SURVEY

The social acceptability and valuation of recycled water in Crete: A study of consumers’ and farmers’ attitudes

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ABSTRACT

This paper investigates the Willingness to Use (WTU) and Willingness to Pay (WTP) for recycled water in agriculture. We report results from surveys of farmers and consumers on the island of Crete, Greece. Crete is suffering from an increasingly severe water shortage coupled with declining groundwater supplies, therefore the wider use of recycled water is an important policy priority. We have investigated WTU and WTP for two crops with two different levels of water treatment. The mean WTP for 1 cm³ of recycled water was 0.15 € for the irrigation of both olive trees and tomato crops, namely 55% of the fresh water price. The mean WTP for olive oil produced from olive trees irrigated with recycled water was 2.65 €, namely 88% of its current market price. We have found that both attitudinal factors, such as environmental awareness and economic factors, such as freshwater prices and incomes, are significant in explaining the WTU and WTP for recycled water and products produced using it, but that important differences exist between farmers and consumers.

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1. Introduction

Recycled water is a valuable resource that originates from wastewater treatment. Wastewater from wastewater treatment plants has typically been disposed of in the sea or rivers. Today, the consequences of increased water demand, prolonged droughts and serious precipitation imbalances, have highlighted the importance of exploiting all other possible sources of water before using up scarce fresh water supplies. Oron (2003) summarizes the multiple benefits from water recycling: “...it has emerged as a realistic option for new sources of water to meet water shortages, expand irrigated agriculture and meet wastewater disposal standards aimed at protecting the environment and public health”. Arrojo (1999) claims that: It is often cheaper and more equitable to increase the efficiency of existing water uses than increase supplies, while Gleick et al. (2002) points out that “the needle to be threaded in water management is how to get the most value from water that is available, while not depriving people of sufficient clean water to meet their basic needs”.

The importance of wastewater treatment and reuse, as part of water resources management, has been widely recognized and is in the foreground of European legislation. Article 12 of Directive 91/271 states that: “Treated wastewater shall be reused whenever appropriate” (EU, 1991). In fact, treatment technologies have reached an advanced level and can produce an effluent quality appropriate for numerous applications. The use of recycled water is advisable for many purposes including toilet flushing (Lazarova et al., 2003), fire protection (Borboudaki et al., 2005), lake creation, industry (Lubello et al.,
Hussain et al. (2002) report that most crops give higher yields, when irrigated with wastewater than with fresh water and have less need for chemical fertilizers, resulting in net cost savings to farmers. However, there are public health risks in this process. Furthermore, if total nitrogen delivered to the crop via wastewater irrigation exceeds crop demands, it may stimulate vegetative growth, delay ripening and maturity, and cause yield losses (Crook, 1998). Moreover, excessive application of nutrients, and particularly nitrogen, may result in significant environmental risks to surface water bodies or groundwater due to runoff and/or leaching (Tomer and Burkart, 2003). Additional risk factors which need to be taken into consideration when applying recycled water for irrigation include the possibility of spreading infectious diseases, soil salinisation, impacts on soil structure, chemical and toxic contamination (Toze, 2006; Paranychianakis et al., 2006b). Of critical importance is the occurrence of pathogens in recycled water. Although they are present in very low concentrations, they may be harmful if the edible parts of the irrigated plant come into contact with recycled water and these crops are then consumed raw. For this reason some countries actually forbid recycled water applications in agriculture. However, recycled water is appropriate for cultivations, such as olive trees, vineyards and the irrigation of parks, where no such risk is present.

Depending on its quality and origin, five simplified recycled water quality levels have been proposed (Table 1) and were used in this research (Sakkas et al., 2004). This categorization system was used to help farmers and consumers understand the different wastewater treatment levels and state their preferences and intentions concerning their usage. We use a simplified coding, focusing only on organic loads and pathogens, although other parameters like heavy metal content and salinity could be examined.

This paper aims to estimate willingness to use (WTU) and willingness to pay (WTP) for crops related to recycled water, on the part of both producers and consumers. To do so, the contingent valuation method was used to elicit peoples’ preferences and their WTP. The ultimate objective was to estimate the value of recycled water in irrigated agriculture. The results from this research will benefit project evaluation for appropriate economic analysis (Parena, 2005; Dutta and Tiwari, 2005; Garcia et al., 2005). The next section of the paper provides information on water resources and demands in Crete. Following this, we review the literature on recycled water acceptability, present a conceptual framework and the research methodology, and then provide results, discussion and a conclusion.

### 1.1. Water resources in Crete

Crete is the largest island in Greece with a land surface of 8335 km² and a population of 535,000 inhabitants (census, 2001). It commits up to 83% of its water resources to agriculture (Tsagarakis et al., 2001). Although ground water resources in Crete are estimated to be sufficient to cover all water needs, temporal and spatial variations in the precipitation, the difficulty of transporting water due to the mountainous terrain, major water losses (seepage, evaporation, Leakage, etc.) during the delivery of water to agricultural sites for irrigation and to municipal sites for domestic use (Chartzoulakis et al., 2001), coupled with the lack of proper organization and infrastructure, have led to serious water shortage problems. These problems are worse during summer, because of tourism and the increased demand for irrigation water by farmers.

### Table 1 – Water qualities

<table>
<thead>
<tr>
<th>Water quality</th>
<th>Explanation</th>
<th>Appropriate uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Untreated wastewater: polluted wastewater in the form it is found in sewerage.</td>
<td>None!</td>
</tr>
<tr>
<td>1</td>
<td>Primary treatment: Wastewater that has been subject to a first cleaning stage. The pollution level (organic load and pathogens) has been reduced by 30–40%. Usually this type of water has received disinfection and therefore is free of pathogens.</td>
<td>It is appropriate for surface tree irrigation, such as olive trees, vineyards, industrial trees and other trees where water does not come into contact with the crops.</td>
</tr>
<tr>
<td>2</td>
<td>Secondary treatment: Wastewater has been subject to a second cleaning stage. The pollution level (organic load) has been reduced by 95%. Usually this type of water has received disinfection and therefore is free of pathogens.</td>
<td>Appropriate for the irrigation of cultivated which are consumed by humans on the condition that the edible parts do not come in contact with this water.</td>
</tr>
<tr>
<td>3</td>
<td>Tertiary treatment: Wastewater has been subject to a third cleaning stage. The pollution level (organic load) is reduced by 99%. Disinfection has taken place and there are no pathogens.</td>
<td>Appropriate for the irrigation of any crop and human use.</td>
</tr>
<tr>
<td>4</td>
<td>Potable water</td>
<td></td>
</tr>
</tbody>
</table>
Irrigation water in Crete usually comes from the same sources as potable drinking water, being itself potable water or generally water of good quality that could be rendered potable with little treatment. Only one third of Greek agricultural land is irrigated (in Crete this is 36%), but the mean annual water demand is increasing at 1–1.5% per annum (Tsagarakis et al., 2001). The potential for water reuse and recycling, particularly in southeastern parts of Greece, such as in Crete, is very high. The usage of recycled water, where appropriate, would relieve Cretan farmers from a water shortage stress during summer months and would free up fresh water for domestic and other purposes, while at the same time safeguarding overexploited groundwater resources. Fig. 1 shows the trend of a lowering of the water table depth, indicating increasing cumulative depletion (2003 was an exception because of considerably higher precipitation). This falling groundwater resource is responsible for the occurrence of the desertification phenomenon, which is due to the irreversible intrusion of seawater in underground fresh water aquifers.

1.2. Recycled water use and acceptability; a literature review

Findings from the literature on the acceptability of recycled water use amongst producers and consumers are mixed. There are many factors which play a role in its acceptance, the most important of which are the extent of “disgust” over the concept, the use for which recycled water is intended, perceptions of risk from recycled water, the sources of recycled water (e.g. is it rainwater or toilet water), choice between recycled and fresh water, trust of authorities and knowledge, attitudes towards the environment, environmental justice issues, the cost of recycled water and socio-demographic factors (Po et al., 2004). Furthermore, the degree of public acceptance is affected by many factors including the political context of a country (Marks, 2005), local history, the recycling terminology used with the public, the degree of public involvement in strategy development, the threat of alternatives, such as dams, river development or ocean outfall, the degree to which potable recycling is pushed as the primary option, the “not in my backyard” phenomenon, cohesion of authorities and the degree and nature of education provided (Queensland Government, 1999).

The perceptions of risks from the use of recycled water are related to health, foremost among peoples’ worries are the safety of their children (Sydney Water, 1999). Water recycling can be more easily accepted in areas with water shortages (Dishman et al., 1989). The acceptability of recycled water decreases as the use moves from public areas (e.g. irrigation of parks) to house (gardening) or to more personal uses, due to risk perception (ACIL Tasman, 2005; Hurlimann, 2005). Socio-demographic factors appear to provide important information as to which demographic groups are most likely to accept recycled water usage. McKay and Hurlimann (2003) predicted that the greatest opposition to water reuse schemes would be from people aged 50 years and over. Such findings on age are also reported by Tsagarakis and Georgantzis (2003) who also found that educated people were more willing to use recycled water. Using conjoint analysis Hurlimann and McKay (2007) have shown that acceptability of recycled water increases with certain attributes, like low salt, lack of colour and odour, and low price. Contrary to a generally held expectation, Po et al. (2004) support that social marketing and information appears to be ineffective in influencing people to use recycled water.

The cost of recycled water is, as noted above, an important factor in encouraging recycled water usage. Hurlimann et al. (2005) found that people were willing to pay 76% of the price of fresh water for recycled water. In order to gain acceptance of water reuse, suppliers tend to offer recycled water at concession prices (Hatton MacDonald and Dyack, 2004). For agricultural purposes, willingness to pay can be low due to the relatively cheap (and often subsidised) freshwater irrigation prices, so that most reuse projects involve a direct or indirect subsidy (Hatton MacDonald and Dyack, 2004).

2. Conceptual framework

Tsagarakis (2005) claims that “any integration, protection and sustainable management of water in today’s societies will incorporate marginal waters that can be recycled”. The main argument is that since wastewater is a by-product of fresh water consumption, several principles and articles of the 60/2000 Water Framework Directive (EU, 2000) can be applied to recycled water.

The present study consists of two parts. The first concerns farmers, who are the potential direct users of recycled water through the irrigation of their cultivations. The second concerns consumers, who will be the indirect users of recycled water through the consumption of irrigated food products. The need for this duality lies in the fact that there is no point in farmers cultivating products that are not going to be bought by consumers and vice versa; consumers cannot consume food products that farmers refuse to grow. Po et al. (2005) found that 80% of people would be willing to consume

![Fig. 1 - Variation of the water table in a Cretan aquifer (Messara basin), as reported from a representative well (Region of Crete, 2003).](image-url)
vegetables grown with recycled water because they did not see any problems with it (48%) or because they supported the use of recycled water (32%). The paper studies both the acceptability (WTU) and the valuation of recycled water (WTP). WTU is a decision that takes place before that of WTP. One decides first whether one is willing to use a good in principle, and then decides how much one is willing to pay for that good. A person may be willing to use but unwilling to pay. WTU reveals how attractive the idea of a good is but if a person states that he is not willing to use the good, then he will not use it, regardless of how attractive the price might be. In that case, other factors might need to be changed, e.g. provision of more information, education etc. Therefore, studying WTU helps in classifying the characteristics of people in terms of the utility they derive from the usage of recycled water. WTP reveals the consumer surplus they enjoy from a certain good and it is vital to know this when a pricing policy for recycled water is under consideration.

Explanatory factors for WTU and WTP models depend on the context of the research problem. In this paper both WTU and WTP models contain environmental conscience and demographic variables. WTP models for farmers also contain the price of the substitute product under discussion (fresh water for irrigation), and a geographical variable, whilst WTU models for farmers also contain a geographical variable. WTU models in the farmers case are set up in a logit regression framework (Models 1 and 2 in Section 4), in which the dependent variable is the natural logarithm of the odds ratio in favor of using recycled water. Therefore these models, as Eq. (1), estimate for farmers the variables that affect the probability of being willing to use recycled water for irrigation, relative to the probability of not being willing to use it:

$$\ln \left( \frac{P_{ij}}{1-P_{ij}} \right) = \beta_0 + \beta_k X_{ik} + u_i$$

with i=1... n indexing farmers and k=1... m being the explanatory variables. Significant variables in this model will provide important insights into the parameters that must be taken into account in order to design a good marketing strategy for recycled water in terms of its take-up by farmers.

WTU models in the consumers’ case (Models 3, 4 and 5 in Section 4) work under the ordered logit regression framework in which the dependent variable is given as a ranking of the likelihood of consumers buying products grown with recycled water, on a 4-point scale. The ordered model is based on the notion that there is some latent continuous variable (Di, utility from recycled water) and that the ordered variable arises from discretizing this utility into ordered groups, as in Eq. (2):

$$D_i = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ik} + e_i$$

where

WTU1=1, if $D_i \leq 0$ “consumer is definitely negative”

WTU2=2, if $0 < D_i \leq \mu_1$ “consumer is maybe negative”

WTU3=3, if $\mu_1 < D_i \leq \mu_2$ “consumer is maybe positive”

WTU4=4, if $D_i \geq \mu_2$ “consumer is definitely positive”

The above model is estimated in the form shown in Eq. (3):

$$\ln \left( \frac{P_{ij}}{1-P_{ij}} \right) = \beta_0 + \beta_k X_{ik} + u_i$$

where j represents the different outcomes of the ordered variable, i and k is as defined above. Significant variables in ordered models tell which factors affect the probability of a consumer being definitely positive in consuming products irrigated with recycled water compared to the probability of being definitely negative. Because the distribution here has been assumed to be the logistic one, the probabilities of belonging to each category of the ordered variable can be calculated exactly (Train, 2003). Observing the supposed utility consumers derive from all the products encompassed in the research, provides valuable information to the policy maker, e.g. how much utility must the consumer be deriving from a product in order to pass from ‘maybe no’ to ‘maybe yes’ in consuming a product irrigated with recycled water. Another question addressed here is how these utility thresholds differ among the different products under examination. An ex-ante expectation is that consumers will pass from ‘definitely no’ to ‘maybe no’ or from ‘maybe no’ to ‘maybe yes’ at lower levels of utility the safer the product is assumed to be, e.g. a park irrigated with recycled water compared to tomatoes irrigated with recycled water.

WTP models, on the other hand, are more or less interpreted in a fashion analogous to linear regression results. In the farmers’ case (Models 6 and 7 in Section 4), it has been modeled as shown in Eq. (4):

$$\log \text{WTP}_i = \beta_0 + \beta_k X_{ik} + u_i$$

with all indexes interpreted as previously. The dependent variable is continuous and is taken as the natural logarithm of WTP because the lognormal distribution is non-negative. In the consumer’s case WTP has been modeled in two ways: One part of the data has been modeled with a least squares linear regression (Model 8 in Section 4) where WTP is in the form of open-ended responses, and another part of the data with a maximum likelihood estimation where WTP is in a double-bound dichotomous choice form (however, due to poor results, the latter – double-bound parametric results – are not reported here).

Policy makers would like to respond to the variables that appear to affect negatively the WTP, e.g. by improving education or by providing more information to certain groups of people. Because recycled water is supposed to be a low quality product compared to fresh water, WTP for it is expected to provide a base for the reconstruction of fresh water prices, which are generally acknowledged to be under priced in Greece (Safarikas et al., 2005).

3. Research methodology

3.1. The surveys

The farmers’ survey sampled farmers from olive oil and vegetable producing villages in Crete, while the consumers’ survey sampled consumers from the largest city in Crete, Heraklion. Selection of both types of respondents was random.
Prior stratification was undertaken in the farmers’ survey with respect to the villages that were centres for significant olive tree and tomato cultivation. Farmers were approached in their houses, cafes or streets. They were informed about the research topic and were asked whether they were willing to participate in the survey. If so, they were provided with illustrated information that explained basic facts about recycled water and its potential use in agriculture. To carry out the consumers’ survey, researchers stood in some of the busiest points in Heraklion city centre from July 2003–October 2003 and randomly selected pedestrians at different hours of the day in the morning and in the afternoon, on a first-to-pass basis.

3.2. The products

The olive tree and the tomato plant were selected for this study as typical crops in Crete which might be the focus for recycled water use. Both these products play an important role in Cretan agriculture and are cultivated by many farmers. In consumers’ survey the products were again olive oil and tomato consumption as well as “park visiting”, after irrigation with recycled water. To facilitate discussion, products in the farmers’ survey were given an alphabetical ordering (Table 2) from a to c, namely Product a, Product b and Product c. Recycled water quality is ascending from Product a to Product c. Products in consumers’ survey were given an enumeration from 0 to 3, namely Product 0, Product 1, Product 2 and Product 3. Similarly, a higher enumeration involves irrigation of the product with a higher quality of recycled water. Products a, b and c in the farmers’ survey correspond to Products 1, 2 and 3 in consumers’ survey. There is thus a correspondence among all products in the two surveys, except for Product 0 in consumers’ survey.

3.3. Questionnaire structure and the set-up of WTU and WTP questions

Two questionnaires were designed, each consisting of an introduction and three main parts. The introduction started with a very simple definition of recycled water and its potential. It was followed by illustrated information similar to that in Table 1. It was particularly stressed that if...
would be further depleted and b) recent investment on wastewater treatment plants which has cost 500 M€ (year base 2003) would not be fully exploited. The first part of the questionnaire contained environmental awareness questions and aimed at sketching the environmental profile of the respondent. The second contained the WTU and WTP questions. The third requested demographic data. During the interview, researchers had the opportunity to debrief some of respondents’ answers.

Farmers were asked two main WTU and WTP questions. First they were asked whether they would “use” (i.e. would cultivate) Product a (olive trees irrigated with quality 2 recycled water — see Table 2). Only those who responded “no”, were then asked whether they would use Product b, which was olive tree cultivation with higher quality recycled water. This also allowed a debrief of negative answers to the first WTU question. No WTQ question was posed after a negative WTU response. Farmers were asked about their WTP for Product a, as an open-ended question. We then asked whether farmers would use Product c — tomatoes grown with recycled water of quality 3. Finally, farmers were asked their WTP on Product c. The variables used in farmers’ models are shown in Tables 3 and 4.

Consumers were asked about their WTU for Products 0, 1, 2 and 3. Their WTQ was examined only in terms of Product 1 (olive oil) and not of Product 3, because tomato cultivation has characteristics (e.g. there are several tomato harvests throughout the year with different production costs), which made it rather difficult to formulate a WTP question analogous to the one for olive oil. Product 2 served the same purpose as Product b did in farmers’ survey, since it tested for willingness to consume the same product (olive oil) produced with higher quality recycled water. WTP data were collected in two different ways to check for elicitation effects, using a split sample. One part of the sample answered an open-ended question while the other answered a double-bound dichotomous choice question. The variables used in consumers’ models are shown in Tables 4 and 5.

**Table 5 – Dependent variables in consumers’ models**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTU0</td>
<td>Willingness to use (visit) Product 0. This is an ordered variable. Respondents choose among: Definitely no, Maybe no, Maybe yes, Definitely yes and I don’t know.</td>
</tr>
<tr>
<td>WTU1</td>
<td>Willingness to consume Product 1. This is an ordered variable. Respondents choose among: Definitely no, Maybe no, Maybe yes, Definitely yes and I don’t know.</td>
</tr>
<tr>
<td>WTU3</td>
<td>Willingness to consume Product 3. This is an ordered variable. Respondents choose among: Definitely no, Maybe no, Maybe yes, Definitely yes and I don’t know.</td>
</tr>
<tr>
<td>WTP0</td>
<td>Willingness to pay for 1 kg of Product 1 (open-ended question).</td>
</tr>
<tr>
<td>WTPd</td>
<td>Willingness to pay for 1 kg of Product 1 (DB-DC question).</td>
</tr>
</tbody>
</table>

4. Econometric estimation and results

4.1. Descriptive results for willingness to use

Willingness to use descriptive results for both surveys are shown in Table 6.

4.1.1. Farmers

The number of farmers reporting that they had faced problems with fresh water was 56%, but the number positively positioned towards using Product a was much greater, i.e. 75.7% (Table 6). This means that many farmers not just those who were facing water shortage problems thought it good to use recycled water for the irrigation of their olive trees. Thus, there are reasons besides water shortage that drive farmers to use recycled water and it is these reasons that are investigated in the WTU models section. About 42% of the respondents who previously had answered that they would not use Product a answered that they would use Product b. This can be seen as a type of “scope effect”, in that Product b has higher water quality than Product a. A smaller number of farmers were willing to use Product c (65.3%) than Product a. This is because the tomato plant is “more sensitive” than the olive tree to water quality, and its crops hang much closer to the ground. Consequently the crop runs a higher risk of coming into physical contact with recycled water.

4.1.2. Consumers

The majority of consumers (80.70%) in Table 6 are positively positioned (replied “maybe yes” or “definitely yes”) towards consuming Product 1 (olive oil grown with recycled water of quality 2). Of these, more than half (48.5%) said “maybe yes” rather than “definitely yes”, meaning that they were not that confident with their positive attitude. According to some consumers, the main reason for all positive responses was that irrigation fresh water is already dirty and that recycled water would not be any dirtier (uncontrolled rubbish dumping, pesticides application and seawater intrusion have contaminated water sources in some areas of Crete). Negative respondents, who replied “maybe no” or “definitely no” (14.7%) were also asked the reason for their response. The most commonly mentioned reason for not wanting to consume Product 1 or Product 3 was the fear that farmers would not use the right type of water for the right plant, or that they would not follow irrigation safety guidelines. Actually, this fear was justifiably expressed more intensively for Product 3, because tomatoes can be irrigated one day before harvesting. Consumers’ fears go back to whether the responsible authorities would do their job well in supervising farmers in their application of recycled water to agriculture and whether the wastewater treatment facility would constantly provide effluent of appropriate quality. The consumers who answered negatively were asked whether they would consume olive oil irrigated with higher quality recycled water (Product 2). 77.3% of consumers who were not willing to use Product 1 said that they would be willing to use Product 2 (replied “maybe yes” or “definitely yes”). This is again some
proof of scope effects, since consumers were not indifferent to a better quality of recycled water. Therefore, in total, 92.7% of consumers would be willing to use olive oil irrigated at least with type 3 of recycled water. A smaller number of consumers (63.2%) were willing to use Product 3, compared to those who were willing to use Product 1, indicating the apprehension with which they regard its use in tomato production relative to olive oil production. For Product 3, the better quality of recycled water is outweighed by the greater sensitivity of the tomato plant and its production. For Product 3, the better quality of recycled water is normal, there is contradictory evidence in literature. Markowska and Zylicz (1999) state that open-ended versions give lower bids because the respondent is deprived of a yardstick. However, Bateman et al. (1995) state that the opposite is also possible and attribute it to the uncertainty respondents experience when answering open-ended questions, which may lead them exhibit strategic overbidding tendencies. Note that besides the non-parametric estimation of mean WTP for Product 1 from the DB-DC data, the authors have also estimated the corresponding parametric mean with a technique described in Cameron (1991) and Cameron (1988). The results are not reported here due to the poor model results (Menegaki, 2005).

### 4.2. Descriptive results for WTP

#### 4.2.1. Farmers

Before posing the WTP question itself, farmers were first asked about their intention to pay, i.e. whether they would be willing to pay “more”, “as much as” or “less” than the fresh water price they were currently paying. Results of this question are presented in Table 7. As regards Product c, the majority still voted for “less”, but there is a considerable number of missing values from people who had difficulty in deciding on a WTP. Mean WTP for Product c (0.16€) is higher than WTP for Product a (0.15€), since farmers acknowledge its better quality. However, when mean WTP is adjusted for “no” responses, mean WTP for Product a is not significantly different than mean WTP for Product c. The WTP descriptive statistics can be seen in Table 8.

#### 4.2.2. Consumers

Like farmers, consumers were first asked an intention to pay question before answering the WTP question. A majority of consumers voted for “paying less” than the equivalent product price irrigated with fresh water (Table 7). The open-ended question gave a higher mean WTP for olive oil than that given by the DB-DC question (Table 8). As to which mean should normally be higher, there is contradictory evidence in literature. Markowska and Zylicz (1999) state that open-ended versions give lower bids because the respondent is deprived of a yardstick. However, Bateman et al. (1995) state that the opposite is also possible and attribute it to the uncertainty respondents experience when answering open-ended questions, which may lead them exhibit strategic overbidding tendencies. Note that besides the non-parametric estimation of mean WTP for Product 1 from the DB-DC data, the authors have also estimated the corresponding parametric mean with a technique described in Cameron (1991) and Cameron (1988). The results are not reported here due to the poor model results (Menegaki, 2005).

### 4.3. Don’t know responses; farmers

The increased number of “don’t know” responses in Product c is because farmers are more skeptical about this more controversial product (Table 6). Of course in this case they could mean “no” rather than “don’t know”. Nevertheless, “don’t knows” were dropped in further analysis, and had no significant correlations with the regressors in Models 1 and 2. “Don’t knows” for Product b, which is the safest product among all products, were only 2.4%. This percentage however, cannot be directly compared to the previous ones, since the sample where it comes from (n=81) is conditional upon farmers saying “no” in the total sample (n=453).

#### 4.3.1. Don’t know responses; consumers

The number of “don’t know” responses (Table 6) increases with the risk of the product: it is the highest for the most dangerous product (Product 3) and smallest for the least dangerous product (Product 0). “Don’t know” responses have been left out of further analysis because they were a trivial part of the sample and because their correlations with the model regressors were insignificant.

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**Table 6 – WTU recycled water products**

<table>
<thead>
<tr>
<th>WTU (%)</th>
<th>Farmers</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product a</td>
<td>Product b</td>
</tr>
<tr>
<td>Yes</td>
<td>75.7</td>
<td>41.9</td>
</tr>
<tr>
<td>No</td>
<td>17.9</td>
<td>55.7</td>
</tr>
<tr>
<td>Definitely no</td>
<td>N/A**</td>
<td>N/A</td>
</tr>
<tr>
<td>Maybe no</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Median</td>
<td>31.6</td>
<td>48.5</td>
</tr>
<tr>
<td>Definitely yes</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Don’t know</td>
<td>6.4</td>
<td>2.4</td>
</tr>
<tr>
<td>No response</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total (observations)</td>
<td>100% (n=453)</td>
<td>100% (n=81)</td>
</tr>
</tbody>
</table>

**Table 7 – Level of paying for recycled water or products irrigated with it relative to fresh water**

<table>
<thead>
<tr>
<th>Intention to pay</th>
<th>Product a (%)</th>
<th>Product c (%)</th>
<th>Product 1 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>More</td>
<td>2.04</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>As much as</td>
<td>19.24</td>
<td>19.85</td>
<td>27.9</td>
</tr>
<tr>
<td>Less</td>
<td>76.38</td>
<td>69.16</td>
<td>69.2</td>
</tr>
<tr>
<td>Missing</td>
<td>2.34</td>
<td>10.99</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
4.4. Econometric results

Table 9 contains the estimated models for both farmers and consumers.

4.4.1. Farmers
The following variables were significant at 5%: in Model 1, LACKW and HERA; in Model 2, ACTIONS, EDU2, EDU3, GENDER and HERA; in Model 6, LOGINCOME, EDU1 and EDU3; and in Model 7, WPRICE. All models are significant; the x2 value for each WTU model has rejected at 5% the null hypothesis that the models did not have greater explanatory power than the ‘intercept only’ models. Also, the F-statistic was significant in both WTU models.

4.4.2. Consumers
All the three ordered models have passed the test of parallel slopes (Boroohah, 2001). The following variables were significant at 5%: in Model 3 INFO, ACTIONS, INCOME and GENDER; in Model 4 INFO, LACKW, ACTIONS, AGE1 and AGE2; in Model 5, CHID, and in Model 8, LOGINCOME. The significance of all models has been confirmed with the same tests as in the case of farmers in the previous paragraph. Kendall’s tau has been used to estimate correlations among all regressors. No significant correlations were confirmed.

4.4.3. The cutoff points in the ordered models

Fig. 2 represents schematically the difference in the utility cutoff points of Models 3, 4 and 5. Consumers are supposed to derive utility from indirect recycled water consumption, which is a function of their health risk, of their personal budget, environmental quality and social welfare. This is connected with the non-use value and the intrinsic value concepts (see Bateman and Langford, 1996). This utility range from 0 to infinity. It is important to note that in choice models, only differences in utility matter and not the absolute utility.

Table 8 – WTP for recycled water or products related to it

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Adjusted mean**</th>
<th>Standard deviation</th>
<th>95% confidence intervals</th>
<th>Adjusted 95% confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP Product a</td>
<td>288</td>
<td>0.01</td>
<td>3.00</td>
<td>0.16</td>
<td>0.15</td>
<td>0.23</td>
<td>0.13–0.19</td>
<td>0.12–0.17</td>
</tr>
<tr>
<td>WTP Product c</td>
<td>239</td>
<td>0.02</td>
<td>4.03</td>
<td>0.17</td>
<td>0.15</td>
<td>0.26</td>
<td>0.13–0.20</td>
<td>0.12–0.18</td>
</tr>
<tr>
<td>WTP Product 1 (open ended question)</td>
<td>128</td>
<td>1.00</td>
<td>4.00</td>
<td>2.67</td>
<td>2.65</td>
<td>0.58</td>
<td>2.57–2.77</td>
<td>2.57–2.77</td>
</tr>
<tr>
<td>WTP Product 1 (DB-DC question)</td>
<td>147</td>
<td>–</td>
<td>–</td>
<td>2.55*</td>
<td>–</td>
<td>–</td>
<td>2.50–2.57*</td>
<td>–</td>
</tr>
</tbody>
</table>

*The non-parametric mean from the DB-DC data was estimated with Turnbull self-consistency algorithm. The confidence interval was estimated with a bootstrapping technique. The Gauss code was written by Olvar Bergland and adapted by Brett Day (Bergland and Day, 2001, 2005).

**The mean was adjusted for the missing values (weighted by the (1-% of missing values)).

Table 9 – WTU and WTP models for farmers and consumers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Farmers</th>
<th>WTU models</th>
<th>Consumers</th>
<th>WTP models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product a (Model 1)</td>
<td>Product c (Model 2)</td>
<td>Product 1 (Model 3)</td>
<td>Product 3 (Model 4)</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.81 (0.47)</td>
<td>-2.29 (0.02*)</td>
<td>-0.00 (0.99)</td>
<td>-1.31 (0.09*)</td>
</tr>
<tr>
<td>INFO</td>
<td>-0.056 (0.61)</td>
<td>0.15 (0.16)</td>
<td>0.27 (0.00*)</td>
<td>0.16 (0.04*)</td>
</tr>
<tr>
<td>LACKW</td>
<td>0.26 (0.01*)</td>
<td>0.05 (0.69)</td>
<td>0.18 (0.10)</td>
<td>0.24 (0.02*)</td>
</tr>
<tr>
<td>ACTIONS</td>
<td>0.09 (0.51)</td>
<td>-0.33 (0.02*)</td>
<td>0.25 (0.03*)</td>
<td>0.31 (0.00*)</td>
</tr>
<tr>
<td>WPRICE</td>
<td>0.85 (0.37)</td>
<td>0.01 (0.95)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>INCOME</td>
<td>0.00 (0.08)</td>
<td>0.00 (0.68)</td>
<td>-0.0003 (0.04*)</td>
<td>-0.0002 (0.13)</td>
</tr>
<tr>
<td>LOGINCOME</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>AGE1</td>
<td>-0.17 (0.77)</td>
<td>0.47 (0.40)</td>
<td>0.63 (0.20)</td>
<td>1.58 (0.00*)</td>
</tr>
<tr>
<td>AGE2</td>
<td>-0.53 (0.12)</td>
<td>0.06 (0.84)</td>
<td>0.64 (0.12)</td>
<td>0.87 (0.05*)</td>
</tr>
<tr>
<td>EDU1</td>
<td>-0.98 (0.25)</td>
<td>0.02 (0.97)</td>
<td>-0.40 (0.63)</td>
<td>0.78 (0.27)</td>
</tr>
<tr>
<td>EDU2</td>
<td>-0.63 (0.35)</td>
<td>1.12 (0.02*)</td>
<td>-0.19 (0.65)</td>
<td>-0.31 (0.39)</td>
</tr>
<tr>
<td>EDU3</td>
<td>-0.80 (0.21)</td>
<td>1.07 (0.01*)</td>
<td>-0.25 (0.32)</td>
<td>-0.34 (0.13)</td>
</tr>
<tr>
<td>GENDER</td>
<td>-0.36 (0.45)</td>
<td>0.78 (0.03*)</td>
<td>0.62 (0.00*)</td>
<td>-0.08 (0.70)</td>
</tr>
<tr>
<td>CHID</td>
<td>-0.41 (0.43)</td>
<td>0.35 (0.46)</td>
<td>0.06 (0.83)</td>
<td>0.52 (0.09)</td>
</tr>
<tr>
<td>HERA</td>
<td>0.62 (0.05*)</td>
<td>1.58 (0.00*)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cutoff points</td>
<td>-</td>
<td>-</td>
<td>0, 0.53, 3.13</td>
<td>0, 0.99, 2.95</td>
</tr>
<tr>
<td>Sample size</td>
<td>383</td>
<td>346</td>
<td>326</td>
<td>321</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.07</td>
<td>0.11</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are p-values, asterisks indicate significance at 5%.
The scale of utility is arbitrary (Train, 2003). Since Limdep normalizes the first cutoff point to zero, no negative utility values appear. The utility level that makes consumers pass from “maybe no” to “maybe yes” is much lower in Product 1 than in Product 0 and Product 3. In addition, the utility level which makes consumers pass from “maybe yes” to “definitely yes” occurs at a lower level for Product 1, then for Product 3 and Product 0.

5. Discussion

5.1. Farmers’ WTU

Water shortage (LACKW) appears to be the only reason why farmers would use recycled water of quality 2 on olive trees. Moreover, the “residents of Heraklion” variable (HERA) explains both WTU quality 2 on olive trees and quality 3 on tomatoes, because the Heraklion prefecture has more extensive olive tree and vegetable cultivations as well as more water shortage problems. The enhanced environmental conscience, as manifested by the involvement of farmers in environmental friendly actions (ACTIONS), drives farmers to be willing to use water quality 3 on their tomatoes. This finding is further strengthened by the significance of EDU2 and EDU3 showing that the more educated farmers are also more likely to use quality 3 on their tomato cultivations.

5.2. Farmers’ WTP

Income is significant with a positive sign indicating that richer farmers are likely to give higher bids for recycled irrigation water of quality 2 on olive trees. Rich farmers might be rich as a result of their having taken wiser actions in their business lives to date, and using recycled water for irrigation is a wise thing to do because it reduces production costs due to the “free nutrients” contained therein. Two of the education variables were significant in explaining WTP for ‘quality 2 on olive trees’, EDU1 with a positive sign and EDU3 with a negative one. According to the former, illiterate farmers are more likely to give higher bids, while the latter suggests that, secondary schools graduates are likely to give lower bids. Farmers’ education is not synonymous with experience in agriculture; uneducated farmers have spent less time at school and more time in work, thus, more time in practice rather than in theory. Another perspective from which this result can be viewed, is that the more educated farmers, such as secondary school graduates, realize recycled water is a lower quality by-product of fresh water and act strategically by bidding a low price. As far as willingness to pay for ‘recycled water of quality 3 on tomatoes’ is concerned, the only significant variable was fresh water price: the higher the price farmers currently pay for fresh water supplies is, the more they are willing to pay for recycled water. This seems intuitively obvious. Madi et al. (2003) in their study on willingness to pay by farmers in Jordan and Tunisia also report that access to fresh water at low price is a hindrance to high willingness to pay for recycled water in irrigation.

5.3. Consumers’ WTU and WTP

The significance of parenthood (CHID) in the willingness to visit the park (Model 5) shows that consumers with children are less likely to visit parks that have been irrigated with recycled water. It is worth noting that parenthood was not significant in the other two models (Models 3 and 4), i.e. for olive oil and tomato production. One might think that parents would be more, if not equally, worried about the

| Table 10 – Comparison of farmers and consumers with regard to willingness to use |
|----------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Farmers                          | Consumers                       | Olive oil irrigated with        | Olive oil irrigated with         | Tomato irrigated with          |
| Recycled water of quality 2       | Recycled water of quality 2      | quality 3                       | quality 3                       | quality 3                      |
| for the irrigation of olive trees | for the irrigation of olive trees|                                |                                |                                |
| 75.7%                            | 78.4%                           | 92.7%                           | 65.3%                           | 63.2%                           |
| Recycled water of quality 3       | Recycled water of quality 3      |                                |                                |                                |
| for the irrigation of olive trees | for the irrigation of olive trees|                                |                                |                                |
| 80.7%                            | 92.7%                           | 63.2%                           |                                |                                |
| Recycled water of quality 3       | Recycled water of quality 3      |                                |                                |                                |
| for the irrigation of tomato      | for the irrigation of tomato    |                                |                                |                                |
| 65.3%                            | 63.2%                           |                                |                                |                                |

This is a double-entry table where only diagonal cells contain information.
food habits their children pursue every day than the space they often play in. It is suspected that the wording in this question has played a role in provoking some fear, although this was not the initial intention. The wording in the questionnaire warned that irrigation in the park would take place at night when there is no risk of anyone coming into contact with the recycled water. This warning may have made parents more reluctant, but this cannot be stated with certainty. Two of the awareness variables, INFO and ACTIONS, were significant for both olive oil and tomatoes, while the third awareness variable, LACKW, was significant only in the demand for tomatoes. The significance of awareness variables means that consumers who appear to have a stronger environmental profile (they consider themselves as being more informed about environmental matters, they are involved in more environment-saving actions and they rank water shortage high in its significance as an environmental problem) are more likely to have shaped a positive opinion (i.e. being in the category of “definitely yes”) on whether they would consume crops irrigated with recycled water. The fact that LACKW is significant in tomatoes and not in olive oil, reveals that those who recognize water shortage to be a serious problem are ready to do more about it. They are willing to use products of higher risk, such as tomatoes. The significance of AGE1 and AGE2 shows that younger people are also more likely to consume tomatoes irrigated with recycled water.

These results point to a high environmental conscience being the factor that most likely determines the definite willingness of consumers to consume tomatoes irrigated with recycled water. Income was significant in the olive oil demand model with a negative sign, which means that poor people were more willing to consume it. Olive oil is a product used daily in large quantities in Greek cuisine. Poorer people’s budgets would be relieved by cheaper olive oil.

Social acquiescence on recycled water usage is confirmed by the general agreement in willingness to use recycled water between farmers and consumers. If farmers are willing to use recycled water in agriculture, then consumers must be willing to use the food products produced with recycled water irrigation. In order to make a comparison between producers and consumers, the corresponding percentages of each product are presented in Table 10. As regards products a and 1, consumers are more willing to use them than farmers are to irrigate with recycled water. The same is true with products b and 2 but with a higher surplus from consumers. For products of higher risk, i.e. products c and 3, consumers are less willing to use them, compared to the farmers WTU recycled water for irrigation. These differences in the attitudes of producers and consumers should be the focus of policy development work.

Income was the only significant variable in explaining WTP for recycled water-produced olive oil, using an open-ended response format (Model 8): higher income translates into higher willingness to pay. According to the responses to the double-bounded dichotomous choice design, the higher the olive oil price, the less likely respondents are to say “yes” to paying, which is as expected. However, Model 8 has a small sample size, and results are poor overall.

6. Conclusions

This research aimed to reveal the attitudes of society to the use of recycled water in agriculture. Public acceptability is a prerequisite for society to establish and promote water reuse projects. Besides the need to circumvent other structural hindrances (cost of infrastructure requirements, lack of trust in assurances of recycled water quality, public sector ownership of water utilities etc.) little can be achieved if there is no social acquiescence on this matter. Experience has shown that social marketing is not enough, and this is why the decision to use recycled water has to be a participatory procedure, with contributions from education and information from the authorities until the public becomes convinced of the safety of this new product. Moreover, the price of recycled water must be set in tune with consumer preferences, farmer preferences, and after revising the price of fresh water for irrigation to reflect its real scarcity.

The need for recycled water in irrigation and for other uses in Crete stems from the shortage of water and is encouraged by the Water Framework Directive. Recycled water can be safely used in agriculture for the irrigation of various crops. WTU and WTP for recycled water and products irrigated with it should not be seen in isolation from each other. The former provides conclusions about which characteristics are more likely to lead to the acceptance (WTU) of recycled water from society. The second provides information on the characteristics that will lead to the formation of a higher or lower willingness to pay for recycled water or for products irrigated with recycled water. The basic conclusion emerging is that there is social acquiescence on the usage of recycled water. Farmers will agree to use recycled water for irrigation purposes and consumers will accept it as an ingredient of their food, because they are willing to incorporate it in their food purchasing habits. The factors that most probably make farmers use recycled water are fresh water scarcity, involvement in environmental friendly actions, and their total water demand. Consumers, on the other hand, in their willingness to use recycled water are affected by their environmental awareness profile, income, price and age. When it comes to WTP, for both farmers and consumers, none of the environmental awareness variables are significant. The cutoff points in consumers WTU models show that information and education might be useful tools in making people realize the benefits of recycled water, allowing them to pass from “definitely negative” to “definitely positive” attitudes.

The significance of fresh water price in WTP models spawns an important policy conclusion. If water authorities charge fresh water at its full economic price so that it truly reflects scarcity, fresh water will become more expensive and farmers will be willing to pay higher amounts for recycled water. Farmers state that they are willing to pay on average 0.15€/m³ of recycled water, which is 55% of the average fresh water price. Furthermore, the authors propose that a legal framework should be established to impose recycled water usage in certain areas. The principle of “pay-because-you-don’t use recycled water in cases where you could” in a fashion analogous to the “pay-as-you-pollute” principle, if incorporated into the pricing of fresh water, will drive more people to use
recycled water as a replacement for fresh water, even for some domestic uses. Finally, our analysis suggests that consumers will, other things being equal, require a price discount to encourage them to purchase crops grown with recycled water.

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