THE WILLINGNESS TO PAY FOR IRRIGATION WATER: A CASE STUDY IN NORTHWEST CHINA

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ABSTRACT

To inform the further development of water pricing in Shiyang River basin, a typical arid region in northwest China with agriculture as the major consumer of water, this research conducted a contingent valuation study on farmer's willingness to pay (WTP) for irrigation water. The results show that the current irrigation water price is to low to achieve sustainable use of water. The main reason of low price is not the farmer's inability to pay, but their unwillingness to pay. Furthermore, a vicious cycle of less willingness to pay and poor services exist in irrigation water management. The probable solutions include the increase of public investment in water infrastructure and determine appropriate price between surface water and groundwater. More important, enhance the communication and cooperation between water use and water agency, the combination of price mechanism and other instruments, such as positive incentives and the establishment of an independent water user organization (WUO), are useful.

INTRODUCTION

The concept that water is a scarce economic goods is increasingly accepted. Consequently, the development of water pricing mechanisms receives high priority among various tools for efficient water management (Bjornlund and McKay, 1998). Because irrigation agriculture is the major consumer of water globally (Johansson *et al.*, 2002), the development of efficient pricing mechanisms for irrigation water is particularly pressing for a sustainable management of water resources. In spite of a vast and diverse body of literature on irrigation water pricing (Boworth *et al.,* 2002; Molle and Berkoff, 2007; Hellegers and Perry, 2004), it remains a challenge to determine the "correct" price for or the economic value of irrigation water. Current reviews on this challenge are provided by Johansson et al., (2002), Hanemann (2005) and Young (2005).

In many locations, irrigation water is effectively regarded as a non-market goods and does not carry a market price. Thus, non-market valuation methods can be employed (Young, 2005; Latinopoulos *et al.,* 2004; Latinopoulos, 2005). The Contingent Valuation Method (CVM) is a flexible non-market valuation method widely used for more than three decades (Mitchell and Carson, 1989). CVM studies

use social science methods in order to estimate the economic value of a resource as the willingness-to-pay (WTP) value as stated by resource users. A farmer perfectly aware of her/his production options is expected to state her/his willingness-to-pay for a marginal unit of water based on the expected marginal increment in farming profits. Thus, the price for irrigation water can be approximated as the balance of marginal farming profits and marginal supply costs. While there are many studies on CVM, including some applications in developing countries, there is only a limited number of CVM studies carried out in the field of irrigation water pricing. Tiwari (1998) assessed the economic value of water supply in northern Thailand, Mallios and Latinopoulos (2001) estimated the value of irrigation water in Chalkidiki (Greece).

In this study, CVM was used to assess the farmers' willingness to pay for irrigation water in a rural area of Shiyang River basin, a typical intensively irrigated area of inland watershed located in northwest China. The purpose of the empirical part of the study is to elicit farmers' willingness to pay for irrigation water in this area, and determine factors influencing willingness to pay. In the discussion, the role of water price in saving irrigation water and improving economic efficiency is analyzed. Then we explore the need for price and/or institutional adjustments to the existing water pricing scheme. Ultimately, the results of the study shall broaden the knowledge base for the application of water pricing schemes in arid China.

STUDY AREA

The Shiyang River basin is located between 101º41´-104º16´ E and 36º29´ - 39º27´N in northwest China which covers some 4.16×10^{6}ha. The climate is a temperate continental desert climate with 7.8 °C mean annual temperature. Mean annual precipitation is 213 mm compared to evaporation potential of 1400-3010 mm which makes irrigation water essential for agricultural production. Agriculture is the most important economic sector with about 66.8% of the local population engaged in agricultural production. The basin is an important center for grain production in over arid region. Today, about 240,000 ha are irrigated accounting for about 86.1% of water use. In recent years, with economic growth and population increase, the conflict between economic water use and ecological water demand gradually resulted in eco-environment deterioration in this area, especially the Minqin oasis which located in the downstream regions of the basin, are suffering from desertification and ecosystem degradation (MWR, 2004). In order to alleviate these serious problems, guided by the government, the "Comprehensive Restoration Plan of the Shiyang River Basin" project was implemented in 2007. The main purpose of this project is to encourage water-saving and allocation of water resources more efficiently. An important component of this project is irrigation water price reform, as agriculture is the major consumer of water.

THE METHOD AND MATERIALS
The contingent valuation

CVM is a standard approach for the valuation of non-market goods and services. It uses social science interviews or questionnaire surveys during which respondents are asked to make a hypothetical market decision regarding the non-market goods at hand. Despite criticism directed, for example, at its hypothetical nature, CVM is widely accepted by many practitioners and academics (Carson *et al.,* 2001).

CVM implementations can differ in the *elicitation technique* used, i.e., in the way how the respondent is prompted to state her/his WTP (Venkatachalam, 2004). Two popular elicitation techniques are open-ended questions and dichotomous choice questions (Boyle et al., 1996). In the open-ended elicitation technique, respondents are directly asked to state their maximum WTP. Although simple to implement, the method is prone to several biases. For example, respondents may try to manipulate study outcomes by stating unrealistically high or low WTP figures (*strategic bias*, Mitchell and Carson, 1989). The dichotomous choice approach tries to reduce such biases. Here, the respondent is asked whether s/he is willing to pay a *specific amount* of money for a particular goods or service.

Respondents are supposed to answer only "yes" or "no". Such an elicitation format mimics day-to-day market decisions (to buy or not to buy a specific product) more closely than the open-ended technique, and can reduce strategic bias (Loomis, 1987). So, a dichotomous choice framework is used in this study. The econometric model of dichotomous choice framework is discussed in detail in Hanemann (1999)

The survey

The Chinese language questionnaire for interviews was carefully designed to provide respondents with adequate and accurate information making them fully aware of the issue. According to the factual conditions for irrigation water distribution and pricing, a price of irrigation water expressed *per area of irrigated land* is used for the WTP questions. For the convenience of local respondents, we used the mu (15 mu=1 ha) which is most prevailing unit of land in China. The proposed bids were chosen based on the results from pre-testing. Initial bid levels were systematically varied between 10 and 115 RMB per mu per year. The target groups of this survey were all categories of rural family lived in Shiyang River basin. During June 2010, 600 rural households were randomly selected and face-to-face interviewed. A summary of surveyed variables is presented in Table 1.

Table 1. Summary of variables

Name	Description	Mean	SD
GENDER	Dummy variable, 1= male, 0 = female.	Male: 59%; Female: 41%	--
AGE	Respondents' age.	42.35	11.24
EDUCAT	Education categories 1 none; 2 primary; 3 high school; 4 college	2.50	0.78
SIZE	Number of household members.	4.4	1.32
INCOME	Households' total income in 2009 (10^4 RMB).	1.45	0.77
LAND	Area of household's irrigated land (mu)*.	11.09	6.62
FEE	The fee of household paid for irrigation water in 2009 (10^2 RMB).	6.43	3.95
TYPE	The major source of irrigation water, equal to 1 if ground water and 0 if surface water.	surface water: 56% ground water: 44%	--
SATIS	Respondents' satisfaction with the management of the water delivery, scale from 1 to 5 (very bad to very good).	2.38	1.05
RECO	Whether current water price could recover the water supply cost, 1 if YES, 0 if NO.	YES: 60.3% NO: 39.7%	--

*NOTE: 15 mu=1ha

EMPIRICAL RESULTS

Sample Characteristics

From 600 respondents, 572 valid questionnaires were obtained. 28 questionnaires were eliminated due to illogical or incomplete answers. A summary of respondent sociodemographic data is given in Table 1.

Of included respondents, 59% are male and 41% female. Average age was 42.35 years, and respondents had, on average, low levels of education with 53% not receiving high school education. Average family size was about 4.4. Average self-declared household income was about 1, 4500 RMB

in 2009 (maximum: 80,000 RMB, minimum of 1,000 RMB), and average per person income 3,293 RMB. The average irrigated area is 11.09 mu/household (0.74 ha/household) and 2.52 mu per house member. Mean annual irrigation water fees are 643 RMB resulting in an average price of irrigation water of 58 RMB/mu/yr. Regarding irrigation water, 56% of households use mainly surface water, 44% use groundwater mainly. Most (66.26%) thought that the management of irrigation water delivery is not satisfaction (very bad or bad), while the proportion of farmers who thought the water management is satisfaction (good or very good) is only 19.58%. As to the cost recovery, the opinions of respondent and government data vary greatly. In our survey, most of farmers (60.3%) thought that the current water price could cover the supply cost of irrigation water. However, the data from local water agency shows the current water price could only cover 63.69% of the supply cost.

Willingness to pay

The analysis shows that LAND is highly correlated with FEE (Pearson Correlation Coefficient is 0.91), so the FEE is excluded in the model to avoiding collinearity. A full bidding model including all other variables (Table 1) was estimated. The results were presented in Table 2.

Table 2. Estimated result of *Logit* model (Values in parentheses are standard errors)

Variable	Coefficient	Marginal effect
CONSTANT	2.668 (1.118)**	0.394
BID	-0.077 (0.007)***	-0.011
GENDER	-0.005 (0.311)	0.001
AGE	-0.008 (0.013)	-0.001
EDUCAT	0.119 (0.199)	0.018
SIZE	-0.207 (0.115)*	-0.030
INCOME	0.768 (0.232)***	0.113
LAND	0.062 (0.023)***	0.009
TYPE	1.344 (0.342)***	0.192
SATIS	1.047 (0.173)***	0.155
RECO	-0.665 (0.301)**	-0.094
Sample size	572	
Log likelihood function	-161.75	
Chi squared (*df*=10)	428.58***	
McFadden's R^2	0.570	
% of correct prediction	89.2%	

NOTE: * Significant at the 0.1 level;** Significant at the 0.05 level; *** Significant at the 0.01 level.

The result of estimation reveals a mean WTP for irrigation water of 80.4 RMB/mu/yr. The 95% confidence interval ranges from 76.5 RMB/mu/yr to 84.3 RMB/mu/yr.

As expected, the bid (BID) variable has a negative and significant (*P*=0.000) coefficient which indicates that the likelihood of accepting an offered bid amount increases as the bid amount goes down and vice versa.

For household family size (SIZE), the coefficient is also negative and significant at the 10%-level (*P*=0.074). This means that bigger families tend, on average, to be willing to pay less for irrigation

water. This may be due to the fact that bigger families have more chance to engage in non-agricultural activities, so less of their total income comes from the irrigation agriculture (Su, 2009). So, compare to the smaller families, the irrigation water may be less important to them. Alternatively, based on the data of family size and household income, the family size is negatively correlated with per person profit (Pearson Correlation Coefficient is -0.35). Therefore, bigger families have less favorable per person profits. This relative weak income position could indicate that bigger families may be *willing* to pay relatively less because they are less *able* to pay. Negative influences of family size were also observed by Tiwari (1998).

The estimated coefficient of INCOME is positive and significant (P=0.001). This indicates that households with higher income have a higher mean WTP for irrigation water as expected from basic economic theory. This result emphasizes that household WTP needs to be interpreted as a reflection of a household's ability to pay. Households with higher income may also command more personal and/or financial capital to make better economic use of the water allotted by their quota.

The variable irrigated area (LAND) is positive and is significant (P=0.007) indicating that households with more irrigated area are willing to pay more for irrigation water. This possibly indicates a positive scale effect.

The coefficient of TYPE is positive and significant (P=0.000). This means farmers using groundwater as the major source of irrigation water are willing to pay more. The reason is that, compared with surface water, the groundwater is more reliable. The coefficient of SATIS is positive and significant (P=0.000). Respondents who consider current water management as satisfied have higher mean WTP for irrigation water. The reason is simple because those dissatisfied with their water service may protest having to pay more for a service they are already unhappy with. The variable RECO is negative and significant (P=0.028), means farmers who thought the current water price can't cover the cost willing to pay more.

GENDER, AGE and EDUCAT have no significant effect on WTP at the 10% significance level (tested two-sided).

Marginal effects give an indication of the magnitude of the various variables on the probability of accepting a donation amount. The TYPE has the largest effect on the probability followed by SATIS and then INCOME. The marginal effect for the BID is much smaller than for these three variables.

DISCUSSION

This research determined farmers' WTP for irrigation water in Shiyang River basin, northwest China using the contingent valuation method. The results show that the average WTP for irrigation water is 80.4 RMB/mu/yr and is substantially higher than current irrigation water price (58 RMB/mu/yr). Explanatory factors such as bid level, family size, household's income, area of irrigation land, the major source of irrigation water, respondents' satisfaction with the management and the farmers' attitude towards whether current waters price could recover the water supply cost, included in the model turned out to be statistically significant.

The study reveals that under existing pricing structure, farmers are charged much lower price than what they are willing to pay in a region where irrigation water is a scarce resource. Basic economics require that the price of a service be at least as high as the cost of providing that service, which indicates that sustainable and efficient use of water require the tariff to match at least the costs of supply. At present, we are unable to obtain accurate supply cost of irrigation water in Shiyang River

basin. However, according to local government's data, the water price could cover only 63.7% of supply cost at the present time. The results of our survey show the average price of irrigation water of 58 RMB/mu/yr. We could heuristically calculate the supply cost by the 58/63.7%, a value of 91 RMB/mu/yr is obtained, which means the currently paid fee irrespective of source of water was found to be considerably less than the supply cost of irrigation water in Shiyang River basin. Thus, the economic conditions for "weak" sustainability are violated in the project region: as prices actually too low from a cost benefit perspective, more water is used than economically desirable (Tsur, 2005). The above analysis has shown that the unsustainable use of irrigation water in Shiyang River basin at present. One of the important policy implications of the this study is that there is a possibility to restructure the existing irrigation pricing system by taking into account the true economic value of irrigation water in order to ensure longer term water use sustainability and cost recovery of irrigation water.

However, as the farmers' average WTP is 80.4 RMB/mu/yr, the supply cost of irrigation water is still higher than the farmers' WTP. Hence it can be concluded that the sustainable use of irrigation water can't be expected at present in Shiyang River basin because charging water depends highly on farmer's WTP from the standpoint of feasible revenue collection.

It is argued that the "willingness to pay" depends largely on the "ability to pay" (Perry et al., 1997). As we have showed, that the WTP is positively related with income. Usually, the ability to pay or affordability is measured by whether the water charge is a reasonable proportion of income. The survey results show that the farmers in Shiyang River basin pay average 4.4% of their net farm income in water charge and willing to pay average 6.1% of their net income in water charge. If the full supply-cost pricing is implemented, farmers would face an increase in the water fee to meet the required supply cost. However, this water rate would still only represent 6.9% of net farm income and this will reduce their net income by less than 3 percent, which is a relatively small value compared to the overall crop budget, so water is a small component of cost (Liao et al., 2007). Comparing to other developing courtiers, this proportion is no too high (Bosworth et al., 2002). Given the scarcity and the importance of irrigation water for crops on Shiyang River basin, farmers have the capacity to pay for the proposed water charges because meaningful agriculture cannot exist without irrigation. Furthermore, farmers will benefit if water agency improve reliability through improved management and infrastructure that will be possible with higher water charges. While there are no significant negative financial implications of increased price for farmers, there is more likelihood of increased returns for farmers as a result of improvements in the efficiency of irrigation systems.

By analyzing the marginal effects of variables (Table 2), the main source of irrigation water (TYPE) has the largest effect on farmers' WTP. Our model predicts that farmers' WTP for groundwater is 90.1RMB/mu/yr as compare to 72.6 RMB/mu/yr for surface water. According to survey, the average price for groundwater and surface water is 59.7RMB/mu/yr and 57.1RMB/mu/yr. The price difference between two types of water is not large compare to the WTP. As the price varies little between two types of water, the farmers would prefer to use groundwater for irrigation for its stable supply. This will lead declining water tables. One implication of this result is that there should be different price for different sources of irrigation water. Failure to determine appropriate water price between different sources of irrigation water may lead to over utilization and over extraction of groundwater which will eventually causes permanent decrease of the groundwater tables

By analyzing the factors affecting the WTP, farmers' satisfaction with current water management (SATIS) has the second largest marginal effect on farmers' WTP besides TYPE. As SATIS is

positively related to their WTP for irrigation, the low average WTP can be explained by their dissatisfaction with current water management. The results of our survey show, the average score of SATIS is only 2.38 and 66.26% of surveyed farmers thought that the management of irrigation water delivery is not satisfaction (very bad or bad). If the mean score of SATIS increased by 1 unit, a value in access of 94 RMB/mu/yr is obtained, i.e., a value slightly above of the supply cost of irrigation water. This indicates the importance of improving the irrigation water services.

Developing countries like China are facing tremendous budgetary pressure arising from the need to defray supply cost of irrigation services. An insufficient budget would lead to a poor infrastructure. And quite often, farmers don't receive adequate service owing to a poor infrastructure. When farmers can't receive enough irrigation services, the crop productivity and household's income would be undoubtedly affected. This will enable them unwilling to pay much for irrigation water. As a result, the water agency can't collect enough money to cover the supply cost and improve the infrastructure, and irrigation water service is poor, and farmers, in turn, become less willing to pay for poor-quality services provided. Normally, a vicious circle exists of poor service delivery, low cost recovery and inadequate maintenance, leading to further decline of services and decreasing willingness to pay (Bosworth, 2002). The fact that users are unwilling to pay because the service is poor is supported by Ahmad (2000) in the Near East, where users are reluctant to pay an increase in fees if it is not related to an improvement in the service provided. Likewise, Molle (2001) stated that users in general will be more likely to pay if payment can be linked to an improvement in management and maintenance. So, it is therefore important to increase investment of government in water infrastructure, which could improve irrigation performance. As the farmers always have a high willingness to pay for timely, reliable water (Rogers et al., 1998), this could help to break the vicious cycle and forming a virtuous circle.

Another noteworthy factor affecting the WTP is RECO (Whether current waters price could recover the water supply cost). More than sixty percent (60.3%) of farmers claimed that the price could cover the cost of irrigation water, though data from the local water agency show that the current paid water fee could cover only 63.7% of supply cost. As the variable RECO is negatively related with WTP, this is another reason for the low stated WTP. According to our model, the respondents who believe the water price could cover the cost have an average WTP of 77 RMB/mu/yr; while the people who thought the water price couldn't cover the cost have an average WTP of 85.6 RMB/mu/yr. Among these respondents who thought current waters price could recover the water supply cost, some thought the local water agency lied, while others believed that the poor management, not the low price, led to the losses. When they were asked how such a judgment was made, the answer usually is that the irrigation fee was collected by local water agency, but the water user didn't know how this money was spent. This means the poor communication and lack of transparency between farmers and water agency. Transparency means that farmers can see how their payments are used, and how water charges are determined. So, it is important that farmers are involved in cost-sharing decisions and in decisions concerning what costs are to be recovered. Farmers are more likely to pay if they are involved in the decision-making process. Furthermore, this could also bring an ownership feeling to the farmers, which will ultimately lead to better use of available water and increased crop production. As a result, more and more countries have started to encourage water user participation by establishing water user organizations (WUAs). The classical examples of community-based institutions of water management analyzed by Ostrom (1993) showed that WUO can even overcome the problem of the transfer of irrigation rights in absence of volumetric measuring devices.

Furthermore, a survey conducted in India has found, in systems with WUOs, 75 percent of the farmers are willing to pay 25 percent higher water charges because of the better service they have received, and the major reasons of local farmers for choosing WUOs are: assurance of water delivery and supply, fewer disputes among farmers, better maintenance, and no corruption. So, the establishment of an independent water user organization (WUO) could be an important step in Shiyang River basin. As is a participatory organization, it could potentially improve the relationship between the water local water agencies and farmers. When the fee collection process is transparent and the fee collected are retained and used on the scheme, the irrigation fee collection efficacy would improve.

CONCLUSION AND POLICY IMPLICATIONS

According to our study, several conclusions can be drawn for the state and the further development of the irrigation water management and pricing in Shiyang River basin. First, as the farmers' WTP is higher than current water price, there is a possibility to restructure the existing irrigation pricing system. However, as the farmers' WTP for irrigation water is still fall short of its supply cost, means the sustainable use of irrigation water can't be expected at present in Shiyang River basin. Second, the low water price that fails to achieve water use sustainability and cost recovery appears to be caused mainly by a lack of willingness to pay rather than by inability to pay. Third, as the perceived value of surface water and groundwater is different, it is important to determine appropriate water price between different sources of irrigation water to prevent the depletion of groundwater. Fourth, as the irrigation water fee comprises only a small proportion of the household's income, this means the main reason of farmers unwilling to pay a higher water price enough to compensate the supply cost is not the ability to pay. Fifth, in study area, a vicious circle exists of poor service delivery, low cost recovery and inadequate maintenance, leading to further decline of services and decreasing willingness to pay. In order to break the vicious cycle, it is important for government to increase public investment in water infrastructure and help improve irrigation performance. Sixth, the lack of transparency in irrigation management and the poor communication between farmers and local water agency is also an important factor discourage the farmers' WTP. This study also suggests that the farmers are willing to pay for irrigation water service, if they are organized properly. So, User participation throughout the entire irrigation management process through local WUOs appears to be another important method to achieve better irrigation water management.

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