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RESEARCH ARTICLE

Farmers' willingness to pay for irrigation water: Empirical study of public irrigated area in a context of groundwater depletion

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ABSTRACT

There was strong support for irrigation water pricing as an indicator of water shortage and opportunity cost in conceiving the development. The purpose of the paper is to assess the willingness to pay (WTP) for irrigation supply improvements and to investigate factors that affect it. Data was collected among 90 farmers in the North of Tunisia interviewed face to face. Contingent valuation technique was adopted. A qualitative dependent variable model (logit) was used. Empirical results showed that water users might accept moderate increase of water prices in order to get better water supply service. The average WTP was of 245 millimes (0.08 US$). Comparing to actual practiced price of 150 millimes/m^3 the farmers accept to pay on average 63.3% more than the price currently paid. The willingness to pay is strongly affectedby agricultural training and education level of farmers. It is proved too that corruption and free riding behaviour reduce significantly the farmers' willingness to pay for groundwater.

Keywords: Contingent analysis; Demand; Irrigation; Logit regression; Water user association.

INTRODUCTION

Water pricing mechanisms is a high priority among the numerous instruments for efficient water management (Bjornlund and McKay, 1998; Mahdhi et al., 2011; Aydogdu, 2016; Kaya and BostanBudak, 2019; Tesfai, 2019). Because irrigation is fundamental for agriculture in arid and semi-arid North Africa, improving irrigation management is fundamental to ensure sustainable use of resources in these areas. Irrigation water is turning into an increasingly rare resource for agriculture in Tunisia and in lots of areas of the world (Abdelhafidh and Bachta, 2016; Ben Nasr and Bachta, 2018; Zema et al., 2018; Mahdhi et al., 2019). Tunisia is one of the countries most faced to water stress in the world and in the Mediterranean basin (Elloumi, 2016, Mahdhi et al 2021). The average annual water availability is 450 m^3 per capita and this average would drop to 350 m^3/capita by 2050 (Abdelhafidh and Bachta, 2016), which is well below the World Bank scarcity threshold (Drouiche et al., 2012). It falls on Tunisia on average 36 billion m^3/year of rainwater. However, the surface water mobilized in lakes, dams, and aquifers total only about 4.8 billion m^3/year of which 2.7 billion m^3 comes from annual rivers in the north, 0.7 billion m^3 from groundwater in the center, plains, and coastal areas, and about 1.4 billion m^3 from the deep groundwater mainly in the south (MA-Ministry of Agriculture and Water Resources, 2016). Water resources are unevenly allocated across the country, with around 60% in the north (MA, 2016). Irrigation is essential for agricultural production. It accounts for approximately 8% of the gross domestic product, and is the largest consumer of water, and irrigation accounts for some 85% of water withdrawals from 212 shallow aquifers (containing 719 millions m^3) and 267 deep aquifers. In 2016, about 460 thousand hectares are irrigated in Tunisia (MA, 2016). The government has traditionally supported the development of both existing and new public irrigated areas. 56% of irrigated areas are located in Irrigated Public Perimeters (IPP), corresponding to an area of nearly 230,000 ha. Over the past decades, the major political and institutional changes consisting of liberalizing the Tunisian economy, boosting and privatizing the rural sector in a context of State withdrawal (Canesse, 2009; Stefano et al., 2018) have directly affected the IPPs. In this perspective, the Ministry of Agriculture has launched an action program to disengage from the direct management

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of IPPs for the benefit of user associations, under the successive statutes of Collective Interest Association (AIC), Collective Interest Groups (GIC), and today of Agricultural Development Groups (GDA) (Mouri and Marlet, 2007). Management delegation to water users and their representatives, however, comes up against various problems, including the lack of user engagement and recognition of new forms of governance. This lack of commitment manifests itself mainly in the low willingness of irrigators to pay the fees for agricultural water. Adopting an adequate irrigation water pricing policy for the regulation of consumption is the main means used by the majority of countries. Setting a "fair" price is seen as a desirable way to allocate water efficiently. The adoption of one or more pricing methods remains dependent on the physical, social, institutional frameworks and policies of each country (Chebil et al., 2007). In Tunisia, irrigation water bills have been for a long time very weak and disconnected from reality costs (Chebil et al., 2007; Abdelhafidh and Bachta, 2017; Abdelhafidh et al., 2021). The low tariffs for irrigation water have not encouraged users to consider the water resource as a scarce commodity like the other factors of production. This has resulted in wastage of water resources as well as large subsidies that strain the state budget. To deal with this situation, the Tunisian government aims in the short term to recover the variable costs of maintenance and operation of the hydraulic infrastructure and, in the longer term, to cover the fixed costs of investments made in this area. Farmers began to complain against these measures by showing their dissatisfaction with the new tariffs, considered too high with the services provided.

In such a situation, it is important to know the water productivity of the farmers for the success of any tariff reform (Abdelhafidh and Bachta, 2016). It is admitted that there is a lack of transparency in the cost structure of water produced and delivered by the State alongside a lack of information on the marginal productivity of water at the level of irrigating farmers. Alternatively, water policies should focus more on minimizing risks and increasing water use efficiency by using well-designed, flexible, and equitable water allocation mechanisms and economic instruments, such as water pricing (Bandara, 2005 Tesfai et al., 2019; Abdelhafidh et al., 2021; Kaya, 2021). Applying true water pricing is thus essential to maintain the infrastructures of public irrigated areas of Tunisia and ensure more efficient water use. Hence, the purpose of this study is to analyze whether farmers in the Nadhour irrigated area in Northern Tunisia are willing to pay an increased water tariff for the ground water they receive and to identify factors that may shape their willingness to pay (WTP) for water. The contribution of this study is essentially empirical. First, it estimated farmers' WTP for water in a developing country where this issue has received little attention. Second, it identified factors related to water management that directly affect the WTP for groundwater.

Policy maker is interested in how much farmers would be willing to pay for irrigation water if an irrigated perimeter project is implemented. These approximations could assist the authorities assessing the sustainability of such an investment (Svendsen, 1993; Abdelhafidh and Bachta, 2017). According to Ward and Michelson (2002) measuring the value of water in opportunity makes use of is needed for rational choices assisting water useful resource management. "Water pricing in should reflect the benefits forgone in the future from using a unit of water" (Pearce and Warford, 1993). These circumstances warrant the use of CVM to estimate the irrigation water value (Gunatilake, et.al. 2007). CVM uses survey techniques to elicit WTP of non-advertised commodities. Respondents express their WTP on a 'described' hypothetical situation, as in this study the supply of ground water for irrigation. The socially optimal rule for water use can be assessed, on one hand, by comparing farmer's WTP and the opportunity cost of water (Ester, 1993; Howe and Dixon, 1993), on the other hand and with regard of revenue collection, irrigation water charges are highly depending on farmer's WTP. Chandrasekeran et al. (2009) indicated that farmers were willing to pay much more than the average operating and maintenance costs supported by the state on tanks and were also willing to pay almost as much or less than the marginal value product of water. Chebil et al (2007) have estimated the WTP of market gardeners in the Teboulba region (Tunisia) to pay for irrigation water and analysed its determinants. A logit and probit models were used. Their results showed that the latter is statistically insensitive to the chosen specification, whether of the probit or logit model. They also showed that farmers are disposed to accept a slight price increase of water to benefit from improved water supply service. Azahara et al., (2012) and Tang et al. (2013) used VCM to estimate WTP for regular irrigation water supply in scarcity context in Spain and China respectively. Respondents with higher productivity were accepting to pay more for the water supply improvement. Tang et al., (2013) have found that households' WTP for irrigation is positively and highly linked to income. Likewise for Azzi et al (2018) who indicated that average increasing surface water charges has also the advantage of reducing government support. Rodrigues et al (2021) showed that farmers' WTP was positively affected by yields and products prices. Pricing water is important not only for generating revenues but also for promoting efficient use of water resource (Maskey, 1994; chebil et al 2007). Farmers' perception about irrigation water availability assumes to be important for their WTP. Biswas and Venkatachalam (2015) find that farmers are disposed to pay much higher than what they are actually paying to secure these profits.

MATERIAL AND METHODS

The contingent valuation

The consumers' WTP is turning into an increasingly popular and is one of the standard instruments used to value goods or services for which no market-based pricing mechanism exists. There are mainly two approaches for analyzing the consumers' WTP. The direct method additionally called Contingent Valuation Method (CVM). It is to directly ask respondents to state their exact maximum WTP for the particular use or non-use value of the water. CVM finds its conceptual basis at the level of the theory of well-being, based essentially on the following assumption: two indicators can assess the behavior of a rational economic agent following a possible change in his economic environment:

- His willingness to pay for welfare gain (WTP)
- Its disposition or consent to accept (CTA).

The main techniques used to solicit the value of a WTP, possibly a CTA, are in three numbers:

- Open question technique. This technique consists of asking the interviewer to directly locate their WTP (or CTA).
- Technique of the bidding game: It is a question of proposing the first auction and it is up to the interviewee to negotiate this price.
- Dichotomous choice technique: This method consists of offering the interviewee a series of prices while asking them whether or not they accept this price.

The empirical literature does not provide a consensus on the elicitation format of WTP. Hanemann (1994) asserts that the format dichotomous can eliminate certain biases that appear in the open format. It offers a logistic structure for the estimation of the WTP function. He established how to measure willingness to pay for a good based on information from discrete responses to a simple dichotomous question of whether or not to accept the proposed payment amount. Based on the theory of maximization of random utility, Hanemann's model (1994) measures well-being, by the mean or the median, from dichotomous choice data according to the following expression:

$$WTP_i = f\left(P_i\right) + \varepsilon_i \quad (1)$$

Where WTP is the dichotomous variable which takes the value1 if the i^{th} individual shows his willingness to pay the price P, and the value 0 otherwise.

The regression logit model is specified as:

$$\pi_i = E\left(Y = 1 / X_i\right) = \frac{1}{1+e^{-\beta X_i}} = 1 - \frac{1}{1+e^{\beta X_i}} \quad (2)$$

Whereπ_i is the probability of a yes response.

Y = response to the willingness to pay which is either 1 if Yes or 0 if No.

X is a matrix of the variables that can be related to the acceptance of the proposed price bid; and β is a vector of coefficients of the variables in X, such as:

$$\beta X = \beta_0 + \beta_1 X_1 + \beta_{21} X_{21} + \ldots + \beta_n X_n \quad (3)$$

The model was estimated by maximum likelihood. The estimated model's coefficients, β, can be used to determine the probability of the binary dependent variable is equal to one given specific values of the independent variables X (Greene, 2007). The β of each explanatory variable is not equal to the marginal effect (ME) of that explanatory variable, which measures the percentage change in the likelihood of the farmer accepting the proposed price offer because of an unitary increase or decrease in that variable. The explanatory's variables included in the estimated Logit model are shown in Table 1. Several water price bids are proposed as explanatory variables. This allowed us obtaining an estimate of the farmers' mean WTP, following Hanemann (1989) and Loomis et al. (2000). The marginal effect of each explanatory variable can be determined by dividing each variable's coefficient by the absolute value of the coefficient on the fee amount (β1) (Loomis, 1987 and Cameron, 1988).

Data collection

Fourteen Irrigated Public Areas (IPA) in the Nadhour region located in the semi-arid bioclimatic, North of Tunisia represented the study area. Nadhour IPA are facing growing problems of water scarcity. The average rainfall within side the area is 400 mm/year with excessive annual variability and vast evapotranspiration. The agricultural area of Nadhour is around 38,200 ha shared by about1,925farmers; 60% of the farms' area are less than 5 ha and 28% range from 5 to 10 ha. The irrigated systems cover an area of about 3,050 ha and are devoted to summer crops. The common annual quantity of withdrawal water is ready 14 million m^3. Two-thirds of this resource is groundwater. Demand is controlled through 34 WUAs. These WUAs put on sell water to users and make certain community maintenance. The volumetric pricing method is the most usually used.

The survey

The CV survey that we had the chance to conduct in close collaboration with the territorial extension unit of Nadhour involved 90 farmers in the region in question**.** Sampling was carried out randomly. Surveys were carried during March

Table 1: List of Variables

Variables	Description	Mean/proportion	Standard deviation
BID	Bid price proposed (Millimes/m^3)	245	76
FSIZE	Irrigated area (ha)	3.040	2.253
AGE	Age of the farmer (years)	50	11
NI	Education level		
	1: Illiterate	15.6%	
	2:Primary level	35.6%	
	3: Secondary level	36.7%	
	4: High level	12.2%	
COURSES	Attendance to farming training (1=Yes, 0=No)	0.644	0.481
FLABOR	Number of farm labor forces	4.467	1.367
CORRUP	1 if there's corruption; 0 : if no	0.589	0.494
FRID	Number of members with free-riding behavior	3.74	3.55
SUPPLYSHOR	Insufficient water supply (1 = yes; 0 = no)	0.122	0.329

and April of 2018 by direct interview with the farmers from the selected area. The questionnaire asked farmers about: a) farm characteristics and economic structure; b) water consumption, price and quality; c) adoption of irrigation technologies and water management decisions; d) opinions about water management; e) farmer's characteristics and f) economic contingent valuation of water. The dichotomous choice technique is used. It consists in proposing an initial price higher than what it is currently paid. Following percentage were proposed: 30; 50; 80; 100; 150; 200 and 250%.

Variables

Explanatory variables are presented in Table 1. Farm's size (FSISE) is ranged between 0.5 and 12 ha, with an average of 3.040 ha. Farmer's age is ranged between 28 and 77 years with an average of 50 years. Regarding their educational level, 15.6% of farmers were illiterate, 72.3 of them held either a primary or a secondary school. Family Labor is on an average of 4.467 persons/farm.

Corruption (CORRUP): For a non-member farmer to benefit from the WUA services, he must first send an approved-written request to the regional agricultural commissioner, from the WUA head. After receiving approval, the requesting farmer can benefit from the WUA services without resolving the water turn and irrigation time problems.

Thus, corruption is, often, resorted to as a tool: (i) to have provisional approval from the WUA head, (ii) to modify the turn and irrigation water quantity to meet his needs. As a result, large users can drain water freely, depriving smallholders and placing them in difficulty and hence negatively affecting the WUA members' performance. Corruption may affect the WTP. It is a dummy variable with a value of one if there is corruption and zero otherwise.

Free riding: individuals will achieve their personal rather than group interests (Olson 1971). The number of members measures "Free-riding variable" with free-riding practices (extending the irrigated area outside the perimeter or allowing an unauthorized connection by a non-WUA member). There are on an average 3.74 persons with free-riding behavior. These practices increase when there is a lack of willingness to apply sanctions in presence of dominant farmers. Moreover, the resource is shared with larger groups or over a larger area, making free riding omnipresent.

Supply shortage: This is a dummy variable. It is equal to 1 if insufficient water supply prohibits the farmer from making the desired cultural choice and zero if not.

EMPIRICAL RESULTS AND DISCUSSION

Water supply scarcity was discussed first. Areas to be cultivated by WUA were fixed from the start of the agricultural season in order to provide the accurate quantity of water, which better meets needs. We asked to mention the area that can be reduced by each of them. The majority of farmers who are in favor of this, i.e. 59%, mention that they are ready to reduce less than one ha of currently cultivated area and to cultivate a minimum of 1 ha otherwise they will abandon this activity. 41% of them agree to reduce between 1 and 3 ha. These farmers currently operate between 5 ha and 7 ha and they are ready to reduce to half the area sown.

Second, to improve the financial situation of the WUAs we asked farmers if they are willing to pay for an increased irrigation water price. 72% of them accepted while 28% thought that the price is enough high and that the bad financial situation is due to the corruption and poor governance of water. Table 2 presents the proportion of positive answers for each proposed proportion of price bid augmentation. All farmers are willing to pay for an augmentation of 30%. While, only 11% of them accept an augmentation of 200% and no one is willing to pay for an augmentation of 250%. The average accepted increase is of 65%. Results for the estimated Logit model are shown in Table 3. The likelihood ratio test indicates that the estimated model was significant (p=0.000), likewise high values of the pseudo-$R2$ and the high percentage of sampled cases (93.3%). The studies showed that WTP is directly affected by prices, Education level, Agricultural training, family labor, Corruption, free riding behavior, and water supply shortage. Kaya and BostanBudak (2019) has found out that educational level, family size, education on irrigation system, keeping record, total annual income, yield, planting area, own property and rent area, credit use. Farm size has a positive effect on the WTP but it is not significant. The average WTP for irrigation groundwater was 245 millimes/m^3, which is about 63.3% increase in the current water tariff. Chebil et al., (2007) found that WTP for surface water in the Coast region in Tunisia can be increased by 38% and the average WTP was 200 millimes. Azzi et al., (2018) showed that WTP for surface water in Algeria may be increased by 64%. This proves that WTP depends heavily on the circumstances under which the product is offered. A farmer's WTP a certain proposed bid was greater when he owns a larger size of irrigated area (FSIZE) and he has a higher educational level (NI). Attending training courses to improve his farming skills (COURSES) is also a positive expected correlation. There is a significant positive relationship between the WTP and family labor (FLABOR). Obtained results show that The WTP increases significantly when there is a water shortage supply (SUPPYSHOR). Oppositely, the probability of a farmer's willingness to pay a given price bid decreases with the water price bid size (BID), the farmer age (AGE),corruption (CORRUP)and free riding behavior (FRID).Findings show that corruption and free riding behavior reduced the likelihood of accepting to pay a certain bid price by 86.7% and 20.4% respectively.

Table 2: Farmers accepting water price bids

Proposed % of augmentation bids	Positives answers	% of positive answers
250	0	0
200	7	11
150	24	37
100	29	45
80	33	51
50	49	75
30	65	100

Table 3: Estimated Logit model of WTP for irrigation water

Explanatory variable	Model Coefficient	P>Z	Marginal effects
BID	-0.022	0.045	-0.006
FSIZE	0.428	0.153	0.104
AGE	-0.168	0.041	-0.041
NI	2.254	0.088	0.549
COURSES	8.083	0.045	0.954
FLABOR	1.382	0.095	0.337
CORRUP	-5.823	0.063	-0.867
FRID	-0.836	0.022	-0.204
SUPPLYSHOR	11.93	0.022	0.761
Likelihood ratio	101.49		
Prob>chi2	000		
Pseudo-R2 McFadden	0.826		
Log likelihood	-10.669		
% of correct predictions	93.3		
% of "0" correctly predicted	92.7		
% of "1" correctly predicted	93.8		

Consequently, these variables strongly affect the WTP. It seemed, on one hand, that when free riding and corruption occurred, this could distort the resources allocation through rent-seeking behavior and maximizing individual interests. Service providers in exchange for access to a water connection may extort bribes. As a result, the system will lose transparency and efficiency, which discourages farmers to pay for any bid increase. On the other hand, it is showed that training, supply shortage and education level have significant positive marginal effects on the WTP with 95.4, 76.1 and 50.9 % respectively. Education and training improve farmers' human capacities, which lead to the efficiency's increase. In a context of water scarcity, farmers seek for sufficient water to meet their needs and to safe their earnings.

CONCLUSION

Farmers' WTP for ground water in Northern Tunisia was investigated using CV techniques. Variables related with such WTP were identified using the discrete election logit model. The average willingness to pay is around 245 millimes/m^3, which represents a price increase of about 63.3%. This would allow financing the maintenance of water distribution infrastructures. The willingness to pay more expensive the water is positively affected by the level of education and the agricultural training and the perception of insufficient water supply. Agricultural training have the most positive marginal effect. Corruption was a key result. It is shown to be the most relevant variable with negative effect on WTP with a marginal effect of -86.7%. Likewise Farmers' WTPs, are significantly and negatively affected by free riding behaviour. More the farmer felt risky his rights, lesser he was willing to pay for irrigation water. Government has to encourage the permanent agricultural training to improve farmers' skills.

Implementing a monitoring system appears to be a feasible solution. In addition to empowering water associations, somehow farmers would have a WTP more than the current fees.

Declaration of competing interest

The authors declare no conflict of interest.

Authors' contributions

Hassen Abdelhafidh and Marwa Ben Brahim, conceived and designed the research work, interpreted the data, wrote and revised the manuscript. Collection, analysis and data interpretation performed by Amal Bacha. Ayoub Fouzai, wrote and revised the manuscript.

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