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# Farmers' willingness to use and pay for treated wastewater in the context of untreated wastewater availability

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## Abstract

This study investigated farmers' willingness to use (WTU) and to willingness pay (WTP) for recycled water for irrigation in a water-scarce region of Ardabil province, Iran, where untreated sewage is available and partly used for irrigation. A sample of 261 farmers was selected for data collection, and the necessary data were gathered through face-to-face interviews. The study utilized the Contingent Valuation Method (CVM) and the binary Probit model. Respondents were presented with four different qualities of treated sewage and three price options for the treated outflow from the treatment plant. Results indicated that a majority of farmers (76.2%) were willing to use treated sewage for irrigation. The WTU increased significantly with treated effluent quality, rising from 11.5% to 52.5% to 97.7%, before stabilizing at 84.3%; a perception that the highest proposed quality was suitable to drink may have tempered adoption at the upper end. More than half of the farmers (57.9%) expressed willingness to pay the same price as freshwater (150000 Rials per hour, Rls/h) for recycled water. Only 23.4% were willing to pay a higher price (187500 Rls/h), while 83.9% were willing to pay the lowest price (112500 Rls/h). Among the variables studied, environmental concern had the most significant influence on WTU, whereas management-related factors most strongly affected WTP. Effective incentives, such as reducing the price of treated wastewater in relation to its quality, training on management, health, and safety aspects of treated wastewater use, and promoting farmers' confidence in water quality, can improve both WTU and WTP for treated wastewater.

**Keywords:** Recycled water, Willingness to pay, Willingness to use, Binary Probit, CVM.

**Article Type:** Research Article

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## 1- Introduction

Water scarcity and the ongoing water crisis have emerged as prominent issues in the 21st century. Globally, concerns over water supply and declining water quality have intensified, driven by rising water demand, climate change, and unforeseen environmental events (Pedrero et al., 2010; Googoochani, 2024). Freshwater scarcity in arid and semi-arid regions is a critical constraint to agricultural productivity (Banerjee et al., 2025; Tabatabaei, 2025). Addressing water shortages remains a critical challenge, particularly for countries in Southwest Asia and the Middle East. Iran, in particular, is experiencing significant water resource challenges (Zarghani et al., 2013). The ongoing water crises have prompted policymakers to consider both conventional and non-conventional water resources, including municipal sewage, as low-quality water resources (Behrouz and Liaqat, 2002). Agriculture is the largest consumer of water globally, accounting for approximately 75% of the world's freshwater use (Gleick, 2000; FAO, 2002). In some low-income countries, irrigation accounts for up to 95% of total water consumption (Pedrero et al., 2010). To alleviate pressure on freshwater resources, various strategies have been proposed, including wastewater and drainage water recycling as alternatives to freshwater use (Toze et al., 2006). Wastewater reuse has been endorsed as a strategic measure to support the achievement of the Sustainable Development Goals by 2030 (FAO, 2016). One significant source of low-quality water is urban and peri-urban sewage, which presents both challenges and opportunities for wastewater reuse (Pedrero et al., 2010). Recycling wastewater for irrigation reduces the overuse of freshwater resources and helps protect water resources from pollution due to untreated wastewater discharges (Banerjee et al., 2025; Neumann et al., 2024; Srinivasan and Yadav, 2023; Mishra et al., 2023). As a result, the sustainable use of treated wastewater (TWW) has been recognized as a viable and environmentally friendly option for irrigation (Márcio et al., 2022; Warrick and Ekwue, 2014). Several studies have shown that the use of adequately treated wastewater can provide numerous environmental and socio-economic benefits, including enhanced water use efficiency and reduced dependence on chemical fertilizers (Neumann et al., 2024; Márcio et al., 2022; Ofori et al., 2021; Canaj et al., 2021; Alkhamisi and Ahmed, 2014). Notably, TWW often contains essential plant nutrients that can supplement or partially replace chemical fertilizers (Shtull-Trauring et al., 2022). Wastewater treatment has become widespread globally, particularly in arid and semi-arid regions (Valdes Ramos et al., 2019). Reusing treated wastewater is a viable option, especially given the limited availability of alternative water sources (Niemczynowicz, 1999; WHO, 2006). Proper management and reuse of municipal sewage offer numerous economic and environmental benefits; for instance, the nutrient content in TWW can enhance agricultural productivity and reduce dependence on chemical fertilizers. The reduction in fertilizer costs can justify the expenses associated with sewage treatment projects, making wastewater reuse in agriculture cost-effective (Khanpae and Karami, 2015). Additionally, utilizing urban sewage for irrigation aligns with environmental sustainability goals. Such practices have the potential to significantly mitigate the impacts of drought and water scarcity in the agricultural sector. However, evidence suggests that wastewater recycling projects often face failure due to a lack of public acceptance (Mainali et al., 2011; Deh-Haghi et al., 2020). Therefore, considering the critical role of wastewater reuse in alleviating drought effects, it is essential to investigate public acceptance of recycled water.

The success of water reuse projects depends on several critical factors, including public opinion, risk assessment, environmental impacts, and evaluations of economic benefits and willingness to pay (Lazarova et al., 2001). Additionally, policymakers often face challenges in developing appropriate water pricing policies and implementing organizational reforms to address farmers' water needs while ensuring full cost recovery. Wastewater used in agriculture can have both positive and negative effects on crop production, public health, soil resources, and ecosystems (Hussain et al., 2002). Municipal sewage may contain hazardous substances, such as heavy trace elements and pathogens, which can negatively impact agricultural produce, consumer health, and neighboring communities, potentially leading to various diseases. However, the severity of these adverse effects varies across regions, depending on factors such as wastewater volume, source, level of treatment prior to use, and wastewater management practices at both source and farm levels (Derchesl and Evans, 2010). Consequently, these concerns pose significant challenges and represent a key weakness in the application of wastewater in agriculture. Therefore, further research is essential to clarify these issues. Numerous studies have examined public acceptance of recycled water (Hurlimann, 2007; Alhumoud and Madzikanda, 2010), while studies in Iran, especially in Ardabil province, are scarce. The objectives of this study are to investigate farmers' attitudes toward the use of treated wastewater, identify socioeconomic and psychological factors influencing their willingness to use (WTU) and willingness to pay (WTP), and estimate willingness to pay for treated wastewater using the well-known method of Contingent Valuation (CVM).

## 2. Materials and Methods

### 2.1. Study area and the TWW quality

Namin County, Ardabil Province, Iran, was selected for this study. The study population comprised all farmers in the region who had access to sewage, specifically the operators of 702 agricultural units managing a total of 2720 hectares of farmland. The primary crops cultivated in the area include wheat, potatoes, and forage plants. Figure 1 illustrates the map of the study area. Drought index data indicate that Ardabil province has experienced moderate to severe drought conditions in approximately 70% of the observed years, and this trend is likely to persist in the coming years (Salahi, 2008). As a result, farmers rely heavily on groundwater resources, often extracting water through both authorized and unauthorized wells. This excessive groundwater use has caused a significant decline in the water table of the region. Given these circumstances, water policymakers need to explore sustainable solutions to mitigate water shortages in the province. Recycling municipal wastewater presents a viable and acceptable option to partially address the irrigation needs caused by water scarcity. This study investigated farmers' WTU and WTP for treated wastewater. Farmers annually pay for freshwater usage based on prices set by the water and sewerage department. Using the existing freshwater prices as a reference, three different price points were proposed to farmers to assess their WTP for utilizing treated wastewater.

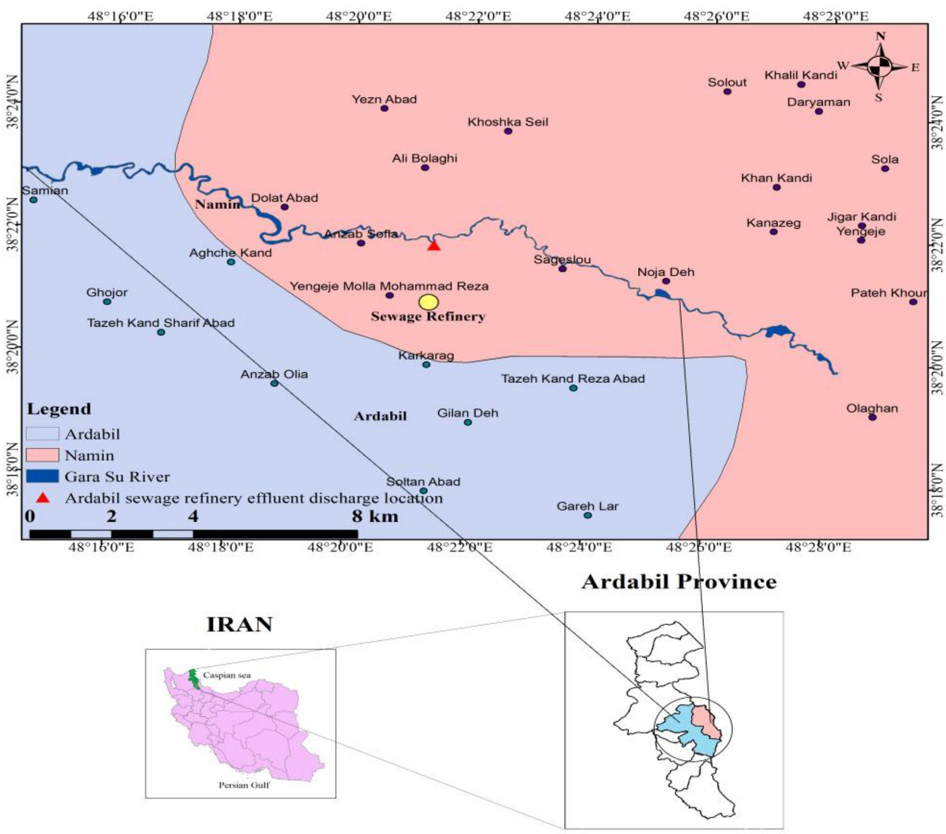


**Figure 1. Geographic location of the study area, Ardabil Province, Iran.**

## 2.2. Treated sewage quality tests

In 2024, effluent samples were collected from the wastewater discharge in Namin County, Ardabil Province, Iran. The samples were taken from the effluent stream into bottles. Bottles were rinsed three times with sample water prior to collection. Samples for general physico-chemical analyses were transported to the laboratory for analysis. Time-sensitive analyses ($BOD_5$) were initiated within 24 hours of collection. Where appropriate, samples were preserved and handled in accordance with standard methods. The samples were tested in the laboratory according to standard methods.
Sodium adsorption ratio (SAR) was calculated on an equivalent basis as:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}Mg^{2+}}{2}}} \quad (1)$$

Sodium percentage (Na%) on an equivalent basis was calculated as:

$$Na\,\% = \frac{Na^{+}}{Mg^{2+} + Ca^{2+} + Na^{+}} \times 100 \quad (2)$$

where $Na^{+}$, $Mg^{2+}$, and $Ca^{2+}$ are in meq. L-1.

WTP and WTU Assessment. The first price (WTP1) was set at 150000 Rials per hour (Rls/h) of irrigation, serving as the base price equal to freshwater irrigation. The second prices, i.e., WTP2, was 25% higher than WTP1, amounting to 187500 Rls/h. The third price i.e., WTP3, was 25% lower than WTP1, equaling 112500 Rls/h. To estimate farmers' willingness to use recycled water, four qualities of treated sewage were proposed based on pollution reduction levels:
Q1, pollution reduced by 30-40%. Suitable for forest irrigation under controlled conditions; Q2, pollution reduced by 95%. This water is typically disinfected, pathogen-free, and suitable for watering all types of trees; Q3, pollution is reduced by 99%. The water has been disinfected and is pathogen-free, making it appropriate for crop irrigation intended for human consumption, provided that edible parts do not come into contact with the water; and Q4, pollution is eliminated (100% reduction). The water is disinfected, pathogen-free, and suitable for human consumption (Sakkas et al., 2004).

## 2.3. Population, sample, and research instrument

All farmers from the villages of Ali-Bolaghi (75), Yengejeh (151), Anzab (217), and Dawlat-Abad (259), in Namin County, Ardabil Province, comprised the statistical population (N = 702). A sample of 261 farmers was selected for data collection using the Cochran sampling formula (Cochran, 1977), and the necessary data were gathered through face-to-face interviews. A researcher-made questionnaire, comprising several sections, was used as the data collection instrument. The first section addressed the demographic characteristics of the respondents, including education level, family size, and number of literate family members, farming experience, and family income. The second section included farm characteristics, such as wheat, potatoes, and fodder yields, as well as the status of recycled water use for irrigation. The third section covered farmers' information sources regarding sewage treatment and the use of TWW. The fourth section investigated farmers' attitudes toward environmental and management-related issues, poisoning symptoms related to the use of untreated sewage in irrigation, water shortage perceptions, and knowledge on TWW use. The fifth section contained questions about farmers' perceptions of the validity of various information sources, and farmers' trust in different authorities providing safe and qualified treated wastewater. The last section focused on the core variables, WTU and WTP, and respondents were asked about their willingness to use recycled water for irrigation. They responded to a binary question (no/yes) regarding their willingness to use treated sewage (Q1, Q2, Q3, and Q4). Participants were also asked to indicate their WTP for recycled water using a dichotomous response (no/yes) at each of three price levels relative to freshwater. Each respondent received mean scores for WTUs, based on four proposed qualities of treated sewage (Q1, Q2, Q3, and Q4), and mean scores for WTPs, based on the three proposed prices.
The most common quantitative definition of WTP is the maximum amount an individual is willing to pay to obtain specific goods or services relative to other options (Olli et al., 2001). In contrast, some studies examining the influence of attitudes on purchase intentions explore WTP qualitatively by investigating the extent to which consumers are willing to pay for a particular product or service. Typically, when consumers decide to purchase a product, they evaluate its features and benefits, which

influence their WTP (Yu et al., 2012). Furthermore, Spash et al. (2006) argue that understanding behavioral and psychological factors, such as attitudes, is crucial for gaining insights into consumer tendencies, including their willingness to pay. This perspective underscores the importance of psychological and behavioral insights in interpreting WTP beyond just monetary valuations.

A panel of experts validated the research questionnaire. To assess the reliability of the research instrument, a pilot study was conducted with a sample of 30 farmers, and necessary modifications were made based on the results.

Given that the dependent variable is dichotomous (0 or 1), the study utilized a binary Probit model based on the general formula for the probability, expressed as $P(Y=1) = \Phi(Xi, \beta)$. This model estimates the likelihood that an observation with specific characteristics belongs to a particular category. In this context, the coefficient vector β captures the marginal effects of the independent variables on Y. Since the dependent variable reflects an unobservable utility, when β is estimated, the probability of Y is modeled as:

$$pi = p(Yi = 1 \mid Xi) = \Phi(Xi, \beta) = \Phi(\beta 0 + \beta 1X1i + \ldots + \beta kXki) \qquad (3)$$

In equation (1), Yi is the dependent, and Xi are independent variables, respectively; Pi is the probability that Yi, I = 1, and k = explanatory variables.

Furthermore, the WTU and WTP were analyzed within binary frameworks as follows:

WTU variables: WTU1 (willingness to use for recycled water Q1); WTU2 (willingness to use for recycled water Q2); WTU3 (willingness to use for recycled water Q3); and WTU4 (WTU for TWW Q4)

WTP variables: WTP1 (WTP for 150000 Rls/hour of irrigation with TWW); WTP2 (WTP for 187500 Rls/h); and WTP3 (WTP for 112500 Rls/h)

The Contingent Valuation Method (CVM) was employed to estimate farmers' WTP. CVM is a flexible technique for measuring non-consumptive values and non-market values of environmental resources (Haneman et al., 1991; Haneman, 1994). In the CVM, the questionnaire presents respondents with dual qualitative choices. Typically, a logit or Probit model is used to analyze such choice data. Based on the logit model, the probability that a respondent accepts one of the proposed options, option A, P, is expressed as:

$$P_i = F_\eta(\Delta \mathrm{U}) = \frac{1}{1+exp(-\Delta U)} = \frac{1}{1+xp\{-(\alpha-\beta A+\gamma Y+\theta S)\}} \qquad (4)$$

Where (U) Fη is the cumulative distribution function, β ، γ and θ are the estimated model parameters, A is the bid amount offered.

In the dual CVM design, each respondent answers two questions, resulting in four possible response combinations: Both answers are YES (YY), Both answers are NO (NN), No followed by YES (NY), YES followed by NO (YN). For these responses: When a respondent answers YES, their WTP is greater than the initial offer t1 but less than the subsequent offer t2. When a respondent answers NO-NO, their WTP is less than the minimum bid amount t2 (Rasekhi et al., 2012).

In this study, we employed face-to-face interviews to administer the questionnaire of CVM, which included bid prices. This method offers high flexibility and is suitable for evaluating the economic value of a broad set of services or goods that are easily understandable and can be consumed in discrete units (Venkatachalam, 2004). The parameters were estimated using the maximum likelihood (ML) method, specifically employing the maximum interval likelihood approach to maximize the probability that farmers' actual willingness to pay falls within the interval defined by the data-derived upper and lower bounds. This approach follows Baghestani and Zibaei (2010). In this framework, there are two dependent variables: the upper bound, WTPM, and the lower bound, WLPL, of WTP. Data were collected through a recurrent bidding process, commonly referred to as the auction method (Baghestani and Zibaei, 2010). In this approach, the maximum WTP, WTPM, is at least as large as the bid amount accepted by the farmer during the auction, whereas the next higher bid delineates the corresponding lower WTP bound (WLPL).

The probability that the WTP for individual i lies between WTPMi and WLPLi can be expressed as:

$$Prob(WTPMi \leq WTPi \leq WTPLi) = Prob(WTPi < WTPli) - Prob(WTPi > WTPMi) \qquad (5)$$

Or as in equation (6):

$$\varphi((WTPLi - EWTPi)/\sigma i) \qquad (6)$$

Where φ is the standard normal cumulative distribution function, and E(WTPi) represents the expected willingness to pay for individual *i*. For each case *i*, the true WTP is bounded between WTPMi (the maximum WTP) and WTPLi (the next larger value). The expected WTP for each individual, considering socio-economic and psychological variables, is modeled as:

$$WTPi = E(WTPi) + \xi i = \alpha + \beta 1X1 + \ldots + \beta 18X18 + \xi i \quad (7)$$

Where: α is the constant term, X1 to X18 represent the socio-economic and perceptual variables listed below: X1: age, X2: education, X3: household size, X4: number of educated family members, X5: number of children, X6: farming experience, X7: income, X8: wheat yield, X9: potato yield, X10: fodder yield, X11: use of recycled water, X12: environmental attitude, X13: management related dimension, X14: poisoning symptoms, X15: use of treated sewage for crop irrigation, X16: attitude towards water shortage, X17: knowledge in using treated wastewater, X18: trust. β1 - β18 are the parameters to be estimated, ξi is the error term, assumed to be normally distributed with mean zero and standard deviation σi.

## 3. Results

The composition of treated wastewater (TWW) from the Namin County refinery outflow was first analyzed in the laboratory against existing irrigation standards. This analysis preceded the investigation into farmers' willingness to use (WTU) and willingness to pay (WTP) for the water. The TWW sample's pH was 7.58 (Table 1), which falls within the permissible range (Table 2). Measured values for total dissolved solids (TDS) and electrical conductivity (EC) were 981.17 mg/L and 1.52 dS/m, respectively (Table 1). These are well below the acceptable limits, TDS < 2000 mg/L and EC < 3 dS/m (Table 2), indicating no significant salinity restriction for irrigation. The major cation concentrations were $Ca^{2+}$ 43.0 $mg\cdot L^{-1}$, $Mg^{2+}$ 15.25 $mg\cdot L^{-1}$, and $Na^{+}$ 87.0 $mg\cdot L^{-1}$. The sodium adsorption ratio (SAR), calculated on a $meq\cdot L^{-1}$ basis, was 2.90, indicating a low sodicity hazard. However, the sodium fraction (Na% ≈ 52.7%) is relatively high, warranting long-term soil monitoring. The electrical conductivity (EC) value places the effluent in a moderate salinity class (Table 2), which may restrict its use for sensitive crops unless managed through blending, leaching practices, or the use of tolerant cultivars. Elevated suspended solids (TSS = 166.2 $mg\cdot L^{-1}$) and a measurable organic load ($BOD_5$ = 78.5 $mg\cdot L^{-1}$, COD = 150.8 $mg\cdot L^{-1}$) necessitate appropriate solids removal and further treatment before use in sprinkler or drip irrigation to avoid emitter clogging.

The wastewater has moderate suitability for irrigation but requires careful management, especially for sensitive crops like potatoes. Its use for wheat is less restrictive but still requires monitoring.

**Table 1 Measured physicochemical composition of wastewater in Namin County, Ardabil province, Iran**

| Constituent | Units | Concentration |
|---|---|---|
| COD | mg/l | 150.75 |
| $BOD_5$ | mg/l | 78.50 |
| TS | mg/l | 1146.83 |
| TDS | mg/l | 981.17 |
| TSS | mg/l | 166.17 |
| PH | - | 7.58 |
| Turbidity | JTU | 119.22 |
| $NO_2$ | Mg/LasN | 0.35 |
| EC | ds/m | 1.52 |
| $Ca^{2+}$ | mg/l | 43.00 |
| $Mg^{2+}$ | mg/l | 15.25 |
| $Na^{+}$ | mg/l | 87.00 |
| SAR | - | 2.90 |

The average age of the participants was 40±13.66 years. The typical family size was four members, and a high percentage of respondents (78.5%) had attained a high level of education. Additionally, a significant portion of farmers (57.9%) had children under the age of 15 in their families. The total annual income of the farmers was approximately 630 million Rials (with an exchange rate of 1 USD = 42,000 Rials). The average agricultural experience among participants was 24 years. Regarding irrigation practices, most farmers (73.2%) had used sewage effluent for irrigation, while 26.8% opposed its use. In terms of yields, the average wheat production was 6.49 tons per hectare, the average potato yield was 34.78 tons per hectare, and the average fodder yield was 1,055.28 bales (Table 3).

**Table 2. Guidelines for interpretation of water quality for irrigation (Pescod, 1992; Pedrero et al., 2010; UN Department of Technical Cooperation for Development, 1985)**

| Potential irrigation problem | Units | Degree of restriction on use | | |
|---|---|---|---|---|
| | | None | Slight to moderate | Severe |
| TS | mg/l | 350 | 700 | 1200 |
| $BOD_5$ | mg/l | 100 | 200 | 300 |
| Alkalinity (as $CaCO_3$) | mg/l | 50 | 100 | 200 |
| **Salinity** | | | | |
| EC | dS/m | ≤ 0.70 | 0.70-3.0 | ≥ 3.0 |
| TDS | mg/l | 450 | 450-2000 | 2000 |
| **Infiltration** (effects of infiltration rate of water into the soil. Evaluate using EC and SAR together) | | | | |
| SAR= 0-3 | | EC ≥ 0.70 | EC=0.70-0.20 | EC ≤ 0.20 |
| SAR= 3-6 | | EC ≥ 1.20 | EC=1.20-0.30 | EC ≤ 0.30 |
| SAR= 6-12 | | EC ≥ 1.90 | EC=1.90-0.50 | EC ≤ 0.50 |
| SAR= 12-20 | | EC ≥ 2.90 | EC=2.90-1.30 | EC ≤ 1.30 |
| SAR= 20-40 | | EC ≥ 5.0 | EC=5.0-2.90 | EC ≤ 2.90 |
| **Specific ion toxicity** | | | | |
| Sodium (Na) | | | | |
| Surface irrigation | SAR | < 3 | 3-9 | >9 |
| Sprinkler irrigation | meq/l | <3 | >3 | |
| Chloride (Cl) | | | | |
| Surface irrigation | mg/l | ≤ 140 | 140-350 | ≥350 |
| Sprinkler irrigation | mg/l | ≤ 100 | >100 | |
| Boron (B) | | | | |
| Surface–sprinkler irrigation | mg/l | ≤ 0.70 | 0.70-3 | ≥3 |
| Miscellaneous effects | | | | |
| Nitrogen (NO3-N) | mg/l | < 5 | 5-30 | >30 |
| Bicarbonate (HCO3) | mg/l | < 1.50 | 1.50-8.50 | >8.50 |
| pH | Normal range 6.5-8 | | | |

**Table 3.** Respondents' demographic characteristics

| Variable | Percent | Mean | SD |
|---|---|---|---|
| Age | - | 40 | 13.66 |
| Family size | | 4.22 | 1.64 |
| Literate member | | 3.61 | 1.58 |
| Children under 15 years | Yes: 57.85<br>No: 42.15 | - | - |
| Income (million) | | 628.10 | 506.80 |
| Faring experience | - | 24.09 | 14.82 |
| using sewage effluent for irrigation | Yes:73.18<br>No:26.82 | | |
| Wheat yield (ton/ha) | - | 6.49 | 2.12 |
| Potato yield(ton/ha) | | 34.78 | 9.46 |
| Fodder yield (bale) | | 1055.28 | 480.44 |

### 3.1. Farmers' WTP and WTU for recycled water

Farmers were asked if they were willing to use recycled water to irrigate their fields (WTU1). The results in Table 4 show that 76.2% of respondents were willing to use recycled water to irrigate their fields. Only 11.5% of them were willing to use recycled water in Q1. Overall, this quality of recycled water, with an average score of 0.115, is not acceptable to farmers. Similarly, 52.5% of respondents were willing to use recycled water in Q2, while 47.5% were unwilling to do so. As a result, this quality of recycled water, with an average score of 0.525, is somewhat acceptable to farmers. Furthermore, 97.3% of farmers were willing to use recycled water with Q3. This quality, with an average score of 0.973, is considered acceptable. Regarding Q4, 84.7% of farmers were willing to use recycled water. However, 15.3% of respondents, or 40 farmers, are unwilling to use recycled water of this quality because they perceive it as potable and unsuitable for agriculture. This quality of recycled water has an average score of 0.847, indicating general acceptance among farmers.

The results also showed that 57.9% of the respondents were willing to pay 150000 Rials per hour of irrigation for recycled water. With an average of 0.579, this price was relatively acceptable to farmers. Additionally, 23.4% of respondents were satisfied with 187500 Rls/h, while 200 farmers (76.6%) opposed this price. Overall, this higher price was met with resistance, with an average opposition score of 0.234. Furthermore, 83.9% of farmers were willing to pay 112500 Rlsh for irrigation using recycled water. This price, with an average score of 0.839, was accepted by the majority of farmers.

**Table 4. Farmers' willingness to use (WTU) and pay (WTP) for recycled water**

| WTU questions | Yes | | No | | Mean | SD |
|---|---|---|---|---|---|---|
| Willingness to irrigate crops with TWW? | 199 | 76.24 | 62 | 23.76 | 0.76 | 0.43 |
| Willingness to irrigate crops with TWW-Q1 | 30 | 11.49 | 231 | 88.51 | 0.12 | 0.32 |
| Willingness to irrigate crops with TWW-Q2 | 137 | 52.49 | 124 | 47.51 | 0.53 | 0.50 |
| Willingness to irrigate crops with TWW-Q3 | 254 | 97.32 | 7 | 2.68 | 0.97 | 0.16 |
| Willingness to irrigate crops with TWW-Q4 | 221 | 84.67 | 40 | 15.33 | 0.85 | 0.36 |
| WTP questions | Yes | No | Yes | No | Mean | SD |
| Irrigation with TWW at cost 1,500,000 Rials/ha (WTP1) | 151 | 57.85 | 110 | 42.15 | 0.58 | 0.49 |
| Irrigation with TWW at a cost of 187,500 Rials/ha (WTP2) | 61 | 23.37 | 200 | 76.63 | 0.24 | 0.42 |
| Irrigation with TWW at a cost of 112,500 Rials/ha (WTP3) | 219 | 83.91 | 42 | 16.09 | 0.84 | 0.37 |

### 3.2. Farmers' knowledge and attitudes toward treated wastewater use

In addition to demographic variables, socio-psychological factors were examined as follows:

Trust in Information Providers: Trust scores indicated that farmers have moderate trust in water experts and researchers. However, they exhibited low trust in water and wastewater authorities, perceiving that these institutions do not fully adhere to safety standards in the wastewater treatment process. Farmers also believed that current technologies are insufficient to provide the necessary treatment of wastewater for irrigation, particularly from health and safety perspectives.

Knowledge: The average score on the knowledge assessment was 1.66, suggesting that farmers are not highly familiar with the proper use of recycled water.

Environmental Attitudes: Respondents demonstrated relatively weak concern about the environmental impacts of untreated sewage and the importance of wastewater treatment.

Perception of Wastewater Management: Respondents held a strongly favorable view of proper wastewater management for irrigation purposes.

Perception of Water Shortage: Farmers perceived that Ardabil Province faces severe water shortages.

Information Sources: Neighbors and fellow farmers were the primary sources of information regarding treated water use, followed by radio and television programs.

Poisoning Symptoms: Over the past six months of agricultural activity, farmers primarily reported experiencing headaches, itching, and diarrhea, which they attributed to the indirect use of untreated sewage.

**Table 5.** Farmers' perceptions towards treated water use

| **Variables** | **Mean** | **SD** |
|---|---|---|
| Perception of wastewater management (1-5) * | Mean | SD |
| Wastewater treatment is necessary to meet international standards | 4.78 | 0.59 |
| Reducing the potential risks of wastewater use by measures such as increasing irrigation intervals and diluting with fresh water is crucial | 4.68 | 1.30 |
| It is necessary to protect wastewater transmission channels from the treatment farms. | 4.44 | 0.81 |
| Protection measures are necessary for people exposed to wastewater applications (workers and farmers) | 4.44 | 0.91 |
| Providing environmental regulations for the use, management, and monitoring of wastewater and recycled water is mandatory for farmers | 4.39 | 1.14 |
| Teaching management practices to reduce the adverse effects of high salinity in these waters is essential | 4.31 | 1.25 |
| Environmental attitude (1-5) | Mean | SD |
| Untreated sewage causes soil salinity and decreases permeability | 3.36 | 1.67 |
| Treated wastewater is suitable for irrigating pastures | 2.93 | 1.62 |
| Wastewater treatment prevents the pollution of rivers | 1.08 | 0.38 |
| Wastewater treatment prevents the spread of unpleasant odors caused by raw sewage. | 1.08 | 0.36 |
| Wastewater treatment prevents animals' death due to contact/consumption of untreated sewage | 1.06 | 0.34 |
| Knowledge (0-4) | Mean | SD |
| Knowledge of recycled water usage | 1.66 | 1.74 |
| Perceptions of water shortage (1-5) | Mean | SD |
| To what extent is Ardabil province facing a water shortage problem | 3.86 | 1.41 |
| Trust (0-4) | Mean | SD |
| Water researchers and experts | 2.57 | 1.99 |
| Existing technologies | 1.80 | 1.77 |
| City and Village Councils | 1.54 | 1.89 |
| Wastewater Administration | 1.13 | 1.52 |
| Information sources (0-4) | Mean | SD |
| Neighbors and other farmers | 3.34 | 1.67 |
| Radio-TV programs | 1.50 | 1.72 |
| Water and wastewater department experts | 0.66 | 1.23 |
| Internet | 0.57 | 1.23 |
| Journals and newspapers | 0.41 | 1.03 |
| Poisoning symptoms (1-5) | Mean | SD |
| Headache | 3.74 | 1.40 |
| Itchy skin | 2.95 | 2.13 |
| Diarrhea | 2.33 | 1.67 |
| Stomach (digestive) problem | 2.30 | 1.66 |
| Skin blisters | 1.70 | 1.72 |
| Fever | 1.68 | 1.34 |

*Likert-type items ranging from 1 to 5, and, in some cases, from 0-4.

### 3.3. Factors influencing farmers' WTU and WTP

The McFadden coefficient of determination (R2) was employed to assess the proportion of variance in the dependent variables accounted for by the independent variables. As shown in Table 3, the R2 values are 28.9% for WTP1, 33.8% for WTP2, and 61.3% for WTP3 models. Similarly, the R2 values are 34.9% for WTU1, 19.3% for WTU2, 52.9% for WTU3, and 35% for WTU4 models. The significance of the entire model was evaluated using the likelihood ratio (LR) index, which was less than 0.05 for all the models (Table 5). This indicates that all the models are statistically significant.

The results indicated that income had a significantly positive effect on WTU2. Age positively influenced WTU1, while potato yield positively affected WTU3. Forage yield positively affected WTP1 and WTP2, but had a negative effect on WTU3. Additionally, the number of literate family members negatively influenced WTU3. The number of children under 15 years old negatively affected WTP1, WTU2, and WTU4. The use of recycled water showed a positive effect on WTU1, WTU2, and WTU4. Conversely, information sources negatively influenced WTP1. Attitudes toward water scarcity had a positive effect on WTU2, while education positively affected WTP1. Environmental concerns negatively impacted WTU3, and perceptions of water management also negatively influenced WTP1 and WTP2. Family size had a positive effect on WTU3 and WTU4. Farming experience exerted a negative influence on WTU1. Poisoning symptoms showed a negative effect on WTP2 but a positive effect on WTU3. Finally, trust had a positive impact on WTU4.Estimating the Average WTP

Farmers' willingness to pay (WTP) for treated wastewater was assessed using the CVM. The primary objective of CVM is to identify and quantitatively measure how farmers' characteristics influence their WTP, as well as to calculate their average WTP for treated wastewater. The proposed pricing technique was used to design the core question for eliciting WTP, following the approaches outlined by Deh-Haghi et al. (2020). In the repeated price offer method, the proposed price varied between 112,500 and 187,500 Rials per hour of irrigation. The results indicated that farmers were willing to pay approximately 87,540 Rials at the 150,000 Rials price point, 106,470 Rials at the 187,500 Rials price, and about 68,740 Tomans at the 112,500 Rials price.

**Table 6. Factors affecting farmers' WTP and WTU**

| Variables | WTP1 | WTP2 | WTP3 | WTU1 | WTU2 | WTU3 | WTU4 |
|---|---|---|---|---|---|---|---|
| Income | 0.017(0.07) | 0.003(0.55) | -0.04(0.31) | 0.012(0.12) | 0.11(0.05*) | -0.015(0.26) | 0.015(0.17) |
| Age | -0.008(0.85) | -0.062(0.38) | 0.291(0.179) | 0.195(0.004**) | 0.015(0.73) | 0.155(0.33) | 0.12(0.066) |
| Wheat yield | 0.174(0.30) | 0.179(0.27) | 1.076(0.29) | -0.17(0.56) | 0.146(0.27) | -0.016(0.94) | 0.223(0.21) |
| Potato yield | -0.019(0.62) | -0.02(0.67) | -0.05(0.75) | -0.001(0.99) | -0.05(0.15) | 0.21(0.026*) | -0.06(0.18) |
| Forage yield | 0.001(0.014*) | 0.004(0.000**) | 0.001(0.52) | 0.001(0.12) | -0.000(0.99) | -0.006(0.02*) | 0.000(1.0) |
| Literate members | -0.048(0.21) | -0.65(0.12) | -4.2(0.099) | -0.27(0.57) | 0.092(0.77) | -2.5(0.018*) | -0.9(0.055) |
| Children | -0.09(0.005**) | -0.31(0.39) | -3.1(0.092) | -0.21(0.65) | -0.56(0.04*) | -0.037(0.95) | -.86(0.02*) |
| TWW use | 0.025(0.75) | -0.06(0.61) | -0.03(0.96) | 0.29(0.03*) | 0.14(0.05)* | -0.33(0.056) | 0.3(0.006**) |
| Knowledge | 0.245(0.18) | -0.18(0.42) | 0.56(0.43) | 0.23(0.39) | 0.13(0.4) | -0.52(0.13) | -0.08(0.73) |
| Information sources | -0.99(0.02*) | 0.25(0.65) | -1.2(0.53) | -1.07(0.13) | 0.04(0.92) | -1.18(0.15) | 0.14(0.8) |
| Water shortage | -0.05(0.79) | -0.04(0.84) | -0.26(0.77) | 0.49(0.18) | 0.42(0.011*) | -0.15(0.67) | -0.26(0.26) |
| Education | 0.28(0.007**) | 0.09(0.38) | 1.3(0.11) | 0.22(0.07) | -0.06(0.43) | -0.18(0.18) | 0.17(0.13) |
| Environmental attitude | 0.77(0.15) | 0.85(0.27) | 2.26(0.21) | 0.4(0.65) | -0.59(0.23) | -3.7(0.042*) | -034(0.44) |
| Management perception | -1.39(0.014*) | -1.72(0.015*) | 2.53(0.28) | -1.07(0.17) | -0.20(0.68) | 1.973(0.09) | -0.38(0.58) |
| Family size | 0.66(0.11) | 0.76(0.7) | 5.13(0.075) | 0.19(0.68) | 0.02(0.95) | 2.87(0.014*) | 1.33(0.019*) |
| Farming experience | 0.05(0.19) | 0.06(0.3) | 0.35(0.16) | -0.2(0.001**) | -0.04(0.3) | 0.059(0.58) | -0.1(0.08) |
| Poisoning symptom | -0.38(0.23) | -0.7(0.026*) | -031(0.83) | 0.21(0.64) | 0.14(0.56) | 1.09(0.013*) | -079(0.056) |
| Trust | 0.21(0.34) | 0.09(0.75) | 2.25(0.145) | 0.002(0.99) | 0.107(0.56) | -0.589(0.36) | 0.8(0.011*) |
| McFadden R-squared | 0.289 | 0.338 | 0.613 | 0.349 | 0.193 | 0.529 | 0.350 |
| LR statistic | 51.766 | 51.998 | 53.299 | 36.332 | 3.473 | 64.840 | 55.465 |
| Prob (LR statistic) | 0.000 | 0.000 | 0.000 | 0.0096 | 0.0069 | 0.000 | 0.000 |

$^{**}p<0.01$ and $^{*}p<0.5$

## 4. Discussion

### 4.1. Physico-chemical composition of wastewater

The SAR computed on an equivalent basis is 2.9, which places the water in the low sodicity hazard class (low risk of structural deterioration of most soils caused by sodium when used under normal management). However, the ionic fraction of sodium is relatively large (Na% ≈ 52.7%). A high Na% with low absolute cation strength can be observed where sodium comprises a large share of the exchangeable cations, even though total base cation concentration is modest. For risk appraisal, SAR and EC taken together provide a more robust indication of sodicity risk than Na% alone; based on SAR = 2.90 and EC = 1.52 $dS \cdot m^{-1}$, the immediate structural hazard is low but warrants periodic monitoring of soil exchangeable sodium and infiltration characteristics during reuse. The values of TSS and turbidity (Table 1) are high for use in sprinkler and micro-irrigation systems. These solids and turbidity levels substantially increase the risk of emitter and nozzle clogging and will require appropriate filtration and maintenance.

The values of $BOD_5$ and COD (Table 1) indicate appreciable biodegradable organic matter. Organic load can cause biofouling of emitters and supports microbial growth in distribution lines; secondary or tertiary treatment and/or disinfection may be necessary if crop safety or drip irrigation systems are to be used. The pH is slightly alkaline but acceptable for most crops; however, carbonate/bicarbonate measurements are absent and are necessary to assess carbonate-induced sodium hazard. The $NO_2$ (0.35 $mg \cdot L^{-1}$ as N) is low, but the dataset lacks nitrate ($NO_3^-$) and ammonium ($NH_4^+$) measurements; nitrogen speciation should be completed for nutrient budgeting and food-safety assessment.

### 4.2. WTP and WTU

This study examined the factors influencing farmers' WTU and WTP for recycled water for irrigation in Ardabil Province, Iran. The majority of the respondents (76.20%) were inclined to use recycled water, and most farmers (83.90%) were willing to pay 112,500 RLS/h (WTP3) for TWW. This amount is 25% less than the cost of freshwater irrigation, indicating that the price is a significant factor affecting farmers' willingness to adopt its use. Farmers' preference for lower prices indicates that cost is a crucial determinant of their decision to use treated wastewater. Due to the perception that recycled water is of lower quality than freshwater, it was expected to be associated with a lower cost (Deh-Haghi et al., 2020). Conversely, when farmers encountered low prices, they may have mistakenly believed that the water bureau would provide them with subsidized or inexpensive water, prompting them to insist on lower prices themselves. Consequently, these findings should be interpreted with caution. Before proposing the use of wastewater, it is essential to gather information on wastewater utilization and people's attitudes toward its use (Mojid et al., 2010). Investigating perceptions of wastewater is crucial, as it enables relevant organizations to develop appropriate health promotion programs and educational activities to inform farmers about the safe use of treated wastewater.

The study also examined the factors affecting farmers' attitudes toward the use of recycled water for irrigation. The results provide policymakers and provincial water and wastewater authorities with valuable insights into farmers' intentions to appropriately use recycled water in agriculture. While respondents recognized that the region faces water scarcity, their knowledge about wastewater was limited, and they showed relatively weak concern regarding the environmental impacts of untreated sewage and the importance of wastewater treatment. Consequently, some farmers resorted to using untreated sewage for irrigation. This behavior may be attributed to a lack of trust in water and wastewater authorities, as farmers perceive that these agencies do not adhere to necessary standards and safety procedures in wastewater treatment. This distrust likely discouraged farmers from seeking guidance from relevant authorities, making them more reliant on information from other farmers. Therefore, it is essential for relevant authorities to develop strategies that foster trust and confidence among farmers, ensuring them that the wastewater supplied is properly and adequately treated.

The results indicated that income significantly and positively influenced WTU2. This finding aligns with previous research (Roomratanapun, 2001; Robinson et al., 2005; Angelakis and Bontoux, 2001; Dolnicar & Schäfer, 2009; Brahim-Neji et al., 2014). Conversely, contrary to Al-Shenaifi et al. (2015), farmers' age showed a significant positive effect on WTU1. Additionally, potato yield showed a significant positive effect on WTU4. Leeuw (2014), in his study on wastewater use in cauliflower cultivation, highlighted the increase in crop productivity attributable to the nutrients present in wastewater. We infer that this advantage may also explain the positive effect observed in this study for the studied crop. Furthermore, fodder yield positively influenced both WTP2 and WTP1; the same reasoning regarding wastewater's benefits may also apply here. The number of children under 15 years of age had a negative effect on WTP1, WTU2, and WTU4. It is hypothesized that families with more children are concerned about health risks and pollution associated with the use of treated wastewater (Abu Shaban et al., 2006), as well as potential health threats to their children (Ravishankar et al., 2018; Saliba et al., 2018). These concerns likely contribute to their unwillingness to consume or pay for this type of water. Lastly, the number of literate family members exhibited a significant negative effect on WTU3. Based on the typical inverse relationship between age and education level observed in many rural development studies in Iran, it is probable that families with higher literacy levels also have more children and adolescents. This demographic pattern may underlie the negative association observed in this case as well.

The use of recycled water significantly and positively influenced WTU1, WTU2, and WTU4. This suggests that farmers who use recycled water are likely to possess sufficient knowledge about the implications of wastewater use. Supporting this, Haddad (2005) found that farmers with greater awareness of wastewater-related issues tend to hold more positive attitudes towards recycled water, which may partly explain these results. In contrast, the information source had a negative effect on WTP1. It is plausible that other farmers, as the main information source, did not understand the importance of wastewater treatment to compensate for water shortages. Attitudes towards water scarcity positively affected WTU2, aligning with the findings of Bakopoulou et al. (2010). Education also positively influenced both WTP1 and WTU1, which is consistent with previous research (Al-Shanaifi et al., 2015; Wester et al., 2015; Robinson et al., 2005). Environmental attitudes had a significantly negative effect on WTU4. This could be because environmentally conscious farmers are less willing to use treated drinking-quality water for agricultural purposes. During the study, several farmers expressed that water suitable for drinking should not be used in agriculture.

The managerial dimension showed a negative impact on WTP1 and WTP2. This indicates that farmers with better management practices related to recycled water likely perceive that recycled water is inferior to freshwater, and thus should be priced lower (Angelakis and Bontoux, 2001). Household size had a positive effect on WTU3 and WTU4. This may be due to increased information within larger families, consistent with previous research (Al-Shanaifi et al., 2015; Wester et al., 2015; Robinson et al., 2005; Saliba et al., 2018; Bakopoulou et al., 2010; Abu Shabaneh et al., 2006). These factors likely contribute to more positive attitudes toward recycled water. Farming experience negatively influenced WTU1, possibly due to the adverse effects of working in wastewater-irrigated fields, such as poisoning symptoms. Additionally, concerns about health risks contributed to a higher willingness to pay for safer water sources, affecting WTP2 positively. Trust in recycled water had a positive effect on WTU5, corroborating findings from Ravishankar et al. (2018), Peters and Goberdhan (2016), and Hartley (2006). Farming experience the WTU1 which may be related to farmers' experience with the negative health impact of untreated water. Symptoms of poisoning while working in fields under wastewater irrigation had a negative effect on WTP2 and a positive effect on wtU4. These results arise from the belief that the perceived quality of recycled water is lower; therefore, its price should be lower than that of freshwater. Consequently, consumers are only willing to use it when it undergoes extensive purification steps and meets high-quality standards. Trust had a

positive effect on WTU4, which aligns with (Ravishankar et al., 2018; Peters and Goberdhan, 2016; Hartley, 2006).
Finally, limitations of the study should be taken into account. The study was carried out exclusively in Namin County, an area facing severe water shortages, and the findings rely on farmers' self-reported prices and on perceptions of recycled-water quality. As a result, generalization of the results should be approached with caution, and insights from other regions would help to place these findings in a broader context. Being cross-sectional, the study cannot establish causality or temporal trends; future longitudinal studies are needed to inform policy decisions.

## 5. Conclusion

While Iran is located in arid and semi-arid regions of the world, suffering from water scarcity, the country benefits significantly from the availability of a large volume of wastewater. This resource has the potential to play a vital role in addressing the country's water crisis, especially in Ardabil Province, an area experiencing severe water shortages and a declining water table each year. Complementing other strategies, the effective reuse of wastewater could help mitigate water scarcity. However, this requires the development of suitable technologies, improved attitudes among farmers towards using recycled water, and proactive engagement from policymakers and stakeholders. Increasing public awareness and knowledge is crucial for facilitating the adoption of this resource. Investigating farmers' perceptions of treated wastewater enables relevant organizations to design targeted health promotion campaigns and educational programs, thereby encouraging responsible use. To explore the factors influencing farmers' WTU and WTP for treated wastewater, this study integrated socio-psychological variables with econometric analysis.
The findings indicate that farmers generally hold a positive outlook toward using treated wastewater for crop irrigation. Notably, the environmental dimension had the most significant influence on farmers' WTU, while the managerial dimension most strongly affected their WTP. Although a majority of respondents expressed willingness to use treated wastewater, most were only willing to pay up to 25% less than the cost of irrigation with freshwater. This highlights price as a critical factor influencing farmers' adoption decisions, driven by perceptions that recycled water is of lower quality and should thus be cheaper. The reduction in the price of recycled water relative to freshwater could be a crucial factor in increasing farmers' WTU and WTP for treated wastewater.
Farmers exhibited limited knowledge about treated wastewater and its reuse, alongside low trust in organizations and individuals responsible for ensuring its safety and quality. Their perceptions of treated wastewater were predominantly negative, compounded by recent experiences of poisoning symptoms, such as headaches, itching, and diarrhea caused by indirect exposure during farm activities. These health issues likely stem from a lack of awareness regarding safety protocols, representing a significant challenge to widespread acceptance and use. Nevertheless, the farmers demonstrated strengths in their positive attitudes toward management practices aimed at proper wastewater reuse. They also placed considerable trust in university researchers and research centers for information related to treated wastewater. To promote safe and effective reuse, water sector authorities and agricultural extension services should collaborate with researchers to enhance farmers' knowledge and attitudes. This can be achieved through extension training programs focusing on management, health, and safety aspects of using treated wastewater. Furthermore, publishing annual reports on water treatment quality can bolster farmers' confidence in the safety and healthfulness of recycled water, ultimately increasing both their WTP and WTU.

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**Authors' contribution**
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## Conflicts of interest

**The authors of this article declared no conflict of interest regarding the authorship or publication of this article.**

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**All data generated or analyzed during this study are included in this published article.**

## References

Abu Shaban, A., Doppler, W., & Wolff, H.P. (2006). Determinants of farmers' acceptance of treated wastewater in irrigated agriculture in the northern Gaza Strip. In: Tropentag 2006, Conference on international agricultural research for development. University of Bonn, October 11−13. Available online at: https://www.tropentag.de/2006/abstracts/full/254.pdf

Alhumoud, J.M., & Madzikanda, D. (2010). Public perceptions on water reuse options: the case of Sulaibiya wastewater treatment plant in Kuwait. The International Business & Economics Research Journal, 9(1), 141. doi:10.19030/iber.v9i1.515

Al-Shenaifi, M., & Al-Shayaa, M., Alharbi, M. (2015). Perception and Attitudes of farmers toward the uses of treated sewage water in palm trees irrigation. Jordan Journal of Agricultural Sciences, 113, 693-704 https://archives.ju.edu.jo/index.php/jjas/article/view/10316

Angelakis, A.N., & Bontoux, L. (2001). Wastewater reclamation and reuse in Eureau countries. Water Policy, 31, 47–59 doi:10.1016/S1366-7017(00)00028-3

Baghestani, M., & Zibaei, M. (2010). Measuring willingness of farmers to pay for groundwater in Ramjerd district: application of contingent valuation method. Agricultural Economics, 4,41–64 (in Persian) https://www.iranianjae.ir/article_9749_en.html

Bakopoulou, S., Polyzos, S., & Kungolos, A. (2010). Investigation of farmers' willingness to pay for using recycled water for irrigation in Thessaly region, Greece. Desalination, 2501, 329-334.doi:10.1016/j.desal.2009.09.051

Banerjee, K.S., Abdal-Adil, S., Azamathulla, H. M., & Prashant Yadev Birbal, P.Y. (2025). Perception of resident consumers and farmers enhancing sustainable use of treated wastewater in urban and peri-urban farming in the Caribbean region – A case study from Trinidad. Environmental Development, 56, 101294 doi:10.1016/j.envdev.2025.101294

Behrouz, R., & Liaqat, AM. (2002). Wastewater use management in agriculture, 11th Seminar of the National Irrigation and Drainage Committee, Tehran. Available online at: https://civilica.com/doc/10088

Brahim-Neji, H.B., & Ruiz-Villaverde, A., González-Gómez, F. (2014). Decision aid supports for evaluating agricultural water reuse practices in Tunisia: The Cebala perimeter. Agricultural water management, 143, 113-121 doi:10.1016/j.agwat.2014.07.002

Cochran, W. G. (1977). Sampling techniques. New York, NY: Willey.

Deh-Haghi, Z., Bagheri, A., Fotourehchi, Z., & Damalas, C. A. (2020). Farmers' acceptance and willingness to pay for using treated wastewater in crop irrigation: A survey in western Iran. Agricultural Water Management, 239, 106262. doi:10.1016/j.agwat.2020.106262

Dolnicar, S., & Schäfer, A.I. (2009). Desalinated versus recycled water: public perceptions and profiles of the accepters. Journal of environmental Management, 90(2), 888-900. doi:10.1016/j.jenvman.2008.02.003

Drechsel, P., & Evans, A.E.V. (2010). Wastewater use in irrigated agriculture. Irrigation and Drainage Systems, 24, 1–3. doi:10.1007/s10795-010-9095-5

FAO. (2002). Crops and Drops: Making the best use of water for agriculture. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 1–22 https://farm-d.org/document/crops-and-drops-making-the-best-use-of-water-in-agriculture/

FAO. (2016). Food and agriculture organization (FAO) of the United Nations AQUASTAT global water information system http://www.fao.org/3/ca0220en/ CA0220EN.pdf.

Gleick, P.H. (2000). The World's Water 2000–(2001). The biennial reports on freshwater resources. Island Press, Washington, DC, 315 pp. https://link.springer.com/book/10.5822/978-1-61091-483-3

Googoochani, S., Ghobadinia, M., Tabatabaei, S.H., Motaghian, H., & Asgari, A. (2024). The effect of using bilevels of geocomposite sheets on the quality of Shahrekord University wastewater. Water and Soil Management and Modeling, 4(4), 203-218. doi: 10.22098/mmws.2023.13732.1362

Haddad, M. (2005). Public attitudes towards socio-cultural aspects of water supply and sanitation services: Palestine as a case study. Canadian Journal of Environmental Education, 101, 195-211 https://cjee.lakeheadu.ca/article/view/187

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. American journal of agricultural economics, 73(4), 1255-1263. doi:10.2307/1242453

Hanemann, W.M. (1994). Valuing the environment through contingent valuation. Journal of economic perspectives, 8(4), 19-43 https://www.aeaweb.org/articles?id=10.1257/jep.8.4.19

Hartley, T.W. (2006). Public perception and participation in water reuse. Desalination, 187(1-3), 115-126. doi:10.1257/jep.8.4.19

Hurlimann, A. (2008). Community Attitudes to Recycled Water Use: An Urban Australian Case Study part 2. CRC for Water Quality and Treatment, Salisbury. Available online at: https://www.scirp.org/reference/referencespapers?referenceid=1524972

Hussain I., Raschid, L., Hanjra, M. A., Marikar F., & van der Hoek, W. (2002). Wastewater use in agriculture: Review of impacts and methodological issues in valuing impacts. (With an extended list of bibliographical references). Working Paper 37. Colombo, Sri Lanka: International Water Management Institute. https://kh.aquaenergyexpo.com/wp-content/uploads/2022/11/Wastewater-Use-in-Agriculture.pdf

Khanpae, M., & Karami, E. (2015). Determinants of farmers' attitudes towards sustainability dimensions of farms under wastewater irrigation: The case of Marvdasht County. Iranian agricultural extension and education journal, 11(1), 89-99 dor: 20.1001.1.20081758.1394.11.1.7.1

Lazarova, V., Levine, B., Sack, J., Cirelli, G., Jeffrey, P., Muntau, H., Salgot, M., & Brissaud, F. (2001). Role of water reuse for enhancing integrated water management in Europe and Mediterranean countries. Water Science and Technology, 4310, 25-33. doi:10.2166/wst.2001.0571

Leeuw J.M.de. (2014). Multiple perspectives on the use of wastewater in agriculture. Earth System Sciences Group. Thesis for the specialization Integrated Water Management ESS-80836. Master of Science in International Land and Water Management. Wageningen University, the Netherlands. Pp:1-59.

Mainali, B., Ngo, HH., Guo, W., Pham, TTN., & Johnston, A. (2011). Feasibility assessment of recycled water use for washing machines in Australia through SWOT analysis. Resources, Conservation and Recycling, 56 (1), 87-91 doi:10.1016/j.resconrec.2011.09.007

Marcio, A.A., Ileana, B., Vox, G., Scarascia-Mugnozza, G., Schettini, E., da Silva, P.L. (2022). The challenge of urban food production and sustainable water use: current situation and future perspectives of the urban agriculture in Brazil and Italy. Sustainable Cities and Societies, 83, 103961. doi:10.1016/j.scs.2022.103961.

Mishra, S., Kumar, R., & Kumar, M. (2023). Use of treated sewage or wastewater as an irrigation water for agricultural purposes- Environmental, health, and economic impacts. Total Environ. Research Themes, 6, 100051. doi:10.1016/j.totert.2023.100051.

Mojid, M. A., Wyseure, G. C. L., Biswas, S. K., & Hossain, A.B.M.Z. (2010). Farmers' perceptions and knowledge in using wastewater for irrigation at twelve peri-urban areas and two sugar mill areas in Bangladesh. Agricultural Water Management, 981, 79-86. doi:10.1016/j.agwat.2010.07.015

Neumann, P., Hidalgo, S., Díaz, M., Quintana, C., & Madrid-L´opez, C. (2024). Exploring the social metabolism of urban wastewater reuse: analysis framework and a case study in South-Central

Chile. Sustainable Cities and Societies, 106, 105349. doi:10.1016/j.scs.2024.105349.

Niemczynowicz, J. (1999). Urban hydrology and water management - present and 702 future challenges. Urban Water, 1, 1-14. doi:10.1016/S1462-0758(99)00009-6

Ofori, S., Puskacova, A., Ruzickova, I., & Wanner, J. (2021). Treated wastewater reuse for irrigation: pros and cons. Science of the Total Environment, 760, 144026 doi:10.1016/j.scitotenv.2020.144026.

Olli, E., Grendstad, G., & Wollebaek, D. (2001). Correlates of environmental behaviors: Bringing back social context. Environment and Behavior, 33(2), 181-208 doi:10.1177/0013916501332002

Pedrero, F., Kalavrouziotis, I., Alarcón, J. J., Koukoulakis, P., & Asano, T. (2010). Use of treated municipal wastewater in irrigated agriculture—Review of some practices in Spain and Greece. Agricultural Water Management, 979, 1233-1241 doi:10.1016/j.agwat.2010.03.003

Pescod, M.B. (1992). Wastewater treatment and use in agriculture. FAO Irrigation and Drainage Paper No. 47. FAO, Rome. https://www.fao.org/4/t0551e/t0551e00.htm

Peters, E. J., & Goberdhan, L. (2016). Potential consumers' perception of treated wastewater reuse in Trinidad. West Indian Journal of Engineering, *38*(2) https://journals.sta.uwi.edu/ojs/index.php/wije/article/view/7706

Rasekhi, S., Karimi, S., & Hamedi R. (2012). Measuring willingness to pay for coastal tourism and its determinants by contingent valuation method: A case study of Caspian Sea Beaches. Tourism Planning and Development, 1(2), 13-32. (In Persian). https://tourismpd.journals.umz.ac.ir/article_301.html?lang=en

Ravishankar, C., Nautiyal, S., & Seshaiah, M. (2018). Social acceptance for reclaimed water use: a case study in Bengaluru. Recycling, 3(1), 4 doi:10.3390/recycling3010004

Robinson, K. G., Robinson, C. H., & Hawkins, S. A. (2005). Assessment of public perception regarding wastewater reuse. Water Science and Technology: Water Supply. 51, 59-65 doi:10.2166/ws.2005.0008

Roomratanapun, W. (2001). Introducing centralized wastewater treatment in Bangkok: A study of factors determining its acceptability. Habitat International, 253, 359-371 doi:10.1016/S0197-3975(00)00041-2

Sakkas, N., Kozyraki, M., Menegaki, A., & Tsagarakis, K.P. (2004). Public awareness towards sensitive areas of crete with emphasis in water recycling and reuse of marginal waters. Hellenic Republic Ministry of the Environment, Planning and Public Works and the Technological Institute of Crete, Heraklio, Greece (in Greek).

Salahi, B. (2009). Studying droughts in Ardabil province using statistical and synoptic indicators. Conference on Water Crisis and the Necessity of Rehabilitation of Ardabil Province. (in Persian). Available online at: https://civilica.com/doc/335176

Saliba, R., Callieris, R., D'Agostino, D., Roma, R., & Scardigno, A. (2018). Stakeholders' attitude towards the reuse of treated wastewater for irrigation in Mediterranean agriculture. Agricultural Water Management, 204, 60-68 doi:10.1016/j.agwat.2018.03.036

Shtull-Trauring, E., Cohen, A., Ben-hur, M., Israeil, M., & Bernstein, N. (2022). NPK in treated wastewater irrigation: regional scale indices to minimize environmental pollution and optimize crop nutritional supply. Science of the Total Environment, 806 (1), 150387 doi:10.1016/j.scitotenv.2021.150387.

Spash, C.L., Urama, K., Burton, R., Kenyon, W., Shannon, P., & Hill, G. (2006). Motives behind willingness to pay for improving biodiversity in a water ecosystem: Economics, ethics and social psychology. Ecological Economics, 68, 955-964 doi:10.1016/j.ecolecon.2006.09.013

Srinivasan, K., & Yadav, V.K. (2023). An integrated literature review on urban and peri-urban farming: exploring research themes and future directions. Sustainable Cities and Societies, 99, 104878 doi:10.1016/j.scs.2023.104878.

Tabatabaei, S.H., Googoochani, S., Ghobadinia, M., Motaghian, H.R., & Asgari, A. (2025). The effect of using bilevels geocomposite sheets on the chemical and biochemical characteristics of soil under wastewater reuse. Water and Soil Management and Modeling, 5(1), 1-14. doi: 10.22098/mmws.2023.13904.1372

Toze, S. (2006). Reuse of effluent water—benefits and risks. Agricultural water management, 80(1-3), 147-159. doi:10.1016/j.agwat.2005.07.010

UN Department of Technical Cooperation for Development. (1985). The use of non-conventional water resources in developing countries. Natural Water Resources Series No. 14. United Nations DTCD, New York. https://digitallibrary.un.org/record/96112?ln=en

Valdes Ramos, A., Aguilera Gonzalez, E. N., Tobón Echeverri, G., Samaniego Moreno, L., Díaz Jiménez, L., & Carlos Hernández, S. (2019). Potential uses of treated municipal wastewater in a semiarid region of Mexico. Sustainability, 11(8), 2217. doi:10.3390/su11082217

Venkatachalam, L. (2004). The contingent valuation method: a review. Environmental Impact Assessment Review, 24 (1), 89-124 doi:10.1016/S0195-9255(03)00138-0

W.H.O. (2006). Guidelines for the safe use of wastewater, Excreta and Greywater, vol. 2. World Health Organization (WHO), France. ISBN: 92 4 154683 2 https://www.who.int/publications/i/item/9241546859

Wester, J., Timpano, K. R., Çek, D., Lieberman, D., Fieldstone, S. C., & Broad, K. (2015). Psychological and social factors associated with wastewater reuse emotional discomfort. Journal of Environmental Psychology. 42, 16-23 doi:10.1016/j.jenvp.2015.01.003

Yue, C., Hall, C.R., Behe, B.K., Campbell, B.L.B., Lopez, R.G., & Dennis J.H. (2012). Comparing willingness to pay estimation models for conjoint analysis: a case study of willingness to pay for biodegradable containers for plants. Integrating Consumers and Economic Systems. 217-224. doi:10.17660/ActaHortic.2012.930.28

Zarghani, S.H., Mohammadzadeh, M., Nadi, M., & Varzdar, M. (2013). Investigation of water challenges in South Khorasan province and its role in security. National congress of South Khorasan. Social Order and Security, 69–83 (in Persian). Available online at: https://elmnet.ir/doc/1543544-97115