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Article

Analysis of Factors that Influence the Willingness to Pay for Irrigation Water in the Kurdistan Regional Government, Iraq

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Abstract: Water availability has become a problem in many countries of the world. Water scarcity can be economic or physical. Agricultural water use accounts for about three quarters of total global consumption; in many developing countries, irrigation represents over 90% of the water used. The purpose of this paper is to explore the willingness to pay for irrigation water among the farmers from the boundaries governed by the Kurdistan Regional Government (KRG). During the field study, 236 farmers from KRG were interviewed. The collected data were analyzed for each of the precipitation zones of the area (secured (A) and non-secured rainfed (B)). The contingent valuation method was used to determine the willingness to pay for irrigation water. The following possible independent variables influencing farmers' decisions were considered: the bid amounts; evaluation scale of the water deficit; source of water for irrigation; cultivated area; education and age of respondents; main agricultural activity. In Zone A, the median willingness to pay of the farmers that used ground water for irrigation is 20.28 USD/10 m^3, and for the farmers that use other sources of water, the willingness to pay is 11.49 USD/10 m^3. The median willingness to pay in Zone B is 18.56/10 m^3.

Keywords: contingent valuation method; total economic value; Kurdistan; probit model

1. Introduction

The last few decades have revealed new challenges for assuring the water supply in many places of the world, where water availability has become a persistent problem [1]. Water scarcity can be economic, when there is a lack of investment in water or a lack of human capacity to keep up with growing water demand. It can also be physical: scarcity occurs when available resources are insufficient to meet all demands, including minimum environmental flow requirements [2].

A decade and a half ago, water was officially recognized as a scarce resource by the international community; the 1992 Dublin Statements declared that water resources are not infinite and that they are "vulnerable" [3]. The Fourth Principle of the Statements defined "water as an economic good". Recognizing that water has been an economic good for many centuries [4] helps to explain, in practical terms, the economic tools that can be used to influence the environmentally-, socially- and economically-efficacious use of the resource. Even among economists, the complexity of water as an economic good has not been suitably assessed [5].

Use of the concept of economic value contributes to an understanding of how the value of water can be measured, as well as how, when and to whom it can be useful. The aim of economic valuation is to quantify the contribution of water resources' use to human well-being [6]. Value is rooted in the idea that many resources are scarce [7], which means that the demand for those resources is higher relative to their availability [8]. The value of water to a consumer is the maximum amount that the user would be willing to pay to use it. The value of water thus also depends on the value of crops; for low-value crops, it is universally very low [9]. Where credible viands are used as high value crops, the value of water can be high [6]. Agricultural water use accounts for about three quarters of total global consumption; in many developing countries, irrigation represents over 90% of water used [10].

Water resources are considerable relative to water use. Less than 25% of water from the surface (rivers) is withdrawn for human goals, but malnutrition still exists [2]. As water scarcity increases, the quality of water suffering from geographical, political and socioeconomic problems increases, too [11].

Water resources are badly managed in several parts of the world, and many people, above all the poor, suffer disproportionately from the lack of a right to use an adequate and sanitary water supply [12]. Farmers try to optimize water allocation among challenging crops and irrigation technologies to maximize production and farm revenue [13]. Policies related to the management of water resources are a current problem throughout the world [14–16]

Current water policies treat water as an economic good, yet water shares a number of characteristics with other resources, like life and politics. Its scarcity becomes a global issue [17]. Water is one of the few renewable resources in the world via the hydrological cycle [18]. Stress is rising concerning the ownership and the control of water for purposes such as agriculture, irrigation and industrial and human consumption [19].

In this context, studies regarding the economic value of irrigation water have been done throughout the world. The study conducted by [20] revealed that farmers are willing to pay for irrigation water sums at least equal to the process and maintenance cost and are able to pay up to the marginal value product of water. In Jordan and Tunisia [21], where agricultural water consumption is high, the water price affects the farming profitability and farmers' willingness to pay for reclaimed wastewater. In Bangladesh, the ground water used for irrigation is highly underpriced [22]. The farmers' willingness to pay for irrigation water is higher than the current price in the Shiyang River basin, China [23]. The factors that affect the willingness to pay of the farmers are many: products, input, education level [11,22], demographic and social characteristics, personal experience in farming [24], bid level, family size, number of income sources and ownership of farmland [22].

The Middle East and North African region (MENA) is characterized by great disparities in wealth and differently-structured economies. The climate is predominantly arid and hyper-arid. Significant agricultural production relies on public or private irrigation using surface water, groundwater or some combination [25]. The water and agricultural sectors are closely linked. In most of the MENA countries, the agricultural sector is the largest consumer of water [26]. Most of the countries in the Middle East have long utilized the same renewable freshwater resources. Irrigation relies on fossil groundwater sources. The irrigation potential of the Middle East region is estimated at more than 38.4 million ha, of which 76% is in Iran, Turkey, Egypt and Iraq [27]. The growth of irrigation as planned in the upstream countries—mainly the southeastern Anatolian (GAP) project in Turkey and the irrigation projects in the Syrian Arab Republic, as well as in Iran on tributaries of the Tigris and on the Dez and Karun—will decrease Iraqi irrigation potential unless a contract is set up between the riparian countries to regulate water use [28]. In view of the fact that water shortages are predicted to occur with the development of irrigation, a solution must be created for integrated water resource management. The promise of a step up in water management in Iraq will require investment, which must, at least in part, come from outside sources. There are good opportunities for investments in water, but still, they have to be identified and prioritized, their costs estimated, their economic feasibility planned and their financing and repayment plans prepared [29].

The most important internal surface or groundwater resources of the Kurdistan Region Government (KRG) come from precipitation resources, which are renewable: rainfall and snow [29,30].

In 2007, 65% of the Kurdistan Region's food was imported, and 35% was produced domestically [31]. The agriculture sector has been greatly hampered by decades of conflict, destructive national government policies, international sanctions, the Public Distribution System (PDS) and two decades of isolation. Currently, over 80% of the region's basic staples are imported, and an open border has resulted in the region becoming a market for often substandard or contaminated goods. The inability to produce its own food puts the Kurdistan Region at a disadvantage when negotiating with neighbors that feed it. Certain agricultural industries, such as poultry, some grains, some fruits and vegetables and livestock, may offer an opportunity for the region to escape from this dependence [31,32].

The cultivated land in the region, both rain-fed and irrigated, comprises over 1,535,000 hectares, representing around 36% of the region's total area. The total area of rain-fed cultivated land is around 1,368,000 hectares, representing about 88% of the overall agricultural land and almost 31% of the total area of the region. The area of irrigated land is more than 167,000 hectares, representing about 11% of total cultivated land and 4% of the overall area of the region [30].

The main objective of this paper is to determine the economic value of the irrigation of water in the Kurdistan Regional Government (KRG), Iraq.

2. Materials and Methods

Based on climate conditions, the KRG can be divided into two main zones: a secured rainfed line (more than 600 mm year^{-1}), known as the Sangassar zone (A), and a semi- and un-secured rainfed line (less than 600 mm year^{-1}), known as the Kirkuk zone (B) (Figure 1) [33]. The droughts that affected the Kurdistan region in the past few years were very harsh, affecting a population that was already suffering under the influence of previous drought spells that had attacked a wider geographical reach and had a disastrous impact on the lives of the population.

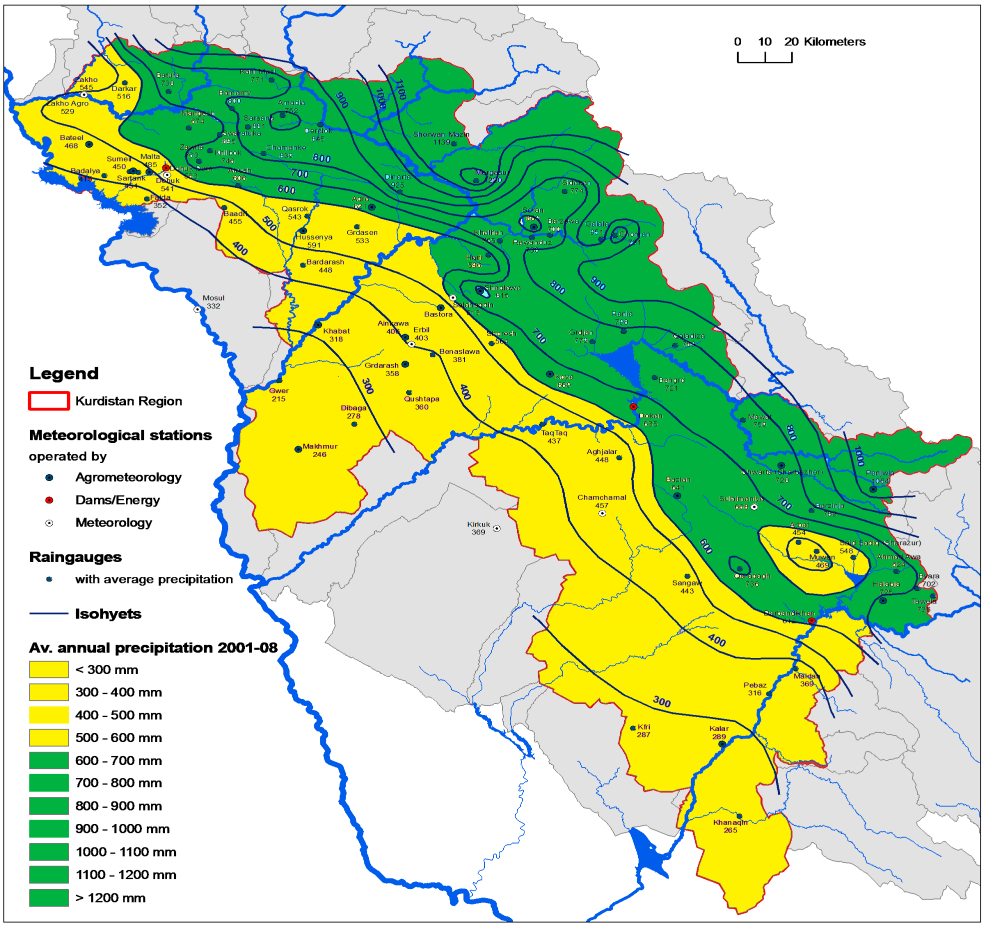

Figure 1. Agro-ecological zones of Kurdistan region. Source: [34].

Estimating the willingness to pay for irrigation water can provide valuable information to policy decision-makers. To achieve the objective of the paper, 236 farmers from KRG were interviewed.

In the case of non-market valuation techniques, such as the contingent valuation method, a random sample of the relevant population is considered best to derive appropriate inference, but this is not always possible (for example, on-site recreation demand surveys will be affected by sample selection problems) [35]. A simple random sample, without replacement, with a continuous variable and a relative error of 2.5% and a 95% confidence interval, was used to establish the size of the sample.

$$n = \frac{k^2 \times \sigma_x^2}{\Delta_{\bar{x}}^2 + \frac{k^2 \times \sigma_x^2}{N}} = \frac{(1.96)^2 \times 244.45}{(2.15)^2 + \frac{(1.96)^2 \times 244.45}{1{,}188{,}108}} = 203.12 \text{ farmers} \cong 204 \text{ farmers} \quad (1)$$

where $\Delta_{\bar{x}}^2$ is the absolute error, n is the size of the sample, k is the probability guarantee, σ_x^2 is the variance and N is the volume of the population.

The selection of farmers was a difficult process that was based primarily on the annual precipitation registered in the area. For each area, 118 farmers were interviewed, resulting in a total sample of 236 farmers.

The contingent valuation method (CVM) was used to elicit the farmers' willingness to pay (WTP) for irrigation water. Since the utility cannot be observed, being "unknown", it is presumed to consist of a deterministic component and a random one [36]. Formally, the individual's utility can be expressed as [37]:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, j = 0.1 \quad (2)$$

where U_{ij} is the utility of alternative j for consumer i, where V_{ij} is the deterministic component and ε_{ij} the random component.

It is assumed that the respondent knows which choice maximizes his utility; thus, the process is deterministic. For the researcher, the response given by the individual is a random variable with a probability given by [38]:

$$\begin{gathered} P_1 = P(Y) = P[V_1 + \varepsilon_1 \geq V_0 + \varepsilon_0] = F_\eta(\Delta V) \\ \text{and } P_0 = P(N) = 1 - P(Y) \end{gathered} \quad (3)$$

where $\eta = \varepsilon_0 - \varepsilon_1$ and $F_\eta(\cdot)$ is the cumulative density function of η, P(Y) is the probability of saying "yes" and P(N) is the probability of saying "no".

The maximum willingness to pay is found by setting ΔV equal to zero and solving for P. The cumulative density function is assumed to be standard normal; thus, the probability that an individual accepts the offer corresponds to a standard probit model.

This study uses the random utility model to determine the willingness to pay for water irrigation. Individuals were asked about their willingness to pay by addressing five single-bounded dichotomous choice questions. This procedure led to five observations per individual, each corresponding to one of the valuation questions from the questionnaire. The willingness to pay for water was estimated using the random effects probit model, which includes the respondent-specific disturbance in addition to the disturbance associated with the model. The general expression for the random effects model is [39]:

$$Y_{it}^* = \beta X_{it} + u_i + \varepsilon_{it} \quad (4)$$

$$Y_{it} = 1 \text{ if } Y_{it}^* > 0,\ Y_{it} = 0 \text{ otherwise} \quad (5)$$

where i is the individual, t the number of responses per individual, Y_{it}^* an unobserved latent variable, Y_{it} the observed random variable, X_{it} a vector of independent variables and β a vector of coefficients.

The median willingness to pay is calculated directly on the sample data, based on the estimated coefficients for all factors affecting the willingness to pay for water irrigation:

$$\overline{WTP} = \frac{\beta_i \cdot X_i}{-\beta_{WTP}} \quad (6)$$

The investigation was conducted only with the aim of identifying potential factors that may influence individual decisions on how much farmers are willing to pay for water irrigation. Due to the specific characteristics of the research area, it was considered necessary to analyze the data for each of the precipitation zones. The dependent variable is represented by the "yes/no" responses to the five valuation questions, which asked respondents if they would be willing to pay the offered bid amounts for water irrigation.

Independent variables considered that may have influenced the decision included the bid amounts (expressed in USD/10 m^3), the evaluation scale of the water deficit, a dummy variable coded 1 if respondents used a well, spring or karez as a source of water for irrigation and 0 otherwise, meaning that respondents used other sources of water for irrigation, such as a stream, river, delivery truck (tanker) and other (because the target of the investigation was to focus on summer crops), education and age of respondents and a dummy variable coded as 1 if the respondent's main activity was agriculture and 0 otherwise. The essential task was to choose the variables as mentioned above, to prove that farmers have knowledge about water and are willing to pay for it as an economic good.

The decision for the final model was taken after testing the significance of the estimated parameters using the two-tailed *t*-test. In each case, the median willingness to pay was determined based on the estimated coefficients of the last model obtained from this process.

3. Results and Discussion

3.1. The Estimation of Willingness to Pay for Water in Zone A

Model 1 includes the bid amount as an independent variable and the constant, whereas Model 2 is extended by including variables directly related to the agricultural activity, such as: the evaluation of water deficit, the dummy variable for groundwater and the area cultivated at the level of year 2011 (Table 1). It can be noted that the variable "cultivated area" is not statistically significant, neither at the 10% level of significance as indicated by the *t*-test (t cultivated area = 0.21 < t crit,10% = 1.645). The analysis was further conducted by estimating Model 3, which is restricted by excluding variable "cultivated area", as suggested by the two-tailed *t*-test. The influence of the socio-economic variables is analyzed by extending Model 3, thus resulting in Model 4. The estimation results indicate that the intercept coefficient becomes not significant (t constant = 0.06 < t crit, 10% = 1.645). The estimation results indicate that the variable "groundwater" and "water deficit" remain statistically significant and have a positive influence on the willingness to pay. Moreover, all of the socio-economic variables influence the probability of saying "yes" to the offered bid amounts. The significant sign of the estimated coefficient for "main activity agriculture" suggests that there is a difference between people who practice agriculture as a main activity and those who practice it as a secondary activity. Further analysis was conducted by estimating Model 5 in which the constant was excluded, since it was not significant. The estimated coefficients of all independent variables remain significant, except for the "main activity agriculture" (t main activagric = 1.33 < t crit, 10% = 1.645). Thus, the analysis cannot be conducted separately on respondents with agriculture as the main activity and on respondents with agriculture as the secondary activity, even if the percentage of the first group (main activity agriculture) is higher (73%). As a result, Model 6 is constrained by excluding the variable "main activity agriculture". All estimated coefficients are statistically significant at the 1% level, and their influence on the willingness to pay remains the same as in Model 5 (Table 1).

Table 1. The estimation results in Zone A.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	10.6596 (0.5912) [a]	6.6024 (1.5937) [a]	6.7636 (1.5555) [a]	−0.2522 (4.1614)		
Bid	−0.4888 (0.0696) [a]	−0.7364 (0.1017) [a]	−0.7199 (0.0971) [a]	−0.7907 (0.1399) [b]	−0.7791 (0.1388) [a]	−0.7809 (0.1137) [a]
Water deficit		0.8187 (0.3964) [b]	0.8721 (0.3915) [b]	1.6289 (0.6592) [b]	1.6097 (0.5410) [a]	1.7449 (0.5975) [a]
Ground water		7.9958 (0.9667) [a]	7.5713 (0.9401) [a]	11.8681 (1.8644) [a]	10.7821 (1.6498) [a]	8.7986 (1.2671) [a]
Cultivated area in 2011		0.0155 (0.0742)				
Education				−2.6008 (0.5419) [a]	−2.5843 (0.6408) [a]	−1.9421 (0.5461) [a]
Age				0.2047 (0.0614) [a]	0.1959 (0.0464) [a]	0.1529 (0.0423) [a]
Main activity agriculture				−3.1387 (1.8731) [c]	−2.2212 (1.6677)	
Ln (L)	−99.3227	−95.1258	−94.2720	−91.9522	−91.8657	−92.3971
ρ	0.9851	0.9912	0.9910	0.9908	0.9903	0.9897
No. of observations (No. of groups)	590 (118)	590 (118)	590 (118)	590 (118)	590 (118)	590 (118)

Standard errors in parentheses; [a] significant at the 1% level; [b] significant at the 5% level; [c] significant at the 10% level.

The coefficients estimated in Model 6 were further used to determine the median willingness to pay for two groups: people who use ground water for irrigation and people who use other sources of water for irrigation, as reported in Table 2.

Table 2. The willingness to pay for water irrigation in Zone A (USD/10 m^3).

Source of water / Type of respondents	Ground water	Other types of sources
All farmers	20.28	11.49

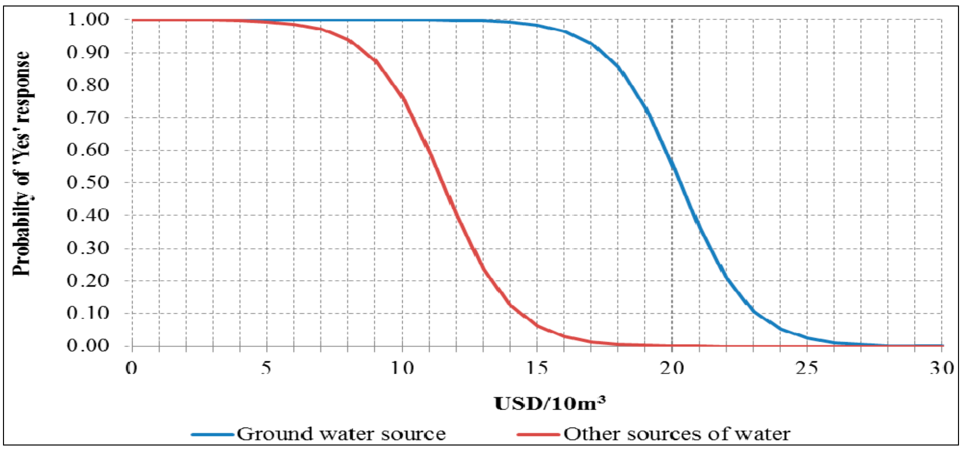

Figure 2. The willingness to pay for irrigation water in the Zone A.

The median willingness to pay is higher for people who use ground water for irrigation with 8.79 USD/10 m^3.

The variables "water deficit" and "groundwater" have positive signs and are statistically significant at the 1% level. People who have appreciated the water deficit situation as being very high are willing to pay more for water irrigation (Figure 2). Moreover, individuals who use wells, springs or karez as a source of water are willing to pay more than those who are using other sources of water for irrigation.

The willingness to pay is negatively influenced by education level, as indicated by the negative sign of the estimated coefficient, meaning that it is lower for more educated people, because of the alternatives they have to find a job in another field.

The variable "age" has a positive sign, meaning that older people are willing to pay more for water irrigation. This is not surprising considering that older people may be more closely linked to their villages and to tradition, which makes them willing to pay more than the younger farmers. At the same time, as was shown before, older people are also less educated, which limits their alternative activities outside of agriculture and the rural area.

3.2. The Estimation of Willingness to Pay for Water in Zone B

Model 1 includes the bid amount as an independent variable and the constant, whereas Model 2 is extended by including variables directly related to agricultural activity, such as: the evaluation of water deficit, the dummy variable for groundwater and the area cultivated at the level of year 2011. In Model 1, the probability of saying "yes" is influenced by the offered bid amount; it decreases as the bid amount increases. This result is indicated by the negative sign of the bid variable, which is statistically significant at the 1% level (Table 3).

In Model 2, the estimated coefficient of the bid amount remains statistically significant and has a negative influence on the probability of saying "yes". The variable "water deficit" has a positive sign, and it is statistically significant at the 1% level. Thus, people who have appreciated the water deficit situation as being very high are willing to pay more for water irrigation. The variable "ground water" has a negative sign, and it is statistically significant at the 1% level. Moreover, individuals who use well, spring or karez as the source of water are less willing to pay than those who are using other sources of water. This can be explained by the high accessibility to ground water relative to surface water. It can be noticed that the variable "cultivated area" is not statistically significant, neither at the 10% level of significance, as indicated by the *t*-test (t cultivated area = 0.56 < t crit, 10% = 1.645).

Table 3. The estimation results in Zone B.

Variable	Model 1	Model 2	Model 3	Model 4
Constant	7.4649 (0.5426) [a]	−44.4277 (5.8659) [a]	−23.9513 (7.0296) [a]	−27.8759 (6.8600) [a]
Bid	−0.1517 (0.0652) [b]	−0.8713 (0.1791) [a]	−0.3822 (0.1452) [a]	−0.4097 (0.1525) [a]
Water deficit		18.1843 (2.6099) [a]	8.2777 (1.6574) [a]	9.5600 (1.9178) [a]
Ground water		−9.7616 (1.6223) [a]	−1.3220 (0.9704)	
Cultivated area in 2011		0.0281 (0.0505)	0.0137 (0.0279)	
Education			−0.1793 (0.6193)	
Age			0.0249 (0.0461)	
Main activity agriculture			−0.5213 (1.0879)	
Ln(L)	−73.6322	−34.3754	−36.5469	−38.1397
ρ	0.9792	0.9895	0.9286	0.9439
No. of observations (No. of groups)	590 (118)	590 (118)	590 (118)	585 (117)

Standard errors in parentheses; [a] significant at the 1% level; [b] significant at the 5% level; [c] significant at the 10% level.

The influence of the socio-economic variables is analyzed by extending Model 2, thus resulting in Model 3. The estimation results indicate that all independent variables, except for "water deficit", are not significant at the 10% level (t groundwater = 1.36, t cultivated area = 0.49, t education = 0.29, t age = 0.54, t main activagric = 0.48 < t crit, 10% = 1.645). Thus, the willingness to pay for water irrigation is not influenced, neither by the age of respondents, their level of education, nor by the main activity in which they are involved. Moreover, the decision of the respondents is influenced neither by the cultivated area, nor by the source of water used for irrigation. The final model is Model 4 (Table 3).

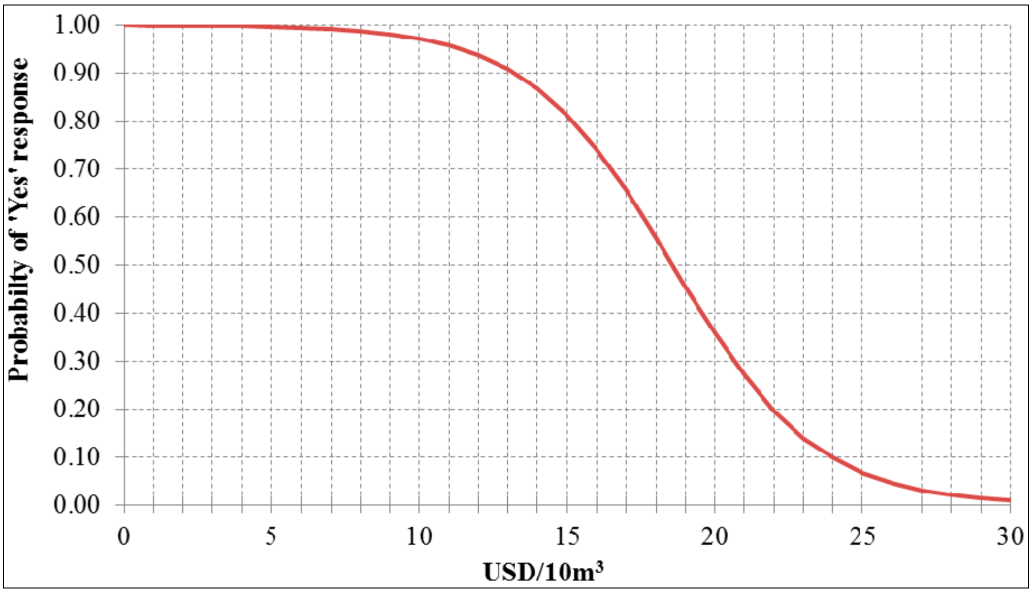

Figure 3. The willingness to pay for water irrigation in Zone B.

The coefficients estimated in the Model 4 were further used to determine the median willingness to pay, leading to a value of 18.56 USD/10 m^3. Figure 3 shows the probability curve represented for Zone B using the estimated coefficients from Model 5 with the sample data. The horizontal axis is represented by the bid amount and the vertical axis by the estimated probability of a "yes" response. It can be noted that the probability of saying "yes" is zero for values greater than 30 USD/10 m^3. The median WTP is to be found at the probability of saying "yes" of 0.5.

4. Conclusions

In the Kurdistan Regional Government, irrigation represents over 90% of the water used, and more than a quarter of irrigation withdrawals are considered unsustainable. Furthermore, the climate, the normal seasonal variations and drought, sand storms and floods all influence the availability and quality of water.

This study, carried out in the rural area of the KRG, took into consideration the particularities of the two precipitation zones in order to find out what were the main differences related to the topic of the research between the two geographical zones, being a new approach to analyzing the willingness of farmers to pay for irrigation water.

This research in the rural areas of the Kurdistan region revealed diversity in attitudes amongst individuals towards willingness to pay for water irrigation, and one of the most interesting aspects of this inquiry was to find out that there is a WTP. The willingness to pay of the farmers for water irrigation is higher in Zone A than in Zone B. In Zone A, the water resources are more used for agriculture than for other sectors, having a higher economic value than in Zone B. The farmers from Zone A are better market orientated than those from Zone B.

The study offers valuable information that can be used by authorities to valorize water at its local market price. Water policy makers may offer irrigation water at a lower price than the willingness to pay of the farmers. To achieve this, there should be a computerized systemization survey of all of the natural water resources in the study region, to make high-quality maps displaying sources of water, soil, vegetation and land use. It is recommended that this database be established before initiating research programs in other locations. A developed structure of the water conservation network, dams and the establishment of new irrigation network technologies for water conservation all over the region should be completed in order to save the highest amount of water and to reduce water consumption by irrigation networks, especially during times of shortage.

The results of the study reveal that there are differences among the factors influencing the willingness to pay for irrigation water between the two precipitation zones. In both cases, as expected, a higher level of water deficit corresponds to a higher willingness to pay. The difference between the two zones lies mainly in the access of the farmers to water resources. In Zone A, due to climactic conditions, the farmers can more easily use the rivers and streams for irrigation, while in Zone B, this is more difficult because of drought. The income was not included in the analysis as a potential factor because of respondents' refusal to reveal their income. Further investigation is needed to find if and how the economic characteristics of the regions affect the decision regarding the use and willingness to pay for irrigation water.

The contingent valuation method, the most well-known monetary valuation technique, was used to assess the economic value of water irrigation. This method was proven suitable in forming indicators associated with commodities that are not usually treated on the marketplace.

The study provides information about the various influences that can convince the farmers to be willing to pay for irrigation water in the KRG rural communities. At the same time, this study illustrates the need for research as a part of developing a local water policy. One should not exclude the impact that other individuals can have on the level of WTP. Most importantly, the findings of this research are generated from specific spatial circumstances; they should serve as indicators for future research into WTP for water for irrigation in other localities.

Author Contributions

All authors contributed equally to this work. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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