

Farmers' Demand for Recycled Wastewater in Cyprus: A Contingent Valuation Approach

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Abstract:

This paper employs the contingent valuation (CV) method, to investigate Cypriot farmers' willingness to adopt a new water resource, namely recycled wastewater, and to estimate farmers' willingness to pay for varying quantities and qualities of recycled wastewater. A pilot CV study is undertaken with 97 farmers located in the Akrotiri aquifer area in Cyprus, a common-pool water resource with rapidly deteriorating water quality and quantity. The results reveal that farmers are willing to adopt this new water resource, and they derive the highest economic values from a recycled wastewater use program, which provides high quality recycled wastewater, and high water quantity in the aquifer.

Keywords: contingent valuation, willingness to pay, water quantity, water quality, recycled wastewater, aquifer recharge

1. Introduction

The Millennium Development Goals of the United Nations lists access to water supply among the most important global challenges (UN, 2005). A third of the world's population lives in water-stressed countries, and by 2025 this figure is expected to rise to two-thirds (UNEP, 2004). Lack of access to and scarcity of water resources are a result of reduced water availability emerging from increased demand and/or of reduced water quality arising from increased pollution. It has been argued that both in developed and developing countries, the main cause of water quality and quantity deterioration is the increasing volume and intensity of the agricultural sector (Young, 2005), which currently accounts for seventy percent of the water used worldwide (FAO Aquastat, 2004). Agricultural production, in return, is likely to become unsustainable in the long run due to reduced water quality and quantity, thereby resulting in food safety and security problems at the face of ever increasing global population.

The main economic reasons behind the inefficient management of water quality and quantity include market and government failures. Market failure arises as a result of the public good nature of many water resources, which implies that water resources are not traded in the markets as other goods are, and hence they do not have readily available market prices, which would make their management efficient and sustainable. Even though several of the water resources used for irrigation, such as groundwater, are not pure public goods, they are common-pool resources, which face problems including overexploitation and pollution, resulting in significant costs to the local economy in the long run, as well as in the short run (Cornes and Sandler, 1996). Government failure arises as several agricultural policies/programs of the governments distort the values of inputs (e.g., subsidies to water, fertilisers, etc.) and outputs (price subsidies and fixed prices for final agricultural produce), such that they do not reflect the economic scarcity of water resources.

The magnitude and gravity of the water scarcity problem, coupled with the imminent food security issues, highlight the urgent need for development and implementation of economic instruments and adoption of new technologies and resources for efficient and sustainable management of the world's scarce water resources. Among economic instruments, efficient pricing of the water resources, which takes scarcity value of these resources into account, is the foremost measure to ensure appropriate economic incentives for efficient and sustainable management of water resources. A detailed account of the economic methods that can be employed to estimate the efficient prices for water to inform sustainable water resources policy making is given in Birol et al. (2006). Among the recent water scarcity alleviation technologies, recycling of wastewater to be used in agricultural irrigation is a promising supply side solution, especially following the recent positive experiences of several countries, including Israel, Jordan, Tunisia (see case studies in Scott et al., 2004), which have employed this technology.

This paper investigates Cypriot farmers' stance to reuse of recycled wastewater for irrigation to tackle water resources scarcity in Cyprus, and

evaluates the efficient price to charge for this new water resource. In order to examine farmers' willingness to adopt recycled wastewater and to establish its efficient price, a non-market valuation method, namely a contingent valuation study was undertaken with 97 randomly selected farmers in the Akrotiri aquifer area. The results of this study reveal that on average farmers are willing to adopt this new technology, and that they also derive significant economic values from higher levels of water quantity in the aquifer, and replenishment of the aquifer with higher quality treated wastewater, expressed in terms of willingness to pay. These results have important implications for adoption of this new source of water in Cyprus; the level of recycled wastewater quality and quantity preferred by the farmers, as well as for determining the efficient price to charge for the water in the aquifer, once it is replenished with recycled wastewater.

The rest of the paper unfolds as follows. The next section presents the current situation of quality and quantity of water resources in Cyprus and the possible impacts of water scarcity on Cyprus' economic growth and food production. Section 3 describes the Akrotiri aquifer case study; the theoretical framework and the data collection methodology employed. Section 4 reports the results of this valuation exercise, and the final section concludes the paper and draws some policy implications.

2. Background

Efficient and equitable management and allocation of scarce water resources have historically been one of the most important resource management challenges in Cyprus. Despite the dam building campaign of the past two decades, which aimed to provide water security for domestic, agricultural and industrial purposes, management of water resources in Cyprus is far from efficient and sustainable.

Water quantity and quality in Cyprus are still at serious risk due to climatic, geographical, social, economic and policy related causes (Koundouri, forthcoming).

Water resources scarcity in Cyprus is primarily caused by climatic conditions. Precipitation rates are low and not sufficient to maintain the hydrological balance in the country. This is further exacerbated by the timing of precipitation, since rain falls during the winter, while water demand for irrigation and domestic use peaks during the summer. In addition, geographical location of Cyprus, as an isolated island in the eastern Mediterranean, complicates the water scarcity problem further by preventing drawing of water from other countries.

These issues that lie beyond the control of policy makers have led successive Cypriot governments to focus their attention on the efficient management of available water resources, in order to maintain high levels of water quality and quantity, although water scarcity still persists and is likely to persist in the mid to long run (Koundouri, forthcoming).

Agriculture is the foremost consumer of groundwater, which accounts for 50 percent of the water supply, using around 60 percent of pumped groundwater for irrigation purposes. Lack of defined property rights, easy access to groundwater and its low (or no) cost have led to over-pumping, resulting in coastal aquifers with

negative hydrological balance, exhibiting a heavily depleting trend. It is estimated that most coastal aquifers have been mined down to 15 percent of their capacity (Iacovides, 2006). This has led to further degradation of groundwater resources through seawater intrusion. Furthermore, there is large discrepancy between the water consumed and the contribution to national income: 70 percent of all water in Cyprus is used by agriculture, a sector accounting for 2.7 percent of national income (Iacovides, 2006; Cyprus National Statistics, 2007). Despite the government's promotion of water saving irrigation schemes, inefficient use of water resources by agriculture persists mainly as a result of the high number of small-scale (hobby) farmers, who constitute a large proportion of those employed in agriculture.

Water quality problems for water resources are also emerging. In general, water quality is considered to be satisfactory for irrigation purposes. Pollution from pesticides, nitrates and fertilizers, however, has been detected both in ground and surface water, especially in areas with intensive agricultural activity. This has led to the planning of gradual phasing out of groundwater from domestic water supply. In addition, if current climatic conditions and demand patterns persist, combined with decreased precipitation rates, it is expected that salinity levels will increase, rendering groundwater from major aquifers unusable (Koundouri, forthcoming).

Sustainable management of water resources is extremely important for Cyprus in order to maintain its current rates of economic growth and development. The well-established and expanding tourism industry of the island strains water resources, especially during summer months, when they are at their most vulnerable period. Water demand from tourism sector is expected to increase further following the controversial legislation approved for the creation of golf courts. Episodes of prolonged drought may affect households, agriculture and industry alike, as experienced in the previous droughts. During the drought of 1990's, for example, water supply was limited to a few hours per day in major cities.

A complex legal framework for managing water resources is in place in Cyprus, with various different government agencies being responsible for their application, leading to sluggish management of water resources. As a result of the recent accession of the country to the European Union (EU), Cyprus is currently in the process of implementing the EU Water Framework Directive (WFD, 2000/60/EC), which calls for integrated water resources management in order to achieve "good water status" for European water resources by 2015.

A well-documented target for Cypriot water management bodies is to achieve water security by the use of alternative water resources that were unexploited in the past, such as desalinated water and recycled wastewater. In the 1990's the need to utilise these resources to respond to the problems arising from climate change and decreasing precipitation rates became pressing. Failure to exploit alternative water resources could lead to permanent desertification of the country, causing irreparable environmental and economic damage. During the past decade, two desalination plants have been built and were successful in addressing demand for domestic water use in Nicosia, Larnaca and their surrounding areas,

by producing a total of 91000m³ per day at a cost of CYP 0.54/m³ and CYP 0.41/m³, respectively.

The use of recycled wastewater has mostly focused on irrigation, to contest the overdependence of agriculture on groundwater (Socratous, forthcoming). Using recycled wastewater for agricultural, domestic and industrial applications has also attracted support from the water authorities during the 1990's. At that time it was realised that wastewater reuse could be seen as a lower cost alternative to desalination. Furthermore, environmental benefits could be attained by using wastewater to recharge depleted aquifers and reduce seawater intrusion while avoiding the ecological costs of discarding wastewater in the sea. Finally large savings in freshwater quantities could be achieved (Papaiacovou, 2001).

Currently all major cities in Cyprus apply secondary or tertiary wastewater treatment, and treated wastewater is used directly for irrigation. The possibility of reusing treated effluent in the Larnaca area has been investigated as early as 1982. However, recycled wastewater use for agricultural irrigation was not deemed cost effective since the particular area had no history in extensive irrigation and there were doubts whether the full amount of effluent could be used. Nevertheless, given sufficient quantities of effluent, approximately 400ha of land in the city and its environs could be irrigated especially for landscaping purposes with a benefit of switching from fresh water irrigation estimated at \$1,476,000 per year, not accounting for landscape beautification that could further the tourism industry and improving living conditions (Mill and Theophilou, 1995). In the Limassol prefecture, where the pilot study presented in this paper is undertaken, large scale wastewater treatment was initiated with the construction of a treatment plant in 1995, with the objectives of providing a safe and reliable system for wastewater disposal and improving environmental and water resource management (Papaiacovou, 2001). Most recently, the Water Development Department focused on using the rapidly depleting Akrotiri aquifer as a storage tank, i.e., to recharge the aquifer with treated wastewater, in order to reduce the effects of seawater intrusion. This study presented in this paper aims to help the policy makers by providing information on the farmers' willingness to accept replenishment of the aquifer with treated wastewater, as well as their preferences for the quality and quantity of water used to replenish the Akrotiri aquifer.

3. Contingent Valuation Study on Farmers' Valuation of Recycled Water

3.1. The Akrotiri Aquifer Case Study

The case study presented in this paper is the Akrotiri aquifer, a common-pool resource and the third largest aquifer in Cyprus, a semi arid country, which faces chronic water shortages, as explained above. The aquifer is extremely important for the local economy. Extending over 42 km², the aquifer not only provides local farmers with irrigation water, but also supplies a significant portion of the water needs of the city of Limassol and the nearby British sovereign bases. The Akrotiri

aquifer is replenished with runoffs from the Kouris River; releases from the Kouris River dam; rainfall, and agricultural return flows (Mazi et al., 2004).

The aquifer faces serious water quality and quantity problems, which are expected to have significant adverse effects on the welfare of the local farmers in the not too distant future. After the construction of the Kouris river dam, inflow in the aquifer has decreased significantly resulting in a lower water table (Mazi et al., 2004). This has led to intrusion of saltwater into the aquifer to maintain the hydrological balance. Water quality in the aquifer is deteriorating further because of the intensive use of fertilizers and pesticides in agricultural production in the area. Recently the Cypriot government has designated the Akrotiri aquifer as a "Nitrate Vulnerable Area" (Ministry of Agriculture, Natural Resources and the Environment, 2004). The quantity of water in the aquifer is also adversely affected by uncontrolled and excessive pumping in the area, an artefact of lack of clearly defined property rights, i.e., the open access nature of the aquifer.

In order to mitigate the adverse effects of reduced water availability and deteriorating water quality in the aquifer, its replenishment with treated effluent from Limassol and nearby villages has been proposed, as explained above. Given that the public good and open access nature of the resource has resulted in its inefficient management, economic instruments, including water pricing have been proposed to enable the efficient and sustainable management of the aquifer.

3.2. Theoretical Framework

A contingent valuation (CV) survey was implemented to estimate farmers' valuation of recycled wastewater use programs to be implemented in the Akrotiri aquifer. Following (Kontoleon and Swanson, 2003) four recycled wastewater use programs were valued, where a respondent's valuation (i.e., total willingness to pay (WTP)) for each program can be defined as the value of simultaneous change in the quantity (water level in the aquifer) and quality (treatment level of the recycled wastewater used to replenish the aquifer) of water in the aquifer. This survey design, which is also known as scenario difference approach, enables estimation of the values of both the quantity and the quality of the recycled wastewater used to replenish the aquifer.

More formally, the valuation exercise presented in this paper takes into account that a recycled wastewater use program might have multidimensional impacts on the state, q , of the aquifer, affecting both its quantity (water level in the aquifer) and quality (treatment level of the recycled wastewater used to replenish the aquifer). The definition of value used in this paper, therefore treats q as a vector [4].

Following (Kontoleon and Swanson) assume that q consists of two dimensions, the quantity and quality of the water in the aquifer, $q=(q_1-q_2)$, where the former is measured by the level of recycled wastewater used to replenish the aquifer and the latter is measured by the quality of treated wastewater used to replenish the aquifer. A farmer's preference function can be specified as $u = u(x(q_1, q_2))$ where x is the composite good, i.e., water for irrigation. For a multidimensional

change in the program that results in the simultaneous change in both dimensions in q , the Hicksian compensating welfare measure is the amount of income paid or received that would leave the individual at the initial level of utility subsequent to the multiple impacts of policy. For the change from q^0 to q^1 a holistic measure of value is represented by:

$$WTP(q^0, q^1) = e(p, q_1^0, q_2^0, u^0) - e(p, q_1^1, q_2^1, u^0) \quad (1)$$

Where $e(\bullet)$ is the standard respondent expenditure function defined for market prices p and fixed utility u^0 . Following (Kontoleon and Swanson), component values can be subsequently defined from (1) by using a simultaneous valuation path that begins at $q^0 = (q_1^0, q_2^0)$ and ends at $q^1 = (q_1^1, q_2^1)$. The simultaneous valuation path estimates the effect of each element of q as the overall vector changes from q^0 to q^1 . The disaggregated expression for (1) is given by:

$$WTP(q^0, q^1) = \int_{q^0}^{q^1} \left[\frac{\partial e(p, q_1, q_2, u^0)}{\partial q_1} \right] dq_1 + \int_{q^0}^{q^1} \left[\frac{\partial e(p, q_1, q_2, u^0)}{\partial q_2} \right] dq_2 \quad (2)$$

where each one of the two components of (2) evaluates a derivative of the expenditure function $\frac{\partial e(p, q_1, q_2, u^0)}{\partial q_i}$, $i \in \{1, 2\}$ as the overall recycled wastewater use program shifts from its initial to post-program level.

3.3. Data Collection

Data collection took place during September and October 2006 in four villages located in the Akrotiri area. The sampling frame is comprised of all the farmers located in the area. The results reported in this paper, however, are from a pilot sample, which was envisaged to include randomly selected 100 farmers from the sampling frame. Overall 97 percent of the pilot sample approached agreed to take part in the survey, and the results reported in the following section are representative of the Akrotiri area.

The CV survey consisted of three parts. In the first section the respondents were informed of the serious water quality and quantity challenges faced by Cyprus. They were reminded of the irrigation water shortages in the Akrotiri area due to uncontrolled pumping from the aquifer. They were also explained that uncontrolled pumping lowers the groundwater level, causing seawater intrusion, and hence increasing water salinity, which makes the groundwater inappropriate for irrigating most crops. Farmers were further reminded that lower levels of water in the aquifer imply higher pumping costs. They were warned that ongoing groundwater overexploitation in the Akrotiri area will eventually result in the permanent desertification of presently fertile areas, thereby causing irreparable

economic damage to local and national agriculture and hence to the national economy.

Farmers were then presented with the new water resource, namely the use of recycled wastewater for replenishment of the Akrotiri aquifer, which they were told would definitely provide long-term water security in the area. They were explained that under the recycled wastewater use program, treated wastewater from Limassol and the nearby villages would be channelled into the aquifer to replenish its groundwater supplies. They were further explained in layman terms what recycled wastewater is and how the program would work. Finally, the farmers were told that if a recycled wastewater use program is implemented, they would be asked to pay a price to the government for each m³ of water they pump from the aquifer, and the Ministry of Agriculture and Natural Resources would monitor the quantity of water pumped. They were explained that the quality of the recycled wastewater used to replenish the aquifer, and the quantity of the water in the aquifer would depend on the price of each m³ of water pumped from the aquifer.

Farmers were presented with four distinct recycled wastewater use programs, characterised in terms of the quantity and quality of recycled wastewater used to replenish the aquifer. The definitions of the recycled wastewater use programs were based on the focus group discussions and personal interviews with the policy makers, ecologists and hydrologists at the Ministry of Agriculture, Natural Resources and the Environment. Farmers were explained that the government would be equally likely to undertake any one of the programs, or to not to undertake any recycled wastewater use program at all, depending on the costs and benefits generated by each option. The four recycled wastewater use programs and the present situation, i.e., status quo, were defined as follows:

Status Quo: This is the present situation in which no recycled wastewater use program is implemented to replenish the aquifer. In this case the quantity of water in the aquifer, which is currently at a medium level, will decrease rapidly to a low level within the next 10 years, implying that the pumping costs will double. In the present situation farmers are not expected to pay for the water they pump from the aquifer.

Recycled Wastewater Use Program A: In this program low quality treated wastewater is used to replenish the aquifer. Low quality treated wastewater is appropriate for irrigating forestland, albeit in a controlled manner which ensures neither humans nor crops come in contact with the water. The quantity of water in the aquifer will stay at its current medium level and the pumping costs will remain the same during the next 10 years. If this program is undertaken, then the farmers are expected to pay for each m³ of water they extract from the aquifer.

Recycled Wastewater Use Program B: Under this program medium quality treated wastewater is used to replenish the aquifer. Medium quality treated wastewater is appropriate for irrigation of trees, such as olive trees, or vineyards, where water does not come in contact with the crops. The quantity of water in the aquifer will stay at its current medium level and the

pumping costs will remain the same during the next 10 years. If this program is undertaken, then the farmers are expected to pay for each m³ of water they extract from the aquifer.

Recycled Wastewater Use Program C: Under this program medium quality treated wastewater is used to replenish the aquifer. The quantity of water in the aquifer will increase to a high level, implying that the pumping costs will decrease to half or even quarter of what they are now during the next 10 years. If this program is undertaken, then the farmers are expected to pay for the m³ of water they extract from the aquifer.

Recycled Wastewater Use Program D: Under this program high quality treated wastewater is used to replenish the aquifer. High quality treated wastewater is appropriate for irrigation of crops whose edible parts do not come in contact with water. The quantity of water in the aquifer will increase to a high level, implying that the pumping costs will decrease to half or quarter of what they are now during the next 10 years. If this program is undertaken, then the farmers are expected to pay for the m³ of water they extract from the aquifer

An “advanced disclosure” approach was employed, where respondents were presented in advance with all four recycled wastewater use programs and the status quo alternative (Kontoleon and Swanson, 2003). The valuation questions consisted of two parts: first the respondents were asked whether they would be WTP some amount of money for m³ of water in order to move from the status quo to program A. In the case where the respondent was willing to participate in the recycled wastewater use program, they were asked for their maximum WTP for m³ of water, using a payment card with amounts ranging from Cyprus Pounds (CYP) 0.01 (€0.018) to over CYP2 (€3.516). Similarly the respondents were asked whether they would like to participate in recycled water use programs B, C and D, and if they were, they were asked to state their maximum WTP to move from the status quo to each one of these programs. Before stating their WTP, the respondents were told to bear in mind how they think the programs described above would affect their production, current income and other financial obligations, as well as their future agricultural income. They were also reminded that if the majority of farmers decline the recycled wastewater use programs, other measures would have to be imposed, such as obligatory taxation, for water pumping. Debriefing questions were asked to identify between protest responses and true zero values.

The second section of the survey collected information on the farm characteristics, farm management practices, as well as farmers’ attitudes and perceptions on how they think consumers would perceive agricultural production which uses recycled wastewater, and what they think are the most important agricultural problems in Cyprus. The final section of the survey collected various social and economic data on the farmers and their families, including age, educational level and household size.

4. Results

The sample statistics are reported in Table 1. The main decision makers in the farm are all male and full time farmers. Only 4.4 percent of them have part time jobs in addition to full time farming. Their average age is 46.1, which is slightly younger than the European Union average of 48 years (Eurobarometer, 2000). The main decision-makers' average years of experience in farming is 20.44 years. 82.4 percent of the farmers have high school diplomas, whereas only 3.3 percent or less have primary school diplomas, and 4.4 percent have university degrees. The average farm household in the area comprises of 3.1 members, and the average number of children is one. The total monthly expenditure of households (proxy for income) is CYP1598.8 (approximately €2896). The average total area of land owned by the households (indicator of wealth) in the sample is 64.9 hectares; the average total area they cultivate is 65 hectares, of which an average of 34.7 hectares are irrigated. 48.6 percent of farmers obtain their water for irrigation from a well located on their land, whereas 41.7 percent get their irrigation water from dams and reservoirs, and only 9.7 percent buy their irrigation water from other farmers in the area.

Table 1. Farmer, farm household and farm characteristics

Variable	Mean (std.dev.)
Age of the main farm decision maker	46.1 (11.6)
Farming experience of the main farm decision maker	20.5 (11.9)
Farm household size	3.1 (1.4)
Number of children in the household	0.95 (0.91)
Total monthly household expenditure (in CYP)	1598.8 (453.4)
Total area of farm land owned by the household (in ha)	64.9 (30.2)
Total area of farm land cultivated by the household (in ha)	65 (29.2)
Total area of irrigated farm land cultivated by the household (in ha)	37.7 (22.6)
	Percent
Education: high school=1, 0 otherwise	82.4
Education: University and above =1, 0 otherwise	4.4
Education: less than primary school =1, 0 otherwise	3.3
Main decision maker has part time job=1, 0 otherwise	4.4
Irrigation water from well on land=1, 0 otherwise	48.6
Irrigation water from dams and reservoirs=1, 0 otherwise	41.7
Irrigation water from other farmers=1, 0 otherwise	9.7

Source: Akrotiri Recycled Wastewater Use Program Survey, 2006.

Farmer perceptions of consumers' attitudes towards food produced with recycled wastewater, as well as their perceptions of the most important agricultural problems in Cyprus are reported in Table 2. Whether or not the farmers agree with the statements reported in Table 3 was graded on a Likert Scale (Strongly disagree=1, Disagree=2, Neither agree nor disagree=3, Agree=4, and Strongly agree =5). The Likert Scale is converted into dummies (Agree or Strongly agree 1, 0 otherwise) for the purposes of the analysis.

When asked how do the farmers think the consumers would react when they know that recycled water is used in agricultural production in the area, the consensus is split, as 47.3 percent of them think that consumers might decrease or stop consumption of agricultural products from the area, and 52.7 percent think that use of recycled water in the area would either have no affect on consumer behaviour or increase consumption of agricultural products from the area. Farmers' perceptions of the most important agricultural problems in Cyprus reveal that about half of them consider water resources related problems, e.g., high water salinity, low water quality and quantity, as the most important agricultural problems in Cyprus.

Table 2. Farmer perceptions of consumers' attitudes towards food produced with recycled wastewater and most important agricultural problems in Cyprus

Statement	Percentage agree or strongly agree
If consumers knew recycled wastewater is being used for agricultural production in the area, they would....	
stop consumption of food produced in the area	13.2
decrease consumption food produced in the area	34.1
not change their consumption of food produced in the area	35.2
slightly increase consumption of food produced in the area	13.1
considerably increase consumption of food produced in the area	4.4
The most important agricultural problem in Cyprus is....	
low food prices	41.8
low fertility of land	36.3
low water quantity	53.9
lack of subsidies to agricultural sector	52.8
high salinity of water	44
low water quality	45.1

Source: Akrotiri Recycled Wastewater Use Program Survey, 2006.

When asked whether or not they would be WTP in order to move from status quo to the recycled wastewater use programs, six respondents stated that they would not be WTP for any one of the programs. In order to differentiate true zero WTP values from protest responses, five follow-up questions in close-ended response format were asked (Haab, 1999): (i) I shouldn't be asked to pay for the water under my land; (ii) I do not believe that the system will succeed in improving conditions; (iii) I have no interest for water quantity and quality in the aquifer; (iv) I don't believe that recycled wastewater is safe and appropriate for farming, and (v) It is not profitable for me to participate. Those respondents that have agreed with the statements (i), (ii) or (iv) were classified as protesters of the recycled wastewater program and were removed from the sample. Consequently, all of the six respondents, i.e., 6.2 percent of the sample were classified as protestors, and the remainder of the sample, i.e., 93.8 percent believe that the recycled wastewater use program is safe for farming, it would succeed and they would pay for the water in the aquifer.

The average and median WTP values for the remaining 91 respondents, who are in favour of the recycled wastewater use programs, are reported in Table 3. On average farmers are WTP CYP0.37 per m³ of water to have the recycled wastewater use program A implemented. This program would ensure that the farmers have as much water as they do now within the next 10 years. Although under this program the quality of treated wastewater is low, this significantly high WTP reveals farmers' concerns with regards to decreasing quantity of water in the aquifer. Farmers are WTP an additional CYP 0.03 per m³ of water for program B, in order to secure medium quality treated water alongside a medium quantity of wastewater in the aquifer within the next 10 years. Farmers' WTP for higher quantity of water in the aquifer in addition to medium quality treated wastewater is CYP 0.03 more, i.e., CYP 0.43 per m³ of water. Finally, they are WTP an additional CYP 0.07 per m³ of water for recycled wastewater use program D, which ensures high quantity of water in the aquifer, as well as the use of high quality treated wastewater for replenishment of the aquifer.

Table 3. Mean and median WTP values for recycled wastewater use programs (in CYP/m³ of water)

Recycled water use program	Mean (std. dev.)	Median
Recycled water use program A	0.37 (0.46)	0.1
Recycled water use program B	0.40 (0.46)	0.2
Recycled water use program C	0.43 (0.47)	0.2
Recycled water use program D	0.50 (0.47)	0.4

Source: Akrotiri Recycled Wastewater Use Program Survey, 2006.

The relationship between farmers' WTP for recycled water use programs and program attributes, controlling for farmer characteristics, attitudes and perceptions was further examined. An ordinary least squares (OLS) stacked regression model was estimated, where respondents' WTP was specified to be a function of medium and high water quantity in the aquifer, and medium and high quality treated wastewater used to replenish the aquifer, taking low quality of treated wastewater and low quantity of water in the aquifer as base levels. The results are reported in Table 4.

The results of the OLS regression reveal that farmers' WTP significantly increases with the use of high quality treated wastewater used to replenish the aquifer, as well as with medium and high levels of water quantity in the aquifer. The only significant determinants of WTP are total irrigated land area, percentage of water obtained from the well on the land, and farmers' perceptions on the importance of water quality and salinity in Cyprus. As expected, those farmers who have higher total areas of land irrigated, and those who obtain higher percentages of their water from wells on their lands, are WTP more for higher levels of water quantity and treated wastewater quality. Further, farmers who think that low water quality is a very or extremely important agricultural problem in Cyprus are WTP more for the recycled wastewater use programs, inline with the findings for higher WTP values for recycled wastewater use program D, which supports high quality

treated wastewater. Those who consider high salinity to be a very or extremely important agricultural problem in Cyprus are WTP less for the recycled wastewater use programs, reflecting that for this new technology to succeed in Cyprus, special water treatment technology, which keeps salinity of recycled water at low levels, should be employed, so as to not to increase the salinity of groundwater.

Table 4. Ordinary Least Squares Regression on determinants of WTP for recycled wastewater use programs

Variable	Coefficient (Std. Err.)
Constant	-0.178** (0.11)
Medium quality water	0.025 (0.047)
High quality water	0.096* (0.067)
Medium quantity water	0.370*** (0.037)
High quantity water	0.401*** (0.060)
Total area of land irrigated	0.0002*** (0.1)
% of irrigation water from well on farm	0.0005*** (0.0001)
% of irrigation water from dams and reservoirs	-0.0002 (0.0004)
Farming experience of the main decision maker	0.001 (0.001)
Education level of the main decision maker	0.016 (0.019)
Total expenditure of the household	-0.00001 (0.00003)
Consumers' perceptions favourable	-0.016 (0.025)
Low water quantity most important problem	0.014 (0.027)
High salinity of water most important problem	-0.103*** (0.042)
Low water quality most important problem	0.134*** (0.041)
Adjusted R ²	0.34
Sample size	91

Source: Akrotiri Recycled Wastewater Use Program Survey, 2006.*** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests

For the purposes of the cost-benefit analysis of the recycled wastewater use programs, WTP values for (i.e., benefits generated by) all four wastewater use programs were calculated by employing the significant regression parameters related to recycled wastewater use program (i.e., high water quality and medium and high quantity), as well as farm characteristics (i.e., total area of land irrigated and percentage of irrigation water from well on land). Farmer perceptions of important agricultural problems in Cyprus were excluded, since these could not be used for cost-benefit analysis. Furthermore, WTP for wastewater use programs A and B are the same since farmer WTP for medium and low quality wastewater are insignificant.

The WTP is calculated for the sample average as well as for six farmer profiles. Since there is no strong correlation between total area of land irrigated and percentage of irrigation water obtained from well on farm, the farmer profiles were created as follows: First, farms were categorised according to size, small size being less than 20 ha, medium ones between 20 and 60 ha, and large ones larger than 60 ha. The average sizes of small, medium and large farms were calculated to be 12.9, 36 and 70.6 ha respectively. An average small farm is found to obtain

45.3 percent of irrigation water from the well on their farm, this figure is 47.9 and 55.7 percent for medium and large farms, respectively. Small, medium and large farms are labelled Farm profiles 1, 2 and 3 respectively. Farm profiles 4, 5 and 6 are categorised according to percentage of irrigation water they obtain from the well on land. Accordingly, the average of farms, which obtain less than 30 percent of their irrigation from well on farm is 8 percent, whereas the average of farms, which obtain between 30 and 70 percent of their irrigation from well on farm is 55.7 percent and the average of farms, which obtain more than 70 percent of their irrigation from well on farm is 91.9 percent. The average sizes of these farms are 35.4, 41.6 and 37.5 ha respectively. The WTP results for these six profiles and for the sample average are reported in Table 5.

Table 5. Farmer WTP for Recycled Wastewater Use Programs (CYP/m³)

Farm Profile	Recycled Wastewater Use Programs A and B	Recycled Wastewater Use Program C	Recycled Wastewater Use Program D
Average farm profile	0.378	0.465	0.536
Farm Profile 1	0.325	0.370	0.441
Farm Profile 2	0.372	0.418	0.489
Farm Profile 3	0.461	0.505	0.576
Farm Profile 4	0.352	0.396	0.467
Farm Profile 5	0.389	0.433	0.504
Farm Profile 6	0.400	0.444	0.515

Source: Akrotiri Recycled Wastewater Use Program Survey, 2006.

The results reported in Table 5 reveal that all of the farmer profiles are WTP higher for higher levels of water quantity and wastewater quality, with Farmer profile 1 having the lowest WTP for Recycled Wastewater Use Programs A and B, and Farmer profile 3 having the highest WTP for Recycled Wastewater Use Program D. These results are expected to aid policy makers in designing efficient and equitable wastewater use programs, since they could be used in cost-benefit analysis of different intensity and scale of wastewater use programs, and could aid establish the price of the water from the aquifer depending on the size of the farm and the extent of extraction of water from the aquifer.

5. Policy Implications and Conclusions

This paper employed the contingent valuation (CV) method in order to estimate the value of (or economic benefits generated by) a new water resource, namely recycled wastewater, so as to inform the policy makers about what quantity and quality of water to provide and which price to charge.

More specifically, a CV exercise was undertaken to examine a) farmers' attitudes towards adoption of this new technology, i.e., the use of recycled wastewater to replenish an aquifer used for irrigation, and b) their willingness to pay (WTP) for different levels of water quantity in the aquifer, and for different

levels of treated wastewater quality used to replenish the aquifer. The case study is the Akrotiri aquifer, located in Cyprus, an arid country with chronic water shortages, where water scarcity may limit economic development and growth, as well as sustainability of food production in the long run. Therefore, adoption of solutions such as use of recycled wastewater for irrigation is essential and urgent for sustainable management for water resources in Cyprus. The Akrotiri aquifer, similarly to several common-pool, open access water resources and public goods, is facing rapid deterioration of its water quality and quantity, and is in need of drastic economic and other measures to ensure its efficient and sustainable management.

The results of this pilot exercise reveal that majority (i.e., 93.8 percent) of the randomly selected farmers located in the Akrotiri area, are willing to participate in and also WTP significant amount for recycled wastewater use programs. Farmers' are WTP higher amounts for those programs, which generate higher water quantity in the aquifer, and use higher quality recycled wastewater for the replenishment of the aquifer. Farmers, however, are WTP even for those recycled wastewater use programs, which use low quality treated water, revealing the gravity of the water quantity scarcity problem faced by farmers in this area. Furthermore, those farmers who have larger areas of irrigated land, and those who obtain most of their irrigation water from wells on their lands are WTP more for quality and quantity of water in the aquifer, compared to those farmers who farm smaller areas and obtain their irrigation water from dams and reservoirs. Finally, farmers are also concerned about the level of salinity in the aquifer as a result of its replenishment with recycled wastewater, as those who consider water salinity to be an important problem are WTP less for recycled wastewater programs.

These results could have important implications for efficient and equitable pricing of water in the aquifer, as well as for adoption of the appropriate recycled wastewater use program, which maximizes the social welfare. In order to be able to draw sound policy recommendations, however, revenues that would be generated under each recycled wastewater use program should be compared to the costs of the programs.

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