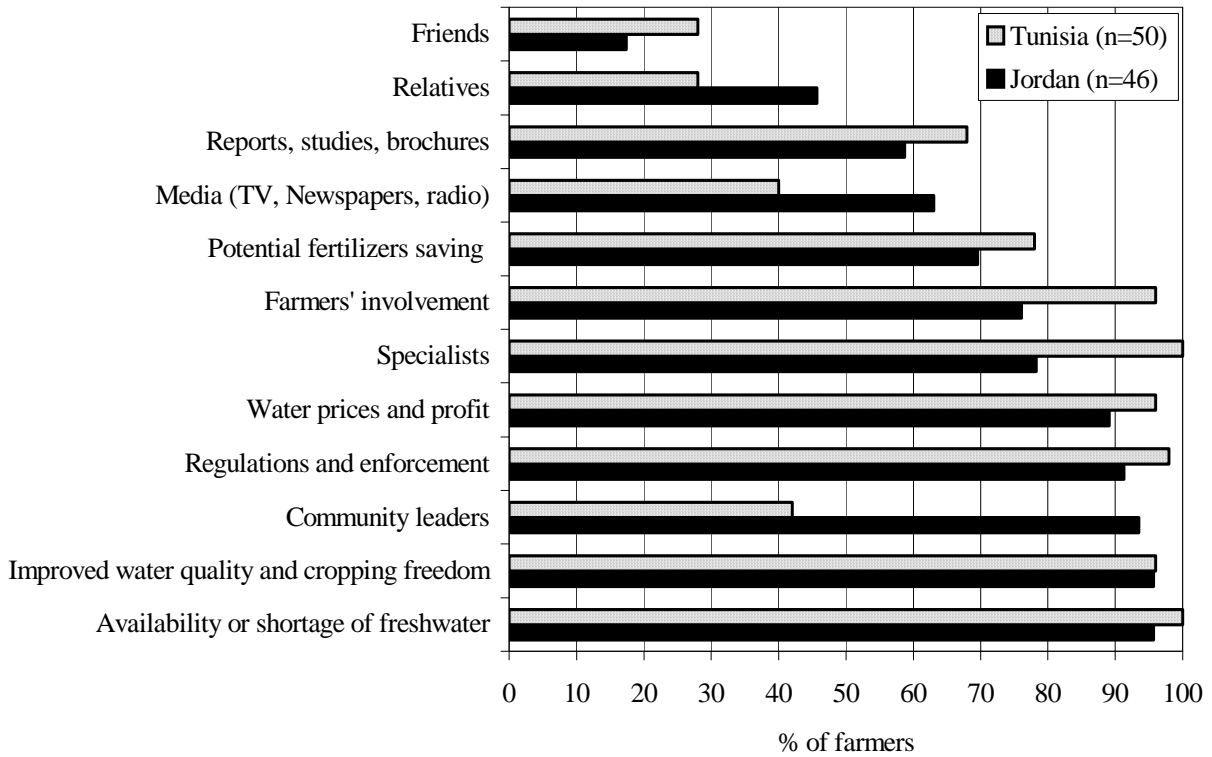


Figure 5: Factors that might change farmers' attitudes in Jordan and Tunisia

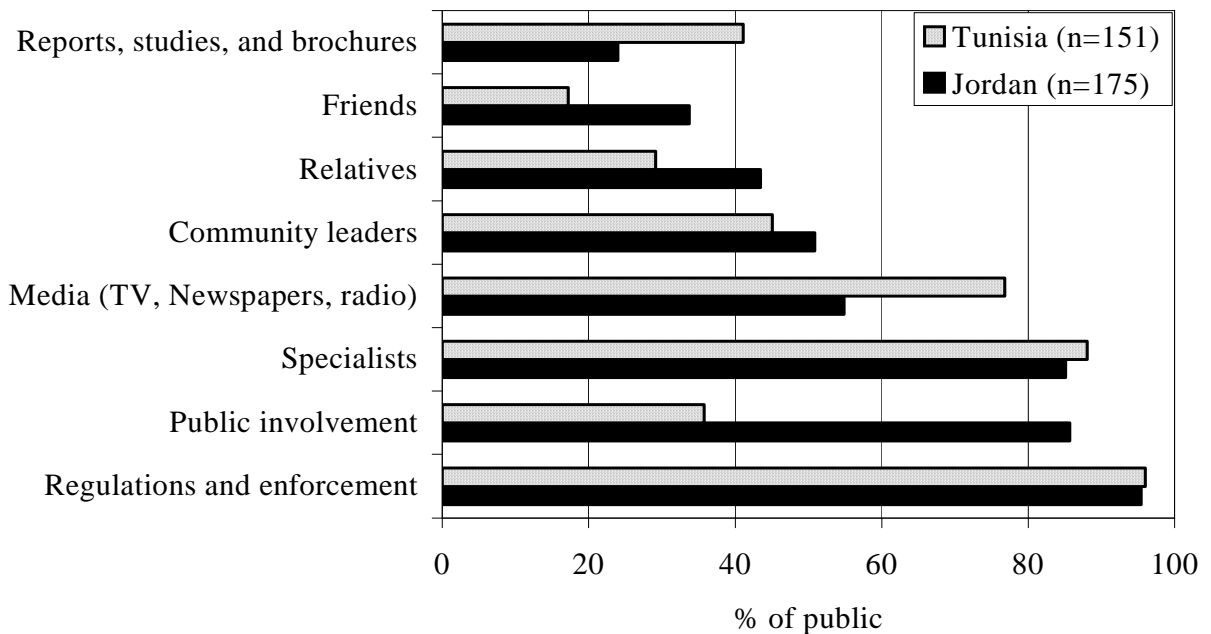


Figure 6: Factors that might change public attitudes in Jordan and Tunisia

Conclusions

1. Freshwater availability/accessibility at scheme level is the most crucial disincentive for reuse as reclaimed wastewater cannot compete with freshwater. This disincentive can be mitigated through enforcing restrictions on irrigation with freshwater wherever reclaimed wastewater can cover the agricultural water demand, and through strengthening the incentives that make reclaimed wastewater competitive with freshwater.
2. The health impact associated with reclaimed wastewater can be very severe; therefore, public health must not be compromised through maximizing reuse rates. Nonetheless, majority of the surveyed farmers do not perceive the actual health risks; on the contrary, they claim no impacts. Some farmers persist to irrigate with raw wastewater. However, more research is needed in order to study the long-term impacts on users of reclaimed wastewater and related crops as well as beneficiaries of the affected water resources.
3. The regulatory, financial, and socio-cultural factors were shown in the field surveys to be of great relevance in the shaping of the decisions of both the farmers – who have to use/buy the reclaimed water and apply certain agronomic approaches – and the public – that must decide whether to buy the crops watered with reclaimed wastewater. These factors could be possibly more influential than the technical ones.
4. Farmers and public seem, in general, in the two countries, reasonably positive towards reuse. There is some evidence to state that perceptions towards acceptance have improved over the past decade. Increasing acceptance means that reuse should not be approached as a technical issue only; the role of the markets, of price incentives, and of other perceptions is crucial. For example, understanding how the crop marketing system operates is necessary because our study showed that in reality the consumers often cannot distinguish between crops irrigated with freshwater and reclaimed wastewater. The effects of the presence on the market of reclaimed-water-irrigated crops needs further study. Also, to improve farmers' acceptance, it is necessary to understand better how they can get more or more reliable income, i.e., how things like crop restriction and competition by too cheap freshwater defeat reuse's purpose.
5. The crop marketing systems and the high public acceptance to use reclaimed-wastewater crops are incentives for reuse, and, thus, the worries of farmers with this regard are not justified. Thus, more effort is needed to make farmers realize this incentive.
6. The attitudes of Islam can be considered as an incentive for irrigation with reclaimed wastewater. However, some farmers and rural dwellers are not aware of this and still conceive religion as an obstacle.
7. Awareness and education can be very effective if properly executed. Farmers and crop consumers are very responsive to the various means of awareness and education. These means include: TV, Radio, newspapers, brochures, seminars, personal visits, and religious breaching. Proper execution of awareness and education entails (i) easy language, (ii) well focused content, (iii) conducted by specialists who are esteemed by beneficiaries, and (iv) supported by demonstration of benefits and of proper management to mitigate risks.

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Perceptions of Farmers and Public Towards Irrigation with Reclaimed Wastewater in Jordan and Tunisia

نظرة المزارعين والعامّة حول استعمال مياه الصرف الصحي للري
في الاردن و تونس

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المخلص

على الرغم من الطلب المتزايد على مصادر المياه الشحيحة في كل من الاردن وتونس، يتم تصريف كميات كبيرة من مياه الصرف الصحي المعالجة في الاودية والبحار. تدرس هذه الورقة تقبل كلا من المزارعين والسكان امكانية اعادة استخدام مياه الصرف الصحي في الري الزراعي. وتعتمد الدراسة على مسح ميداني استهدف 96 مزارعا و 326 منزلا في كلتا الدولتين. تظهر النتائج مستوى عالي من تقبل المزارعين لاستخدام المياه العادمة المعالجة في الري الزراعي ومستوى عالي من تقبل السكان لاستخدام المحاصيل الزراعي المروية بذات المياه. كما تحلل الدراسة العوامل التي تؤثر في قرارات المزارعين والسكان بخصوص تقبل او رفض اعادة استخدام مياه العادمة. كما تحدد الدراسة العوامل الرئيسية التي قد تؤدي الى تغيير اراء المزارعين والسكان.

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