Valuing Households' Willingness to Pay for Water Transfers from the Irrigation Sector: A Case Study of the City of Seville (Southern Spain)

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Abstract: Water scarcity is increasing in many countries worldwide, and conflicts between alternative uses have arisen due to the high demand and the effects of climate change, among other factors. This paper employs a contingent valuation (CV) method to determine households' willingness to pay (WTP) compensation to the irrigation sector to guarantee urban supply reliability under extreme water-scarcity conditions (e.g., during a drought period) through inter-sectoral water transfers. The data was obtained from a survey covering 250 households in the city of Seville. In order to estimate households' WTP, a double-bounded approach is used. Results show that the average WTP would be between 2.53 and 2.59 euros (on a monthly basis), which would represent a viable annual water transfer of 14.3 Hm^3 from the irrigation sector, which would be compensated accordingly. This study shows that inter-sectoral water transfers should be considered a viable adaptation measure to manage the consequences of water scarcity in urban areas.

Keywords: contingent valuation; water transfers; urban users; willingness to pay

1. Introduction

Increasing climate variability and global warming due to climate change will definitely trigger major effects on the distribution of surface-water availability over space and time. These effects are compromising water-supply reliability in cities worldwide, especially for those located in semi-arid regions. According to the IPCC [1], projections for semi-arid regions continuously indicate: An expected decrease of precipitation, run-off, and water availability; greater frequency and intensity of drought periods; and a progressive rise in the average global temperature, which will increase demands and conflicts between alternative uses (e.g. agricultural vs. urban uses). The recent literature has addressed the urgent need to implement prevention and adaptation measures due to climate-change effects [2–4]. In this regard, it is important to start looking at the likely effects of water allocation policies on the flexibility of society in adapting to climate challenges, such as the societal viability of transfers between alternative uses and their socio-economic implications [5].

According to the European Commission [6], during the last forty years, drought episodes in the European Union have increased dramatically in both frequency and intensity. The number of areas and people affected by drought events increased by almost 20% between the years 1976 and 2006. In that same period, the economic cost of droughts recorded in Europe was estimated to stand at approximately 100 thousand million euros. Nowadays, water scarcity affects 11% of the European population and 17% of the territory of the EU [6]. These problems are expected to be even more acute in the future, since a significant part of the European basins are subject to severe water stress, especially in the countries of the Mediterranean region, which are extremely vulnerable to drought episodes [7,8]. In the specific case of southern European regions, such as Andalusia (southern Spain),

evidence shows that the population is currently facing increasing water-scarcity risks associated with climate change [9]. Traditionally, water supply for human consumption has been secured through the construction of storage and transfer infrastructures [10]. However, supply-side solutions are not unlimited, especially in semi-arid regions, where an increase in supply is not always feasible, largely due to economic and environmental constraints. Under these conditions, basins are said to be closed, where no additional resources are expected to be added [11,12]. In this context, new (or increasing) demands face an increasing risk of exposure to water shortages, and thus reallocation decisions, primarily from irrigators to urban users, may act as temporal or permanent solutions. As highlighted by Young [13], transfers from irrigated agriculture to urban uses are based on the low economic value of agricultural water uses, and therefore constitutes the default source of increased re-allocations to urban sectors. The increase in demand, due to population and income growth, will lead to much greater competition for water, especially in water-stressed regions such as Andalusia in southern Spain [14,15]. Hence, the agricultural supply of water is expected to decrease in the future, with a large increase in the number and volume of transfers from agriculture to other uses, such as urban and environmental uses [16]. This is the case in other regions of the world that suffer from chronic or temporary shortages in supply for urban uses: Taiwan [17]; south-western USA [18–20]; Aurora, Colorado, USA [21]; and the Edwards Aquifer region, Texas, USA [22].

In the case of Spain, the issue of water transfers between uses and regions has attracted previously unheard levels of public attention in Europe [23]. Nevertheless, the assessment of economic compensation for transfers between users has attracted little interest in the existing literature. This might be explained by the legal priority of households over other alternative uses in the majority of countries worldwide. In Spain, the Water Act of 1985 declared the public nature of all water resources, which were managed by public agencies organized on a river basin scale. This Act also stated that any private use would require legal authorization from the State. Additionally, this concession would be authorized for a fixed period of time and for a designated use, and would be subject to restrictions on the volume of water authorized depending on resource availability and the water stored in the reservoirs. Despite this concessional system, household consumption holds the highest priority in terms of satisfying demand needs. In this context, transfers from agricultural to urban users should not be subject to any kind of direct compensation from urban users to cover agricultural losses. This compensation is normally covered by the State through public subsidies financed by regional, national, and European public budgets. Nevertheless, these reallocation policies (as given by a priority ranking) raise equity and efficiency issues, since the benefitted users (e.g., households of a certain region or city) remain unaware of the costs associated to the inter-user transfer, such as infrastructure costs and compensation to affected users, since they are assumed by society as a whole. As described later in this study, the city of Seville has been severely affected by persistent droughts over recent decades, which has led to transfers from agricultural users as a means to guarantee urban water supply [24]. In these cases, no direct compensation from benefitted users was considered.

This paper uses a contingent valuation (CV) method to determine households' willingness to pay (WTP) a compensation to the irrigation sector to guarantee supply reliability by means of transferring water resources. The data used in this study was obtained in May 2018 through a survey covering 250 households. The purpose of this survey involved the assessment of voluntary compensation by the household sector to the agricultural irrigation sector for water transfers to guarantee the same quantity and quality supply standards during a severe water-scarcity episode. To the best of our knowledge, the approach used in this study has not been used by the existing literature, and hence we firmly believe that this constitutes the first use of CV methods to explore compensation between household and agricultural users. Additionally, the approach used in this study allows us to account for the effects of certain demographic and socio-economic variables, such as gender, age, income, and the level of education of households in the compensation valuation. In short, the objective of this paper is threefold. First, it seeks to estimate the households' mean willingness to compensate the irrigation sector for water transfers from the irrigation sector in the case of the city of Seville. Second, the study

aims to determine the effects of a set of demographic and socio-economic variables on the estimated compensation values. Third, it offers a brief discussion on the viability of transfers, and their associated compensation to the irrigation sector. We believe that knowledge regarding users' WTP to guarantee supply reliability can not only help policy-makers predict the potential of inter-user water transfers, but also design flexible adaptation policies to climate change in water-stressed regions. Therefore, this study contributes to the current literature on the assessment of WTP by urban users, as well as on inter-sectoral transfer valuation. The case of the city of Seville, the capital city of Andalusia, constitutes a perfect example of a large economically developed urban agglomeration located in one of the most water-stressed regions in the world. The results offered are therefore interesting in that they may provide useful information for decision-makers in similar regions and cities worldwide.

The structure of the paper is as follows. Section 2 offers a brief review on the related literature on the assessment of households' WTP for a guaranteed water supply and on the use of CV methods. The case study is presented in detail in Section 3. The method, sampling process, and data are all described in Section 4. Section 5 presents the results of CV estimations, and finally, a brief discussion and concluding remarks are given in Section 6.

2. Literature Review

Water is valued in the dimensions of quantity, quality, timing, and location in terms of satisfying human needs, and providing ecological services [13]. Several methodologies have been developed to assess the (economic) value of water as assigned by a certain group of users, such as urban households. CV methods, value of marginal productivities obtained by regression estimations, and methodologies based on hedonic prices, provide three examples of these widespread methodologies that are employed in the assessment of the value placed by users on the consumption of a specific resource. Specifically, CV methods are most well-known as monetary valuation techniques that assess the economic value of those commodities that are not usually market traded [25]. This is normally carried out by means of estimating the WTP of a certain group of users who are surveyed to find out how much they would be willing to pay for improvements in the quality, quantity, time, or location dimensions of water, which would affect the economic value assigned by those users.

The use of CV methods for WTP estimation in the irrigation sector is widespread in the literature [23,26–30]. The most recent studies, however, have focused on the assessment of WTP for better supply reliability, especially through the valuation of the willingness to accept interruptions in irrigation supply. Regarding the household sector, studies assessing households' WTP began in the early nineties. The studies of Howe et al. [31], Barakat and Chamberlin [32], Griffin and Mjelde [33], Koss and Khawaja [34], Raje et al. [35] and Hatton McDonald et al. [36], among others, assessed the economic value associated with greater water-supply reliability and the role played by users' preferences. Other studies, such as those by Hensher et al. [37] and Martin-Ortega et al. [38], have specifically assessed households' WTP to avoid water-supply restrictions due to the occurrence of drought episodes. Nevertheless, studies aiming to assess WTP for inter-sectoral water transfers remain scarce.

One of the first attempts to assess WTP of households to avoid supply shortfalls was that of Barakat and Chamberlin [32]. They examined a specific case-study in California with ten water utilities. Using a double-bounded CV method, a representative group of households were asked whether they would be willing to pay pre-defined amounts of money (or bids) to avoid supply shortfalls of a specified strength and frequency in the future. The study of Howe et al. [31] focused on three Colorado towns, and used CVM to measure demand for various levels of supply reliability. Based upon a survey of 450 households, the study offers an assessment of the WTP for increased reliability and willingness to accept (WTA) lower water bills for reduced reliability due to water shortages, thus offering one of the first assessments of the costs associated with drought for urban water users. Several years later, Griffin and Mjelde [33] carried out a similar study in seven Texas cities to evaluate future water-supply reliability. Similarly, the study by Koss and Khawaja [34] analyzed a sample of 3769 surveys carried out

in ten water districts in California. Through the use of a double-bounded dichotomous choice model, this study evaluated water-supply reliability by asking two alternative WTP questions for different shortage scenarios in terms of frequency and length. In the case of India, Raje et al. [35] carried out a survey on 755 households in Mumbai in order not only to quantify the satisfaction level of consumers relating to water-supply service, but also to assess the WTP in alternative supply reliability scenarios. The results showed that WTP and satisfaction level both increase as supply reliability improves. The study of Hensher et al. [37] was conducted in 2002 in the Australian city of Canberra with a total of 211 respondents interviewed. Their results indicated that households were willing to pay for incremental changes in supply reliability under extreme scarcity conditions.

In the case of southern Europe, the study of Martín-Ortega et al. [38] is worth noting, since it aims to assess the non-market value of guaranteeing water supply for households in a water-stressed area, such as the Guadalquivir River Basin in southern Spain. A total of 354 respondents were interviewed, and the majority of the sample (approximately 63%) believed that they would probably face water restrictions in the future due to increasing water scarcity and competition between users. Interestingly, 60% of the interviewed households had suffered water restrictions in the past. Results showed that the average estimated WTP for a reduction in the frequency of household water restrictions by 1 year out of the next ten would be approximately 39.50 euros per household annually. By using a similar CV method, the study of Saz-Salazar et al. [3] assesses the WTP for improvements in water-supply infrastructure and for the reduction of leakages upon a representative sample of households in the Guadalquivir river basin. On average, individuals would be willing to pay an extra charge of between 8.23 to 9.65 euros in their bi-monthly water bills.

The existing literature on assessing households' WTP shows that these users would be willing to pay an extra charge to avoid supply shortages in the case of water-scarcity episodes, which therefore suggests that inter-sectoral transfers between urban and irrigation uses would be feasible through the establishment of a compensation system. Additionally, the diversion to urban areas of water currently used by irrigated agriculture may act as an effective means of adaptation to minimize the negative effects of an increase in the frequency and length of drought periods. Despite the constraints by a range of institutional and legal limitations on water diversions between alternative users (such as a ban on water markets) [39,40], certain agreements, although extraordinary, have become feasible in the Canary Islands (Spain), where the tourist sector has purchased a significant part of growers' water rights to guarantee supply for their clients during drought periods [41].

This study aims to contribute towards the scarce literature on the assessment of the willingness to compensate sectors to guarantee water-supply reliability under extreme water-scarcity conditions (e.g., drought episode). Compensation agreements may alleviate economic losses suffered by the sector providing the water, as well as increase awareness of the economic value of water by the receiving sector. Furthermore, to the best of our knowledge, no similar analysis for the assessment of the willingness by households to compensate the irrigation sector has yet been addressed in the literature, neither in Spain nor elsewhere, although the inter-sectoral diversions (temporal or permanent) of water will probably become a common adaptation measure during drought periods, especially from the agricultural sector to other economic sectors.

3. Case Study

3.1. Spanish Context

The Spanish Water Act of 1985 declared all water resources to be public property administered by public basin agencies. Therefore, any private use requires authorization from the State for a fixed period of time and for a designated use, and is subject to restrictions on the volume of water authorized depending on the resource availability and amount of water stored in the reservoirs. Among agricultural, industrial, and urban (which includes households) uses, the latter use has the highest priority to be served in the case of severe supply restrictions, such as during drought episodes.

Water-scarcity periods are part of the normal climatic variability in the Mediterranean region, and Spain features among the most water-stressed countries in Europe [42]. It is a country with higher risk of exacerbating conflicts between users, as shown by its water exploitation index (annual water abstraction/long-term freshwater resources) of 0.29 compared to an average for the EU-28 of 0.13 [43,44]. Additionally, climate-change effects are exacerbating the intensity and length of droughts [45,46]. The National Hydrological Plan and the Water Act of enable a variety of actions to mitigate the negative impacts of extreme water scarcity during drought episodes [47]. As an example, powers are given to River Basin Authorities to modify abstraction concessions (Art. 55) and to constitute a Drought Board (Comisión de Seguía) (Art. 58) in order to study extraordinary measures to guarantee population needs, and to limit irrigation uses with the necessary guarantee of survival of tree plantations, such as olive and citrus trees.

Spain is a country where the characteristics of the Mediterranean climate are dominant in 80% of its territory. Intense periods of drought have been suffered throughout its recent history, among which are those that occurred between 1941 and 1945, between 1979 and 1983, that correspond to the period from 1991 to 1995, which was even more intense than the previous droughts, and later the period between 2004 and 2007. Traditionally, droughts have been managed exclusively as an emergency situation, considering that they represent a crisis situation, which has to be faced by mobilizing extraordinary resources, usually by way of urgency. However, droughts constitute a normal and recurring component of the climate in Spain, and as such they have to be managed within the river basin planning framework [48]. The drought of 1991–1995 and its remarkable impacts acted as triggers for this change in mentality. Its impacts were extremely significant in the Guadalquivir river basin, with hundreds of towns suffering from daily water shortages, including Seville, the fourth biggest city in Spain. The consequences of this change of mentality were already noted in the 2004–2007 drought, quite similar in intensity to that of 1991–1995, with effects on the entire territory, but especially in the most arid areas of the eastern, central, and southern regions [49].

Although the special drought plans were not approved until 2007, the 2004–2007 drought was already managed according to the principles established therein, and the negative impacts were limited compared to that produced in the previous decade [50,51]. Nevertheless, the revision of the National Hydrological Plan approved in 2001, and later revised in 2005, needs to incorporate new measures and instruments in order to adapt to increasing drought periods that affect a significant part of the Spanish territory and several river basins. At the same time, the drought plans accompanying the river basin hydrological plans (second-cycle, 2015–2021) and the design of the third-cycle plans for the period 2021–2027, should incorporate new instruments for their adaptation to drought episodes while minimizing socio-economic impacts. In this respect, inter-sectoral compensation for water transfers should be considered.

3.2. City of Seville

Seville is the capital city of Andalusia, with 0.8 million inhabitants and an urban water demand of nearly 98 cubic hectometers (Hm^3) per year. Located in the Guadalquivir RB, it is characterized by an extremely high exploitation index, around 0.85, which has been forecast to increase to 0.90 by 2030 [3]. Its climate is characterized by a large temporal variability in the level of rainfall, both intra-year (when wet winters and dry summers alternate) and year-on-year (when a series of years occurs with precipitation above or below the annual average value). In this context, droughts have been a recurring phenomenon in the city of Seville and its area of influence, and these are expected to continue with even higher intensity and durability in the future. In the case of the Guadalquivir RB, the study of Iglesias et al. [52] shows that with a horizon of 2030, simulations show a temperature increase of at least 1 °C and a reduction of 5% in mean rainfall, leading to a decrease of mean yields of 12% in the basin.

The Seville metropolitan water utility (EMASESA) manages six reservoirs with a total storage volume of 641.1 Hm^3, a regulation volume of 187 Hm^3, and a total area of 2287 square kilometers

(Km^2) of the receiving basins [53]. This public company serves water to the city of Seville and to another 11 towns in the Seville metropolitan area, where a total of 1.1 million inhabitants reside (689,400 inhabitants in the city). Seville's metropolitan area was traumatized by the impact of the 1992–1995 drought, which resulted in supply shortfalls of up to 12 hours a day and a serious deterioration in the quality of the water supplied. In that period, the situation of the water supply became so alarming that, in the middle of 1995, the Civil Protection Services put on the table the possibility of a partial evacuation of the city before the impossibility of guaranteeing the essential basic supply of the population, even with a desalination plant that would have to be installed in the Guadalquivir estuary as an emergency solution [24]. During this drought period, EMASESA declared that, although the National Water Act grants priority to urban uses, legal, political, and administrative factors could not prevent agricultural users from still using water resources [54]. However, the drought of 1992–1995 was not the first that the city had to suffer in recent decades. By going back to the previous decades, the periods 1974–1976 and 1981–1983 were characterized by persistent and dramatic droughts, during which the population also suffered constant shortages in supply. Table 1 shows the origin of water resources used during these more recent drought periods. As shown, transfers from agricultural users were used during the 1974–1976 and 1992–1995 periods as a means to provide water for urban uses in the city of Seville, and represented 5.5% of total resources. Nevertheless, this was insufficient to avoid supply shortfalls. These transferred resources came from El Pintado reservoir (with a storage capacity of 213 Hm^3), which served urban and irrigation users. These irrigators are organized in an irrigation district called "Zona Regable del Viar", which represents 1924 irrigators and 12,000 irrigated hectares. Negotiations between EMASESA and the irrigation district took place during the three drought periods, and agreements were reached for only two of these periods (Table 1). Agreed compensation amounted to: 21 million pesetas in 1974 (4.2 pesetas per cubic meter (m^3)), and an equivalent of 1.9 million euros in 2019; and 231 million pesetas in 1994 (7.7 pesetas/m^3), an equivalent of 2.5 million euros in 2019; plus the payment to the Guadalquivir basin authority for all exploitation costs during the use of these transfers. These compensations were assumed by the public water utility company, which receives financial support from public budgets of the municipalities and central government.

Table 1. Origin of water resources used during drought periods in the city of Seville.

	1974–1976		1981–1983		1992–1995	
	Hm^3	%	Hm^3	%	Hm^3	%
Water utility reservoirs	231.0	83.0	193	71.7	232.5	42.4
Transfers from other reservoirs:	47.0	17.0	52.5	19.5	81.5	14.9
From irrigation uses	5	1.8	-	-	30	5.5
Direct withdrawals from river	-	-	22.0	8.2	229.0	41.8
Groundwater withdrawals	-	-	1.8	0.6	5	0.9
Total	278.0	100	269.3	100	548.0	100

Source: Author's own based on EMASESA [54].

During the recent periods of 2004–2007 and 2014–2017, the Guadalquivir river basin and the city of Seville have suffered significant scarcity episodes, which triggered a 50% reduction of irrigation withdrawals and led to the Guadalquivir basin authority to consider applying to the Ministry counsel for a Drought Emergency Decree (Decreto de Sequía) in order to implement emergency measures, such as water transfers and greater restrictions on irrigation. Fortunately, these drought episodes were insufficiently long for there to be the need for the implementation of extraordinary measures, although they did constitute the ultimate proof for the need to analyze the viability of transfers between users and the willingness to compensate the party providing said transfer. This study aims to contribute to the empirical evidence in this field of research through the assessment of the WTP of Seville households for water transfers from the agricultural sector under severe scarcity conditions. This measure may act as

an effective, equitable, and efficient measure for the adaption to drought periods while simultaneously minimizing economic losses in the irrigation sector.

4. Method and Materials

4.1. Method

CV methods are classified as stated preference techniques and constitute a direct method for the evaluation of non-marketable goods and services, thereby eliciting individuals' WTP for a specific change in those goods or services (e.g., reduction of water availability due to a supply shortfall) [34]. Alternatively, indirect methods, such as the travel cost method and hedonic pricing, focus on the observed consumption behavior of individuals of marketed goods and services in order to assess the non-market one of interest. Direct methods, such as CV and choice modelling, attempt to elicit information about the value of the non-market goods or services directly from the individual. These CV methods imply the use of surveys on a representative sample of the studied population, who are asked for their WTP a certain amount of money to avoid an undesirable change in a non-market service, such as an improvement in the reliability of water services [26]. Additionally, elicited WTP values are contingent upon the respondents' knowledge and the information provided during the survey [55]. The initial studies during the 1990s generally asked respondents to state their exact maximum WTP as an open-ended question, although this can provoke an unreliable answer or even discourage any response, as participants lack information regarding the true value of the service under study [56,57]. Alternatively, researchers started to use dichotomous choice approaches, which present certain advantages. The basic approach asks the respondent whether he/she would be willing to pay a specific amount of money, with two possible answers: Yes or no. This approach, also known as "single-bounded" approach, needs great samples of respondents to achieve a significant WTP estimation. In order to avoid this problem, Hanemann, Loomis, and Kanninen [58] demonstrated that a double-bounded dichotomous choice approach, where a second follow-up question (with an alternative amount) is offered, is asymptotically more efficient, and hence smaller samples can give accurate WTP estimations. In this study, a 'double-bounded' dichotomous CV survey method is employed. Double-bounded CV methods have been extensively reviewed in the recent literature as a reliable method for the assessment of households' WTP for improvements in water-supply reliability under scarcity and climate-change conditions [59–61].

Our respondents had to answer two related questions that offered two different amounts of money or bids. If the individual answers "yes" to the first question, then he/she is asked about his/her WTP a higher bid. If the answer is "no" to the first question, then a lower bid is offered. This implies that the second question depends on the answer obtained in the first question, and much more information is obtained from the individual than with the single-bounded approach, thus implying a more complex econometric analysis. Recent studies, such as those by Lopez-Feldman [62], Mesa-Jurado et al. [26], Islam et al. [61], and Makwinja et al. [63] have used this method in various contexts but with similar research purposes.

Subsequently, the model used in this study is briefly described. As an example, the probability that an individual answers "yes" (y) to the first equation and "no" (n) to the second can be expressed as $P(y,n)$, under the assumption that $WTP(z_i, u_i) = z_i'\beta + u_i$ where ui follows a normal distribution $N(0, \sigma)$:

$$P(y,n) = P\left(t^1 \leq WTP < t^2\right) = \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right), \tag{1}$$

Similarly, the probabilities of the remaining possible answers to the two-bid questions can be expressed as follows:

$$P(y,y) = P\left(WTP > t^1, WTP \geq t^2\right) = \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right), \tag{2}$$

$$P(n, y) = P\left(t^2 \leq WTP < t^1\right) = \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right), \tag{3}$$

$$P(n, n) = P\left(WTP < t^1, WTP < t^2\right) = 1 - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right), \tag{4}$$

Consequently, the likelihood function can be estimated in order to obtain estimates for β and σ parameters through maximum likelihood estimation:

$$
\begin{aligned}
\sum_{i=1}^{N} \Big[& d_i^{yn} \ln\left[\left(z_i'\tfrac{\beta}{\sigma} - \tfrac{t^1}{\sigma}\right) - \phi\left(z_i'\tfrac{\beta}{\sigma} - \tfrac{t^2}{\sigma}\right)\right] + d_i^{yy} \ln\left[\left(z_i'\tfrac{\beta}{\sigma} - \tfrac{t^2}{\sigma}\right)\right] \\
& + d_i^{ny} \ln\left[\phi\left(z_i'\tfrac{\beta}{\sigma} - \tfrac{t^2}{\sigma}\right) - \phi\left(z_i'\tfrac{\beta}{\sigma} - \tfrac{t^1}{\sigma}\right)\right] \\
& + d_i^{nn} \ln\left[1 - \phi\left(z_i'\tfrac{\beta}{\sigma} - \tfrac{t^2}{\sigma}\right)\right] \Big],
\end{aligned}
\tag{5}
$$

where d_i^{yn}, d_i^{yy}, d_i^{ny}, d_i^{nn} are variables that take the value 1 or 0 depending on the answers given by each individual. Therefore, each individual contributes to the logarithm of the likelihood function in only one of its four parts. Once the function is attained, then estimates of β and σ can be obtained and WTP can be estimated.

4.2. Sampling Process and Survey Design

In our specific case, the sampling process began with a focus group discussion with representatives of EMASESA to define the type of questions to be asked and the stratification of the sample by city district, age, and gender. A sample of 300 households was obtained from this stratification process, in the line with the sample size of other studies using the double-bounded approach [29,30,37,38,64]. In order to determine the interval of bids to be offered in our WTP assessment, a pilot survey was carried out face-to-face with 20 clients. The bid price values were then set as 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, and 5 euros. This pilot survey also served to validate the designed questionnaire, including three types of questions: i) Household demographic and socio-economic characterization (age, gender, education level, and household income); ii) respondents' perception on water-supply shortfalls (previous experience and probability of future shortfalls) and tap-water quality; and iii) questions regarding WTP in order to elicit respondents' values for compensation: Two bids offered and an open-ended follow-up question. The initial bid price offered is randomly assigned to the respondents, thus guaranteeing that all possible values from 0.5 to 5 euros are equally offered. After the initial bid, the second bid price offered is higher or lower depending on the answer obtained to the first bid, as explained in previous sub-section. Similar groups of questions are used in previous recent studies, such as Martín-Ortega et al. [38], Makwinja et al. [63], Jian et al. [65], and Asibey et al. [66], among others.

Upon our initial stratified sample of 300 households, 250 valid surveys were obtained on a door-to-door basis by a market research firm in May 2018 (response rate of 83%). For the elicitation exercise, we adapted a double-bounded approach with two bids (compensation values to be paid monthly on the water services bill) offered, followed by an open-ended follow-up question about the maximum compensation that the respondent would be willing to pay. If the respondent was (was not) willing to pay the first bid offered, a higher (lower) second bid was offered. This semi-open-ended format enjoys the advantages of the open-ended formats, since it minimizes the problem of starting-point bias at the same time as when higher certainty on the compensation that respondents are willing to pay is achieved [67,68]. Additionally, the double-bounded approach used with an open-ended follow-up question allowed us to identify inconsistent answers. Specifically, an inconsistent response occurs when the respondent agrees to pay for a randomly-assigned bid price (in the first and/or second question), but states a lower maximum compensation in the open-ended question (e.g., the respondent accepted to pay 2 euros in the first bid offered and 3 euros in the second bid offered, but declared a maximum compensation of 1 euro in the follow-up open-ended question).

Regarding zero WTP responses, and as highlighted by Jorgensen and Syme [69], these should be explained to identify protest answers, such as those triggered for political reasons. In our study, protest zero responses correspond to those individuals who attached zero value due to the fact that they considered that they had already paid a sufficient amount and/or that the administration should be solely responsible for said compensation. These responses were confirmed by the interviewer through debriefing with the respondent. Specifically, less than 5% of the responses were classified as protests and were excluded from our WTP analysis, as shown by common practice in the literature [36,38].

Following the procedure suggested by Poe and Vossler [70], in order to maximize the implication of respondents, the introduction of the interview emphasized the importance of the research study for information regarding water policy in the city. Additionally, the sample frame was designed to ensure that a fair number of respondents had experienced supply shortfalls during drought periods (28% of our sample, as shown in Table 2) [33,36]. As noted by Griffin and Mjelde [33], experienced respondents may attach lower values, since the learning of coping strategies to face the inconvenient experience may reduce the assigned value. On the other hand, unexperienced respondents may overestimate the value assigned to an unknown and non-desired event. Therefore, the suitable combination of both types of respondents, together with a well-designed survey providing complete information to the respondent, significantly increases the accuracy of the elicitation. To this end, before being interviewed, respondents were presented with detailed information about the average water bill for households in the city of Seville, which amounts to 394 euros/year in 2018 [71]. Respondents were also informed about the past drought episodes suffered in the city and the compensated transfers from irrigation uses occurring during those periods. With this presentation, the goal was to provide sufficient information to ensure that every respondent had identical information while answering WTP questions. The payment vehicle proposed was an increase in the water bill currently paid by each household [38], and therefore free-rider behavior typical of voluntary payments is minimized in a context of an existing marketable transaction [59]. Additionally, questions regarding demographic and socio-economic perceptions of interviewed households helped us to interpret and validate our WTP estimates.

Table 2. Variable description and basic statistics (mean and standard deviation).

Variable	Description	Mean	St. dev.
Choice 1	Value 1 if respondent is willing to pay the proposed first bid price, otherwise 0	0.57	0.49
Bid 1	First bid price offered (Euros/month)	2.56	1.32
Choice 2	Value 1 if respondent is willing to pay the proposed second bid price, otherwise 0	0.45	0.49
Bid 2	Second bid price offered (Euros/month)	2.50	1.30
Age	Value 1 (18–25 years old); 2 (25–35); 3 (35–45); 4 (45–55); 5 (55–65); 6 (65–75); 7 (75+)	3.52	1.41
Gender	Value 1 if male); 0 if female)	0.50	0.50
Education	Value 0 (illiterate); 1 (primary studies); 2 (mandatory secondary studies); 3 (further secondary studies); 4 (university)	3.85	1.21
Income	Average per capita income of the household: Value 1 (<600 euros/month); 2 (600–1000); 3 (1000–1500); 4 (1500–2000); 5 (2000–2500); 6 (>2500)	3.80	1.51
Q1	Value 1 if the respondent has experienced supply shortfalls in the past, otherwise 0	0.28	0.45
Q2	Value 1 if the respondent believes that supply shortfalls would occur with a high probability in the near future due to climate-change factors, otherwise 0	0.49	0.50
Q3	Value 1 if the respondent believes that tap water quality is not as good as bottled water, otherwise 0	0.29	0.45

5. Results

5.1. Descriptive Results

The descriptive statistics provided in Table 2 offer basic information on the responses to our survey. Regarding the main demographic and socio-economic characteristics of respondents, the selected sample fairly represents the population of the Seville city, as it shares main characteristics with the census profile of Seville city in terms of gender, age, educational level, and household average income [72]. Specifically, our analyzed sample has the same mean household size (2.8 people per household), a gender balance has been maintained in the sample, and the average respondent is between age groups 3 and 4, that is, between 35 and 55 years old. The average respondent has secondary or university studies and an average per capita income of the household between 1000 and 1500 euros per month.

Regarding the WTP questions, approximately 56% of respondents declare that they will be willing to pay to avoid supply shortfalls through water transfers from irrigation users in their water bills at the first choice, with an average bid price offered of 2.56 euros/month. In the case of the second choice, around 45% of respondents accept the second bid price offered (2.50 euros/month in average terms). Regarding the respondent perceptions measured by questions 1 to 3, 28% declare that they remember having had experienced supply shortfalls in the past due to extreme water-scarcity conditions, while 49% consider that this situation might probably occur in the near future due to the climate-change phenomenon. In order to measure the satisfaction of the respondent with the water service provided in terms of quality, question 3 shows that only 29% of respondents consider that bottled water is of better quality than that of potable tap water. Consequently, most respondents seem to be satisfied with the provision service in the city and indicate that households would be willing to pay for higher supply reliability under water-scarcity conditions instead of substituting the water source (e.g., bottled water).

Distribution of the answers to both choice questions show that 101 (41%) respondents accepted both bid prices, while 53 (21%) refused one of the two bids offered. However, 96 (38% of the sample) respondents reported that they were unwilling to compensate because they could not afford to pay any extra amount. These responses have been considered legitimate zeros and have been included in our analysis. Conversely, those negative responses based on political arguments or on the fact that the Administration should assume the compensation, have been considered protest responses and they have not been taken into account in our analysis. In order to further examine the validity of the obtained responses, the distribution of affirmative responses for each bid offered requires analysis [3]. The response distribution should show a monotonically decreasing percentage of affirmative answers as the amount proposed increases, since the probability of accepting it would increase. This behavior in the responses given by our respondents can be easily observed in Table 3, and suggests that our respondents have answered to our WTP questions rationally, thereby confirming the consistency of the information gathered.

Table 3. Distribution of bids (euros/month) and affirmative answers to WTP questions (%).

Bid	1st WTP Question	2nd WTP Question
0.5	79.8	63.1
1	68.7	58.1
1.5	64.5	47.2
2	64.5	57.5
2.5	61.5	36.7
3	50	44
3.5	48	40.9
4	45.4	31.8
4.5	40	30
5	0	25

5.2. Model Results

Table 4 shows the estimated results of the double-bounded dichotomous choice model used in our study. In order to attain various WTP estimates and to test the statistical robustness of the findings, several models have been adjusted. These models present results in a step-by-step manner. The simplest model (Model 1) is constructed upon the answers given to the two bids offered and without considering any other determinants (e.g., socio-economic variables and perception factors). In this specific case, we assume that the elicited WTP is not affected by these other explanatory variables and thus, the B-estimate can be interpreted as the estimated average WTP. Subsequently, Model 2 incorporates households' demographic and socio-economic factors, since age, gender, income, and level of education have shown to be significant explanatory factors in the literature [29,65,66,73]. The inclusion of additional explanatory variables that may influence the WTP estimate leads to a second step in our analysis, since it enables the role played by these additional factors determining the estimated average WTP to be examined. Perceptions on water scarcity and supply might also play a significant role in explaining WTP among our sample of households [66,73]. Therefore, Model 3 takes into account perception questions (Q1, Q2, and Q3), together with demographic and socio-economic factors. These perception questions are described in Table 2, together with the rest of variables considered in our analysis. Finally, and with the aim to assess the robustness of the results, only those significant factors detected in Models 2 and 3 have been considered in Model 4: Age, and questions Q1 and Q2. For each model, coefficient estimates and standard errors (SE) are offered.

Table 4. Alternative CV model specifications.

	Model 1		Model 2		Model 3		Model 4	
Variable	**Coeff.**	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
Beta	2.539 [a]	0.171						
Age			−0.629 [a]	0.136	−0.415 [a]	0.150	−0.379 [a]	0.133
Gender			0.095	0.332	0.262	0.339		
Education			−0.089	0.169	−0.154	0.170		
Income			0.113	0.130	0.196	0.132		
Q1					1.596 [a]	0.451	1.519 [a]	0.451
Q2					0.934 [a]	0.353	0.940 [a]	0.356
Q3					0.110	0.373		
Wald Chi-square	-		23.00 [a]		38.88 [a]		36.50 [a]	
Log-likelihood	−282.283		−269.018		−255.310		−256.706	

[a] Significant at the 1% level.

As shown by the results obtained by Models 2, 3, and 4, the respondent's age together with questions 1 and 2 were found to play a significant role in the choices made by the respondents. The older the respondent is, the lower the probability to be willing to pay compensation becomes, which could be explained by the higher sensitivity among younger people regarding the consequences derived from climate change in terms of water scarcity in a context of increasing awareness of the global environmental impact of human activity. Regarding answers to question 1, respondents who have experienced supply shortfalls in the past are more willing to pay for water transfers from the agricultural sector. Similarly, respondents who think that these events may occur in the near future are more willing to accept the bid price offered. The role played by perception questions (Q1 and Q2) to explain increases in the average WTP estimates can be clearly seen in Table 5 (Models 3 and 4). The WTP estimate by model 1 amounts to 2.539 euros per monthly bill, which means that, on average, respondents will be willing to pay (compensate) the irrigation sector for water transfers to guarantee water supply under extreme water-scarcity conditions. The remaining models show slightly different WTP estimates, whereby it is interesting how this estimate increases to 2.585 euros when perception

questions are considered (Model 3), and to 2.597 euros when only significant factors (i.e., householder's age and questions Q1 and Q2) are included (Model 4).

Table 5. WTP estimates for alternative CV model specifications (euros/month).

Model	WTP	SE
1	2.539 [a]	0.171
2	2.535 [a]	0.165
3	2.585 [a]	0.166
4	2.597 [a]	0.168

[a] Significant at 1% level.

Wald Chi-square statistics and log likelihoods of the estimated models show that used explanatory variables are adequate to explain WTP estimates and elicited coefficients are not equal to zero (Table 4). Additionally, WTP estimates are statistically significant at 1% of significance level (Table 5). Regardless of the potential limitations related to using or omitting a household's characteristics and perception questions in the estimated models, WTP estimates from the various models are very similar (Table 5). Standard errors (SE) are also shown. Additionally, as noted by Whittington and Pagiola [74], the results obtained from the open-ended maximum WTP question have not been used, as this approach tends to offer an underestimated value. In fact, the maximum WTP declared by each household gives an amount of 2.521 euros, significantly below all WTP estimates shown in Table 5.

The magnitude of WTP estimates are now examined by comparing these measures with the average household water bill in the city of Seville of 394 euros per year in 2018 (2.13 euros/m^3). The WTP estimate of 2.535 euros/month may imply an increase of 7.7% (30.42 euros/year), amounting to an increase of 7.9% in the case of a WTP estimate around 2.597 euros/month.

6. Brief Discussion and Concluding Remarks

The current over-allocation of resources in semi-arid regions (e.g., southern Spain) is based on an allocation of rights that responds to a historical trajectory and seldom coincides with the current priorities of society [75]. These new priorities contemplate a growing demand for urban and industrial uses and also for ecosystem services (i.e., ecological flows), in contrast with customary allocation, where agriculture had traditionally become the main user (e.g., representing 85% of total water use in the southern and south-eastern Spanish basins) [76]. Several international organizations have raised awareness regarding the need to introduce mechanisms that enable a better allocation of water resources, largely by means of reducing agricultural uses in order to allocate these resources to meet environmental uses or other uses of greater economic value [7,75,77]. The Green Paper on Water Governance indicates that, in the case of Spain, the conflicts between economic sectors are expected to increase in the future as both water scarcity and water demand increase, thereby triggering the urgent need for a more flexible allocation of rights [51]. This higher flexibility would better suit both the long-term demands of society and the short-term episodes (drought episodes) and structural (due to increased demand and reduced supply) water scarcity. In this context, the possibility of water transfers between users and the implementation of water markets to enable economic compensation could play a significant role in improving the efficiency of water management [14]. The review of the reports of the aforementioned international organizations indicates that there are technical (e.g., improvement of efficiency in the use of the resource), institutional (e.g., reforms of concessional and administrative rights), and economic (e.g., water markets) solutions that allow either the temporary reallocation (e.g., transfers) or the definitive re-allocation of concession rights. This study has shown that temporary reallocation of water concession rights from irrigation to domestic users would be an effective reallocation instrument, since households would be willing to pay compensation for the water transferred in their water bill.

Basic calculations show that the city of Seville (without taking into account its metropolitan area) with its 275,773 households (2.5 people per household) could afford to pay 8.6 million euros per year to compensate the agricultural sector for water transfer under extreme water-scarcity conditions. Following Expósito and Berbel [76], the apparent productivity of water in the irrigation sector in the Guadalquivir river basin (where the city of Seville is located) amounted to 0.60 euros/m^3 in 2012 (latest estimation). This means that irrigators obtain an additional value of 0.60 euros per unit of water used (m^3) compared to rain-fed agriculture. Based on this estimation, and considering that no increases of apparent productivity of water are expected in the Guadalquivir basin in subsequent years [12], a basic calculation shows that the city of Seville could afford compensation for 14.3 Hm^3 transferred from irrigation uses. This represents 14.6% of the total 98 Hm^3 that the city needs under normal conditions [50]. This transferred amount of water would be similar to those made during the drought period 1992–1995, where 14% of total water resources were obtained from transfers, which demonstrates the initial viability of the compensation measure. Moreover, any price increase due to the introduction of this compensation factor would also help to control urban water demand. Currently, the average price paid in the city of Seville amounts to 2.13 euros/m^3, which lies below the Spanish average price.

These results are significant, since the increasing water scarcity and rainfall variability in southern Mediterranean Europe will probably lead to an increase in the number and volume of transfers of water resources from agriculture to other uses in the near future. This entails increased efforts in the assessment of the value of water in a number of different uses and the need for integrated re-allocation measures in basin-wide management plans [77]. In this respect, water transfer programs between alternative uses should be integrated into an overall water resource management regime to adapt and mitigate water-scarcity effects on society as whole [78]. In 2007, the European Union approved the communication called "Facing the challenge of water scarcity and drought in the European Union", which sought to respond to the call for action against water scarcity and drought carried out by the Union Environment Council in June 2006 [79]. In that communication, a first set of actions were outlined that should be put in place in order to increase efficiency and savings under extreme water-scarcity conditions (e.g., drought periods). These actions included: The need to recover all costs associated to water services through price management in order to effectively manage water demand; the promotion of water markets to re-allocate resources efficiently; the improvement of drought-risk management, and the consideration of additional water-supply infrastructures to allow water transfers whenever necessary. Since this approval, the implementation of these strategies in the different demarcations of the EU has been monitored through the evaluation of the first-cycle hydrological plans [80]. This has led to the completion, in 2012, of a report on the review of policies to combat water scarcity and drought, which forms part of the "Plan to safeguard Europe's water resources", otherwise known as Blueprint, and adopted by the European Commission [81]. However, no significant advances have yet been achieved.

Among economic instruments, water pricing has been seen in the water management literature as a key instrument for the regulation of water use, the induction of water conservation, and the promotion of efficient use. Mansur and Olmstead [82] examine the welfare implications of urban water rationing in response to drought in the US. These authors think that a price-based approach to drought policy has a theoretical welfare advantage over water rationing. Nevertheless, its limited impacts in terms of reducing demand and resource reallocation have attracted much discussion in recent years, especially in the case of urban and agricultural uses [83]. Conversely, the literature on water markets and banks has highlighted the benefits of establishing the possibility of trading water rights, thereby allowing effective water transfers between users [40]. In fact, water markets are expected to gain relevance as management instruments in the promotion of: Allocative efficiency (i.e., the optimal use of inputs in production processes); scale efficiency (the optimal level of outputs that require water as an input); and dynamic efficiency (the optimal investment decisions over time in terms of water use). Under these instruments, the diversion to urban areas of water currently

used for irrigated agriculture would become feasible [84]. Water markets introduce the possibility that water rights may be purchased from irrigators and employed to increase the supply of water for alternative uses, including those of environmental concerns. Water markets have been shown to increase allocation efficiency in water-stressed regions in Spain [85]. Furthermore, George et al. [86] highlights that re-allocation of water from agriculture to domestic uses might exert a major positive economic impact on the urban sector, thus improving use efficiency of water resources.

In summary, this study has offered a preliminary analysis of the viability of water transfer compensation paid by households to the irrigation sector under extreme scarcity conditions, such as during a drought period, in the case of the city of Seville. Our estimations show that the average WTP would stand between 2.53 and 2.59 euros (on a monthly basis), which represents a viable annual water transfer of 14.3 Hm^3 from the irrigation sector, and would be compensated accordingly. These results seem plausible if they are compared with those obtained in other studies carried out in southern Spain. In this respect, Martín-Ortega et al. [38] estimated an average WTP of 39.53 euros/year per household for a reduction in the frequency of household water restrictions by one year out of the next ten, and Saz-Salazar et al. [3] offered an average WTP of urban households for the improvement of water-supply infrastructure between 8.23 and 9.65 euros in their bi-monthly water service bill.

Findings presented in this study lead to an interesting policy discussion regarding the feasibility of compensation mechanism to facilitate inter-sectoral water transfers. In the case of southern EU regions, such as Andalusia, as well as in other areas of the world, facing similar water shortage problems, higher guarantee of water supply could be achieved by establishing an extra charge on the water bill for urban consumers in order to compensate irrigation users. These compensation mechanisms would also minimize social conflicts. Therefore, this study has shown that inter-sectoral water transfers should be considered a viable adaptation measure to successfully manage water-scarcity consequences in urban areas. The results of this study can help River Basin Authorities, water utilities, and public administrations to design drought contingency plans that incorporate innovative reallocation instruments, such as inter-sectoral water transfers and compensation mechanisms. Nevertheless, alternative adaptation measures, such as demand control and awareness campaigns, should be promoted among all users, especially in those river basins with increasing social conflicts derived from water scarcity, as is the case of the Guadalquivir river basin in southern Spain. Finally, further research based on other locations and with greater samples of respondents is still needed in order to investigate the economic viability of water transfers between alternative uses, especially in those regions of the world with increasing conflicts derived from water scarcity.

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