Willingness of farmers to pay for reclaimed wastewater in Jordan and Tunisia

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Abstract Despite water scarcity and high agricultural water consumption in the Middle East and North Africa region, substantial amounts of treated wastewater are discharged into seas without proper utilization. This can be attributed to either farmers' unwillingness to use or to pay for reclaimed wastewater. Therefore, a field survey was conducted in Jordan and Tunisia, which are considered as representative to the MENA region, using a prepared and pilot tested questionnaire. This study applies the contingent valuation method to elicit the willingness of farmers to pay for reclaimed wastewater. Logistic regression analysis is applied in an attempt to build a model that correlates qualitative responses of farmers to monetary stimuli. The water price seriously affects farming profitability and farmers' willingness to pay for reclaimed wastewater. Farmers prove to be unwilling to pay more than 0.05 $/m^3 of reclaimed wastewater primarily because of quality concerns, comparatively easy access to freshwater, and price.

Keywords Acceptance from farmers; irrigated agriculture; reclaimed wastewater; willingness to pay

Water Science and Technology: Water Supply **Vol 3 No 4 pp 115–122** © IWA Publishing 2003

Introduction

Agriculture consumes about 87% of the total water consumption in the Middle East and North Africa region (MENA) while water is a scarce commodity. Reclaimed wastewater (RW) has been recognized as a valuable non-conventional resource (Angelakis *et al.*, 1999). Yet, the market for RW in the MENA is unbalanced. On the supply side of the market there is growth, revealed by the increasing number of wastewater treatment plants. On the demand side of the market there is stagnancy, revealed by the substantial proportions of RW being discharged into receiving water bodies without proper utilization. Balancing the market for RW means reducing the gap between supply and demand, which is of major concern in the region. Securing a market or users for the RW is the most critical factor to success of reuse projects; this should be a key task in the planning process (Mills and Asano, 1996; Al-Hamdi, 2001). Assessing the potential market for the RW has rarely been recognized by planners of the eighties, which may partially explain the low rate of wastewater reuse (Bahri and Brissaud, 1996; Mills and Asano, 1996). In general, the receptive market for such water comprises three major elements: (a) availability of agricultural land, (b) availability of infrastructure for conveyance and distribution of the treated effluent, and (c) availability of farmers who are willing to accept and pay for this water. The availability of agricultural land and infrastructure for conveyance and distribution of RW do not seem to be an obstacle in the MENA countries experiencing reuse. Mills and Asano (1996) emphasize that only identifying a potential RW market for planning purposes is not enough, but there must be some assurance that particular users (farmers) intend to use and pay for RW before embarking on design and construction of reuse projects.

Across the world water pricing has been a reliable tool to reduce freshwater (FW) consumption, and simultaneously raise revenues. In Israel, for example, a gradual 50% drop in FW use was reported after a series of tariff increases. FW use in agriculture declined from 74% to 62% between 1986 and the early 1990s whilst use of RW proportionally increased, and overall productivity per unit land doubled (Sanz, 1999; Ahmad, 2000). The objective of this study is to elicit the willingness of farmers to pay for RW and to understand the financial stimuli that might influence farmers' willingness to pay (WTP).

Methodology

Field survey

In 2001, four-months of fieldwork was conducted in Jordan and Tunisia within the framework of a longer-term research. One month was specified for surveying various irrigation schemes using a questionnaire that was prepared prior to the fieldwork and pilot tested on 15 farms in Jordan. The survey was limited to 104 farms. Roughly a quarter of this sample would each use primarily either groundwater, surface water, blended water + wastewater, or treated wastewater. The reasons for this limited sample size were: (a) absence of the right persons who could provide reliable information – in many cases either workers or farmers' kin were available; (b) some farmers were suspicious and hesitant to cooperate; and (c) logistical and budget limitations. Still, this sample provided sufficiently consistent information to be used to achieve the objective of the study.

In order to ensure collection of reliable information, the following measures were applied.

(a) Knowledgeable respondents. Interviewing only knowledgeable persons who could provide detailed information increased the chances for getting reliable feedback.

(b) Mitigation of farmers' suspicions. Observing few issues that would please the farmer and using them as a starter discussion prior to interviews, considerably helped in gaining farmers' trust and getting more reliable information. In some instances admiring a kid that sticks to his father, in other cases flattering a farmer for a nice farm or talking about the healthy atmosphere in the area. However, it is worth mentioning that excess flattering and showing sympathy with farmers were avoided to prevent influenced responses.

(c) Data crosscheck. Three different levels of crosscheck were applied. The first deals with structure of the questionnaire by having questions that have direct and indirect answers. The second was having side talks with the field workers either before or after interviewing the eligible person. The third was confirming parts of the quantitative data from staff of the agricultural departments within the area and representatives of the farmers' unions, if any. As a result, eight out of the 104 cases were rejected because farmer's responses were contradictory and misleading.

Willingness to pay

In this study, the contingent valuation (CV) method is used to test some hypotheses concerning farmers' WTP for RW. These hypotheses are: (a) WTP is expected to decrease as the price of RW increases, (b) WTP is expected to increase as farmers' income or profit increases, (c) WTP is expected to increase as the price of current irrigation water (competitive water source) increases, and (d) WTP is expected to increase as the availability or accessibility to FW decreases (Bahri and Brissaud, 1996; Al-Hamdi, 2001).

The CV method is criticized by some as unreliable because it depends on what respondents say rather than what they do (Snell, 1997; Al-Hamdi, 2001). Nevertheless, CV has gained increased acceptance amongst academics and policy makers as a versatile and powerful methodology for estimating respondents' WTP (Hanneman and Kanninen, 1996; Whittington, 1998; Vaughan *et al.*, 1999; Hanely, 2001). According to Johansson (1999), elicitation of respondents' WTP could be done in several different ways: (a) in an open-ended question, (b) in a single referendum question, or (c) in the form of bidding game. In an open-ended question, the respondent is asked to state the maximum amount that he/she is willing to pay, while in the referendum format, the respondent is presented with a posted price that he/she is asked to accept or reject. The bidding game is a repeated process, which tries to bracket the respondent's maximum WTP by presenting higher and higher values (bids). A lower value for the WTP can be bracketed in a similar manner (Johansson, 1999). Most CV studies that have compared estimates of WTP obtained have found that dichotomous (Yes/No) choice yields higher estimates than open-ended format (Snell, 1997; Hanely, 2001; Emre *et al.*, 2002). Therefore, bidding technique and dichotomous choice are used in this study.

Prior to presenting the WTP questions respondent farmers were informed that as a consequence of water scarcity tougher laws would lead to higher prices of FW for irrigation, meanwhile reliable RW of high quality would be provided. Subsequently, farmers were asked to respond to sequential dichotomous questions; if they would vote in favor of paying the proposed price (bid) for RW. Literature recommends that extreme bids should be avoided, since they can lead to efficiency losses, and that the number of bids used should be six at a maximum (Cooper, 1993; Alberdin, 1995; Hanemann, and Kanninen, 1996). Therefore, six bid values (0, 0.05, 0.10, 0.15, 0.20, and 0.25 $/m^3) were pre-selected based upon the pilot testing of questionnaire in Jordan to ensure a bid range that approximately covered: (a) current prices of RW, (b) the operational costs for conveyance and distribution of the treated effluents to the irrigation sites, (c) the total costs (including investment) for conveyance and distribution, and (d) operational costs for treatment. An additional independent question was if farmers would accept to pay any price if FW would not be available anymore and RW would be the only source of water available.

Responses to the CV question provide only qualitative information about WTP. Thus, from the raw responses alone, one cannot obtain a quantitative measure of WTP. Therefore, in this study, we employ two methodologies for analysis of the filed survey. The first is descriptive that presents farmers' WTP as frequencies (count and percentile). The second embeds the data in a model in an attempt to link the qualitative responses to monetary and other stimuli that induced them (Hanemann and Kanninen, 1996).

Descriptive approach for assessing farmers' acceptance and WTP. It presents WTP as frequencies (count and percentile) of the accept responses for each of the presented bid values compared with the four types of water that are currently used for irrigation.

Regression analysis for assessing WTP. Farmers' responses have been analyzed using models for discrete (qualitative) dependent variables, where we may relate the probability of making a certain choice ("pay" or "not pay") to some explanatory variables (independents). The discrete structure of WTP surveys implies the adoption of logistic regression (*logit analysis*) procedures (Maddala, 1983; Hanemann and Kanninen, 1996; Ardila *et al.*, 1998; Creel, 1998; Emre *et al.*, 2002). The goal of logistic regression is to correctly predict the category of outcome for individual cases using the most parsimonious model. In this way, logistic regression estimates the probability of a certain event occurring. To accomplish this goal, a model is created that includes all predictor variables that are useful in predicting the response variable. Several methods are available for selecting independent variables. One is the forced entry method where any variable in the variable list is entered into the model. The other is the stepwise method where logistic regression can test the fit of the model after each coefficient is added or deleted. Stepwise regression is used in the exploratory phase of research or for purposes of pure prediction, not theory testing (Menard, 1995). Exploratory testing makes no *a priori* assumptions regarding the relationships between the variables, thus the goal is to discover relationships. Theory testing is the testing of priori theories or hypotheses where selection of the variables is based on theory, not on a computer algorithm. Menard (1995) writes, "there appears to be general agreement that the use of computer-controlled stepwise procedures to select variables is inappropriate for theory testing because it capitalizes on random variations in the data and produces results that tend to be idiosyncratic and difficult to replicate in any sample other than the sample in which they were originally obtained". Therefore, the entry method is applied in this study to test the aforementioned hypotheses.

The sequential nature of the dichotomous questions entails considering the sample size separately for each bid being studied as shown in Table 1. The sequential models are easy to handle provided we make the probability of choice at each stage independent of the choice at previous stage. In other words, different models are needed to explain farmers' responses to each presented bid value (Maddala, 1983).

The SPSS software package is employed in this study where the dichotomous responses to each of the seven bids are entered as dependent variables. The current price of irrigation water (\$ cent/m^3) and the gross profit (\$/Donum) including the value of farmers' own labour are entered as independents. Other independent variables that are thought to be influential are not included in the model because each time a new independent is added the model significantly becomes unstable. This is because some independents have majority voting (e.g. availability of FW) and some others cause collinearity problems to the logit model.

Assessing model fit. In assessing model fit, several measures are available (Hair *et al*., 1998). First, the log likelihood value (–2LL) value; smaller values of the –2LL measure indicate better model fit. The goodness of fit measure compares the predicted probabilities to the observed probabilities, with higher values indicating better fit. There is no upper or lower limit for this measure. Next, three measures comparable to the R^2 measure in multiple regression are available. The Cox and Snell R^2 measure operates in the same manner, with higher values indicating greater model fit. However, this measure is limited to that it cannot reach the maximum value of 1, so Negelkerke proposed a modification that had the range of 0 to 1. The third measure is the "Pseudo" R^2 measure based on the improvement in the –2LL value [The Pseudo $R^2 = [(-2LL_{initial}) - (-2LL_{model})]/(-2LL_{initial})]$. The final measure of model fit is the Hosmer and Lemeshow value, which measures the correspondence of actual and predicted values of the dependent variable. Better model fit is indicated by smaller differences in the observed and predicted classification. A good model fit is indicated by a non-significant chi-square value (Hair *et al*., 1998).

Results and discussion

Acceptance to irrigate with reclaimed wastewater

The percentages of farmers that accept to use RW for restricted and unrestricted irrigation are 56.3% and 75.0%, respectively (Table 2). The percentages of unsure farmers are 28.1%

Table 1 Distribution of sample size for the sequential responses of farmers

Bid value (\$/m^3)	0	0.05	0.10	0.15	0.20	0.25	Any price
Total responses	3 No						60 No
	93 Yes	12 No					36 Yes
		81 Yes	36 No				
			45 Yes	21 No			
				24 Yes	16 No		
					8 Yes	5 No	
						3 Yes	
Sample size	96	93	81	45	24	8	96

Table 2 Farmers' acceptance to use reclaimed wastewater for irrigation ($n = 96$)

Type	Accept		Unsure		Reject	
	Count	%	Count	%	Count	%
Restricted irrigation	54	56.3	27	28.1	15	15.6
Unrestricted irrigation	72	75.0	17	17.7	7	7.3

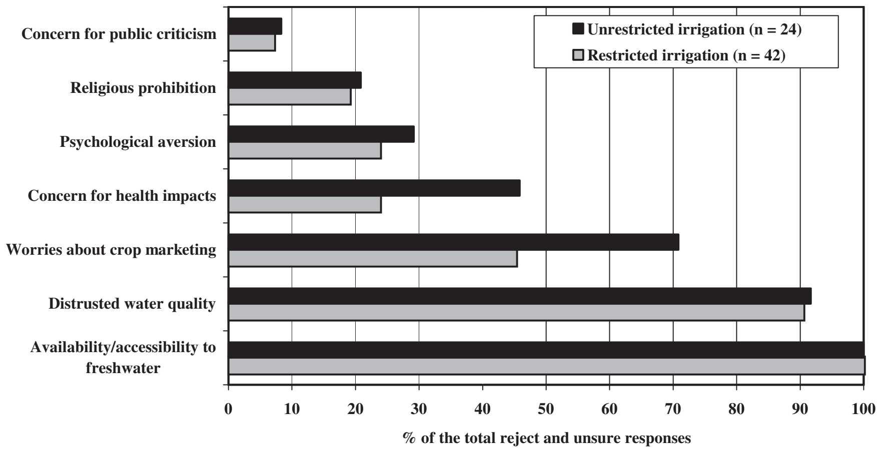

Figure 1 Comparison of factors that make farmers reject or be unsure about using reclaimed water

and 17.7%, respectively. Farmers prefer to use RW for unrestricted irrigation rather than for restricted irrigation. These results reflect a promising stage in the era of wastewater reuse for agricultural irrigation. On the other hand, only 15.6% and 7.3% refuse to use RW for restricted and unrestricted irrigation, respectively. Therefore, more efforts are needed in order to improve the farmers' acceptance by mitigating the factors that might make farmers reject or hesitant to use RW.

The major obstacles for farmers to accept RE are shown in Figure 1. Accessibility to FW at low price is the most critical one. In other words, in order to make farmers use RW their access to FW must be restricted. However, this issue should be carefully dealt with, especially where the supplies of RW cannot offset the agricultural water demand.

Willingness to pay for reclaimed wastewater

Results of three models (WTP_0, $WTP_{0.05}$, and $WTP_{0.25}$) are non-significant (Table 3), thus unrepresentative and cannot be interpreted. This is mainly because of super-majority voting, which according to Hanemann and Kanninen (1996), interrupts model fit; but it still may be considered ethically superior. This is the case in our study for bid values 0 and 0.05, where majority of the interviewed farmers accept to pay up to 0.05 $/m^3 of treated wastewater. Whereas results of the model for bid value 0.25 are non-significant and thus rejected mainly because the sample size is too small ($n = 8$) as a consequence of sequential questioning and majority reject responses.

Results of the other models ($WTP_{0.10}$, $WTP_{0.15}$, $WTP_{0.20}$, and $WTP_{\text{any price}}$) are significant at 95% and 90% confidence. Thus, accepting the hypotheses that water price and profit significantly influence farmers' WTP; the positive sign indicates that higher prices of FW as well as higher profit increase the WTP. The logit model for each bid value can be written as:

$$P = \frac{e^{(K+\beta_1 X_1+\beta_2 X_2)}}{1 + e^{(K+\beta_1 X_1+\beta_2 X_2)}} = \frac{1}{1 + e^{[-(K+\beta_1 X_1+\beta_2 X_2)]}} \quad (1)$$

where,

P = Probability that a farmer is willing to pay the presented bid value

K = Model constant

β = Logistic coefficient

X_1 = Prices currently paid for irrigation water (\$ cent/m^3).

X_2 = Net profit including the value of farmers' own labor (\$/Donum) or (\$/1,000 m^2).

The survey results show that farmers in general have a high WTP for RW if the unit price is low, the quality is high, and if access to FW is restricted or its price is high. This means that

Table 3 Regression results for analysis of WTP

Model	β	S.E	Wald	Sig.	R	Exp(β)	Goodness of fit measures
P_0 = Probability that a farmer responds yes to Bid = 0							–2LL = 24.045
X_1 PRICE	–0.043	0.026	2.664	0.103	–0.158	0.958	Cox and Snell R^2 = 0.027
X_2 PROFIT	–0.002	0.002	0.747	0.387	0.000	0.998	Negelkerke R^2 = 0.112
K CONSTANT	4.213	0.916	21.173	0.000	–	–	Pseudo R^2 = 0.099
							Hosmer and Lemeshow = 9.729 8 df 0.786 sig.
$P_{0.05}$ = Probability that a farmer responds yes to Bid = 0.05							–2LL = 59.396
X_1 PRICE	0.031	0.041	0.597	0.440	0.000	1.032	Cox and Snell R^2 = 0.122
X_2 PROFIT	0.004	0.002	9.035	0.003	0.314	1.004	Negelkerke R^2 = 0.228
K CONSTANT	1.912	0.410	21.775	0.000	–	–	Pseudo R^2 = 0.171
							Hosmer and Lemeshow = 13.072 8 df 0.109 sig.
$P_{0.10}$ = Probability that a farmer responds yes to Bid = 0.10							–2LL = 88.858
X_1 PRICE	0.206	0.073	7.916	0.005	0.231	1.229	Cox and Snell R^2 = 0.242
X_2 PROFIT	0.003	0.001	5.802	0.016	0.185	1.003	Negelkerke R^2 = 0.324
K CONSTANT	–0.909	0.372	5.965	0.015	–	–	Pseudo R^2 = 0.202
							Hosmer and Lemeshow = 23.059 8 df 0.003 sig.
$P_{0.15}$ = Probability that a farmer responds yes to Bid = 0.15							–2LL = 35.801
X_1 PRICE	0.444	0.151	8.654	0.003	0.327	1.559	Cox and Snell R^2 = 0.444
X_2 PROFIT	0.004	0.002	6.649	0.010	0.273	1.004	Negelkerke R^2 = 0.592
K CONSTANT	–3.059	1.002	9.330	0.002	–	–	Pseudo R^2 = 0.424
							Hosmer and Lemeshow = 2.161 7 df 0.950 sig.
$P_{0.20}$ = Probability that a farmer responds yes to Bid = 0.20							–2LL = 12.056
X_1 PRICE	0.169	0.090	3.511	0.061	0.222	1.184	Cox and Snell R^2 = 0.537
X_2 PROFIT	0.004	0.003	2.307	0.128	0.100	1.004	Negelkerke R^2 = 0.746
K CONSTANT	–4.610	1.859	6.151	0.013	–	–	Pseudo R^2 = 0.605
							Hosmer and Lemeshow = 14.522 8 df 0.069 sig.
$P_{0.25}$ = Probability that a farmer responds yes to Bid = 0.25							–2LL = 6.415
X_1 PRICE	0.163	0.279	0.340	0.559	0.000	1.177	Cox and Snell R^2 = 0.406
X_2 PROFIT	–0.006	0.006	1.067	0.302	0.000	0.994	Negelkerke R^2 = 0.554
K CONSTANT	–8.259	14.909	0.307	0.580	–	–	Pseudo R^2 = 0.394
							Hosmer and Lemeshow = 5.137 6 df 0.526 sig.
P_{Any} = Probability that a farmer responds yes to Bid = Any price							–2LL = 111.371
X_1 PRICE	0.039	0.018	4.752	0.029	0.147	1.040	Cox and Snell R^2 = 0.150
X_2 PROFIT	0.003	0.001	9.151	0.003	0.237	1.003	Negelkerke R^2 = 0.205
K CONSTANT	–1.048	0.287	13.348	0.000	–	–	Pseudo R^2 = 0.123
							Hosmer and Lemeshow = 8.351 8 df 0.399 sig.

[a] Wald statistic is a test used in logistic regression for the significance of the coefficient (β). Its interpretation is like the *F* or *t* values used for testing the significance of linear regression coefficient

X_1 *Price* = Prices currently paid for irrigation water (\$ cent/m^3)

X_2 *Profit* = Net profit including the value of farmers' own labor (\$/Donum); One Donum = 1,000 m^2 = 0.1 ha

β = Logistic coefficient; S.E. = standard error; Wald = Wald statistic; Sig. = significance level; *R* = correlation; Exp(β) = exponentiated coefficient; –2LL = –2log likelihood; df = degrees of freedom

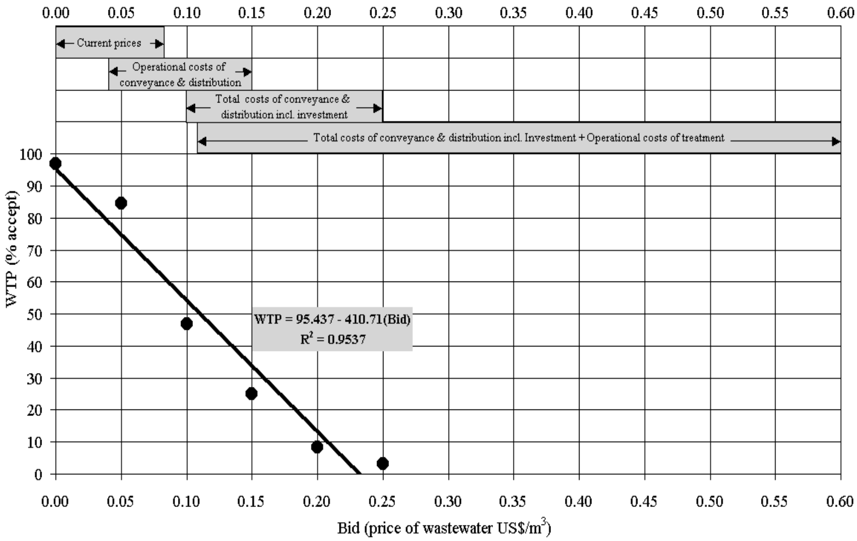

Figure 2 Willingness of farmers to pay for different prices of reclaimed wastewater

the current prices are highly perceived by farmers as suitable having the quality of service improved. Increasing the water prices to cover the operational costs of conveyance and distribution is inversely reflected on the farmers WTP. Ambitious attempts might fail to recover the full cost, not only for treatment, but also for conveyance and distribution (Figure 2).

Conclusions

In Jordan and Tunisia, in principle, farmers are willing to apply RW for agricultural irrigation with preference for unrestricted irrigation. Availability or accessibility to FW and concern for water quality and crop marketing are the major factors that make farmers reluctant or hesitant to irrigate with RW. Farming profitability as well as the prices of FW and RW significantly influence farmers' WTP. Farmers prove to be unwilling to pay more than 0.05 $\$/m^3$ of RW primarily because of comparatively easy access to FW at low price. The water price that farmers are willing to pay hardly covers the operation and maintenance costs for conveyance and distribution of the RW. Ambitious attempts to recover the full cost of treatment and conveyance and distribution might not succeed. Contingent valuation and logistic regression analysis prove to be reliable for elicitation of farmers' WTP.

Acknowledgements

The authors are grateful for the Dutch government for funding this research and the Jordanian and Tunisian governments for providing all help needed to accomplish this study.

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