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Can Contingent Valuation be Used to Measure the in Situ Value of Groundwater on the North China Plain?

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Abstract The over-exploited groundwater resources on the North China Plain have caused ecological problems, including lowering of the groundwater table, enlarging the depression zone and land subsidence. The contingent valuation method, a technique that reveals peoples' preferences, is applied to measure the in situ value of groundwater in order to provide policy makers information on protection and restoration of groundwater in the region. It was found that only 28% of households were willing to pay some amount of money to preserve ground water. The estimated mean willingness to pay for each household was found to be only 1.26 Yuan/m^3 annually. The in situ non-use value of groundwater subject to over-exploitation was estimated to be 0.014 Yuan /m^3. These amounts are insignificant when compared to the cost of protecting and restoring the groundwater, which are several hundreds times higher than the estimated willingness to pay. While some discrepancy was expected, the extent of this difference was unexpected. Thus, it would appear that the contingent valuation method does not provide an adequate estimate of the in situ value of groundwater on the North China Plain. It is hypothesized that one reason for this result may be the very low income and education levels of respondents in this area. An integrated economic-ecological modeling technique is recommended as an alternative option to the contingent valuation method in this case.

Key words contingent valuation · groundwater · over-exploitation · the North China Plain

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1 Introduction

The North China Plain is one of the most important regions in China and is critical for economic development. It is the "bread basket" of China. However, since the mid 1960s, the continued growth in both population and the economy in this region has resulted in the rapid growth in groundwater usage. This in turn has led to significant falls in groundwater levels and associated environmental problems. According to a report from the Global Environmental Management Institute (2000), many wells in North China have gone down to the deep aquifer and the region is losing its last water reserves – its only safe cushion.

Proper valuation is a critical requirement if the efficient management of groundwater development and its protection and remediation is desired. Generally, groundwater values can be divided into two basic categories: its extractive and "in situ" values. The extractive values of groundwater can be derived using a farm budget residual approach or by estimating production functions, amongst many other techniques (Salman and Al-Karablieh 2004; Acharya and Barbier 2000). The in situ values of groundwater include the value of holding a stock, buffer, the avoidance of seawater intrusion, subsidence avoidance, ecological attributes, existence worth (i.e. the value attached to groundwater existing even if its use is not ever contemplated and the option) (i.e. the willingness to pay a certain sum today for the future use of the groundwater). In situ values are very difficult to assess.

The Contingent valuation (CV) method is a method of determining individuals' stated preference (Ciracy-Wantrup 1947). It has been widely used for directly measuring the economic benefits of non-marketed goods, especially those with a non-use value, such as those possessing an option or an existence value (Gregory 1999). However, it has been argued that CV can not be used in developing countries where there are an overwhelming number of low-income and illiterate respondents (Whittington 1998). Most CV studies of the contamination of groundwater have been conducted on cases in the United States and little if any work can be found to exist in the rest of the world (CWCN 1997; Dosi 2001).

In this paper the in situ values of groundwater subject to over-exploitation in the North China Plain is assessed using the CV method. The focus is on the rural area of the North China Plain, as it is here that the groundwater use for agriculture accounts for 70% of total groundwater use. In addition, 80% of people live in the rural areas of the North China Plain having an average annual income of only 2,173 Yuan and over 80% received only a primary level of education. The purpose in this study is to explore the applicability of the CV method to valuing the in situ of groundwater in this region. If CV does provide a reasonable estimate of the in situ values of groundwater, then this can become the basis for initiating policy to protect and restore groundwater in this region.

2 Study Area

The North China Plain is in the north east of China, between 32 and 40° north and 100 and 200° east (see Fig. 1), covering an area of 350,000 km^2. It is mainly concentrated in Hebei, Henan, Shanxi, Shandong, Anhui and Jiangsu Provinces and two city municipalities of Beijing and Tianjin. The North China Plain is an important component in the economic development of the country, as it is known as the "bread basket of China". The North China Plain accounts for 38.5% of the cultivated land in the country, 30% of the irrigated land and 40% of the total grain production, including 52% of the wheat and 33% of country's maize production (Shu et al. 2001).

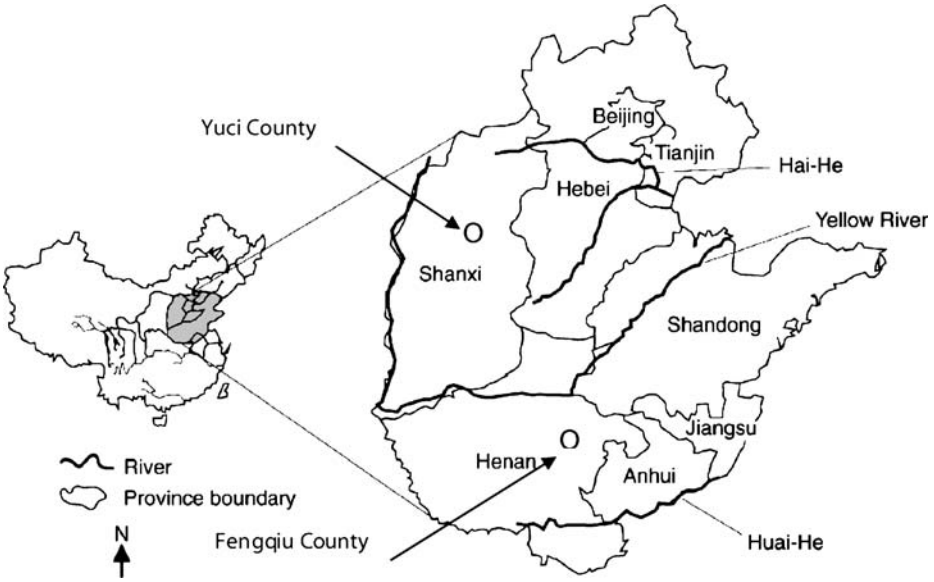

Fig. 1 North China Plain

Water resources are scarce in this area. The annual average per capita water resources in most parts of this area are approximately 500 m^3 per person (Yang et al. 2003). To put this in perspective, on average water resources per person are five times higher in the rest of China and are 20 times higher in the rest of the world. Of the total available water resources, the ratio of groundwater to surface water is 0.69, which is over twice as much as the average situation in the whole country. Thus, groundwater resources are an important component of the total available water resources in the North China Plain. Groundwater accounts for over 70% of total water use in this region. The annual over exploitation of this resource is estimated to be 5.5 billion m^3. More noteworthy, approximately 25% of all groundwater used was from the deep aquifers, which have a limited recharge capacity (Bi 2003).

The rapid growth of groundwater use has led to a decline in aquifer levels and associated environmental problems. The Land Resources Ministry of China (2004) estimated the average depletion rate of groundwater levels in the North China Plain was between 1 and 1.5 m^3 per year. They identified over one hundred depression zones of groundwater, covering 150,000 km^2 (or 20% of total land area). The depression zone spans Hebei, Beijing, Tianjin and Shandong provinces. The total area of land subsidence greater than 100 mm in Hebei Province has exceeded 33,900 km^2 (or for 55% of the total land area). This subsidence has caused the settlement of structures, bridges to collapse, storm water drainage problems and degradation in the capacity of the river levees to resist high tides and floods. Similar problems have occurred in many other key cities throughout the North China Plain (Evans 2002). Seawater intrusion into the aquifers has affected 1,500 km^2 in Shandong and Hebei provinces (Bi 2003), affecting more than 1 million people, as well as industry and agricultural production (Shu et al. 2001). Few regions in the world have such vast areas of over-exploited groundwater resources. The groundwater in North China cannot continue be used in such a way without accepting the self-terminating consequences will result.

Given the geographic size of the problem a comprehensive analysis of the value groundwater to the people of the North China Plain is not possible. In order to meaningfully assess the value of groundwater on the North China Plain it is necessary to look at a small subset of the problem. To this end, Fengqiu County, Henan Province was chosen as the representative study area, and the region where the main survey was conducted. Yuci County, Shanxi Province was chosen as a study area, to verify the results. If the CV method was found to be inadequate in these regions, it is reasonable to assume that it would not work elsewhere on the North China Plain.

Fengqiu County lies in south east of North China (see Fig. 1). It is representative of the agricultural production and social-economic conditions found in the rural areas of the North China Plain (see Table 1). Fengqiu County has a little more irrigated area and agricultural population that the average for the whole North China Plain and uses more groundwater. Yuci County lies in the middle of Shanxi Province. Compared with the average situation in the North China Plain, people in Yuci County have less water resources, but relatively higher income as it closer to the provincial capital, Taiyuan.

3 The Contingent Valuation Survey

3.1 Questionnaire Design

The CV method was applied in order to determine the in situ value of groundwater that is subject to over exploitation in North China Plain. The actual valuation has three elements: (1) portrayal of the groundwater to be valued; (2) description of the particular mechanism to be used to pay for the groundwater; and (3) the question format to elicit the respondents' monetary value of willingness-to-pay (WTP).

The cover section and first sections of the survey provides a series of maps to remind respondents where the North China Plain is and where they lie in the scheme of it. This is followed by an introduction of the current situation of over-exploitation of groundwater and its adverse impacts on the North China Plain.

In the second section the key in situ value of groundwater is presented to respondents. This value was obtained from protecting and restoring groundwater subject to over-exploitation. It included a stock value, a buffer value, the subsidence avoidance value, the cost of avoiding sea water intrusion, an ecological value, an existence value and a bequest value. Their values were introduced to the respondents using simple, understandable and intimate words, as Whittington (1998) suggests.

In the third section the CV questions was stated. First, the payment card was used as the elicitation technique, as it was believed that the people living in rural areas of China are unfamiliar with market prices (Xu et al. 2003). Further, it was felt that it would be simpler for both respondents and the researcher. Then three methods of payment respondents would be familiar with were presented to the respondents, i.e. donation, added agricultural tax, and a water bill. A fourth option was left blank, so that respondents could fill in the method of payment they preferred. The survey was designed to overcome the problems of non-acceptance of payment vehicles that may lead to individuals to the perception of inequity regarding the methods of payment.

Table 1 Comparison of characteristics between the North China Plain, Fengqiu County and Yuci County

Characteristics		North China Plain[a]	Fengqiu County[b]	Yuci County[c]
Climate	Type	Temperate, semi-humid, monsoonal	Temperate, semi-humid, monsoonal	Temperate, semi-humid monsoonal
	Average annual temperature (°C)	10–20	18	12
	Frost-free days per year (d)	175–220	210	180
	Rainfall (mm)	480–1050	609	483
	Evaporation (mm)	880–1680	1,505	1,010
Land	Total land area (km^2)	350,000	1,220	1,220
	Percentage of total cultivation area	50	49	69
	Percentage of cultivation area under irrigation	65	90	60
	Average cultivation area per person (ha)	0.09	0.09	0.09
Water	Total water available (billion m^3/year)	212	0.385	0.24
	Water available per person (m^3/year)	528	550	480
	Exploitable groundwater (billion m^3/year)	59.5	0.2	0.2
	Groundwater overdraft (billion m^3/year)	5.5	0.02	0.02
	Annual depletion rate of groundwater (m/year)	1–1.5	1.0	1.5
	Percentage of groundwater used for agriculture	70	95	80
	Groundwater management for agricultural use	Free access, no water extraction charges	Free access, no water extraction charges	Free access, no water extraction charges
Socio-economy	Main crops and their yields (kg/ha)	Wheat (5,000) Maize (4,200)	Wheat (6,200) Maize (5,800)	Wheat (4,900) Maize (8,000)
	Population (million)	407	0.7	0.5
	Percentage of agricultural population	80	95	75
	Average household size	4	4	4
	Average annual net income in rural area per person (Yuan)	2,173	2,025	2,462
	Percentage of residents who have graduated from the high school or universities	14.8	14.0	15.2

[a] data from Liu 2003; Shu et al. 2001; Yang et al. 2003

[b] data from Fengqiu County's Agricultural Bureau 2004

[c] data from Yuci County's Agricultural Bureau 2004

The wording of the CV question section is illustrated below (a complete copy of the survey in Chinese can be provided upon request).

In order to keep the groundwater resources to be used sustainably not only for the current generation, but also future generation, there are several methods that the government possibly adopt to protect and restore the groundwater to a rational level. These methods include diverting water from the south, artificially recharging with treated water from the plant etc. Those in the region who would benefit from the increased protection and restoration of groundwater would, however, need to make an annual payment. We are interested in discovering what you would be willing to pay for the program.

In the payment card below, please draw a circle around the maximum amount your household will be willing to pay every year for the following 20 years:

$$0 \quad 2 \quad 5 \quad 10 \quad 20 \quad 35 \quad 50 \quad 100 \quad 200 \quad 300(Yuan)$$

If you answer "0", please provide the reasons:

[1] *I am not interested in or do not care about protecting and restoring groundwater.*
[2] *I can not afford to pay this amount.*
[3] *It is unfair to expect me to pay.*
[4] *The government program often does not achieve the desired effect. I am opposed to paying for this government program.*
[5] *I cannot understand this project and I need more information before I will rely*
[6] *Other reasons. Please identify*:

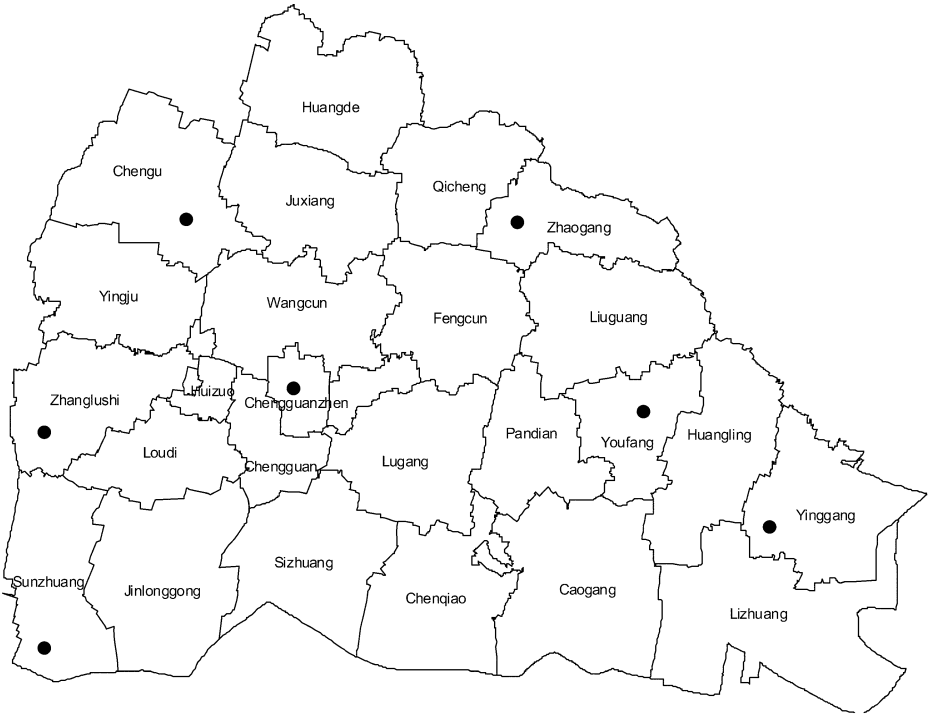

Fig. 2 Town-based map of Fengqiu County, Henan Province

3.2 Scope and Sample

In Fengqiu the survey scope is the whole county. A multistage random sampling method was employed to locate towns, villages and sampled farmer households. The sampled areas were dotted in black in Fig. 2. The total sample size was 210, which accords with a suggestion by Loomis and Walsh (1997) that samples should not be less than 200 households. Yet in Yuci County, only 20 farmer households were randomly chosen.

3.3 Pretest Assessment

The survey was first pretested on Chinese colleagues in a research group at the University of Melbourne. It was then peer reviewed by Chinese economists, scientists, and officials from the county agricultural bureau. Finally, a sample of ten households in Pandian Town were used to uncover any misinterpretation of the questions, ambiguity in response categories and clarity of visual aids (such as graphs and photos), their preference of payment vehicle and the maximum amount used as a guide in arriving at the alternate WTP. In addition, conducting the ten pretest interviews provided an opportunity to train and test the interviewers. The information on the reliability of the survey was gathered through direct interviews of those it was pretested on.

3.4 Survey Implementation

The information was collected using in-person interviews. The survey group consisted of four people from the University of Melbourne and the extension office of the county agricultural bureau, who had been trained in advance. It was found that this was a successful combination of academic rigidity and ease of communication between the group and the respondents. The interviews were conducted from May 25 to July 24, 2004. The interviews for each household lasted between 30 min and 1 h. The interviews took place in a variety of locations, including the fields, barn grinding areas, farmers' homes, the street, the office where the villagers hold meetings, etc. They were held in any other place that was convenient for the respondents.

Before directly asking respondents how much they would pay for protecting and restoring groundwater, respondents were given 5 min to think about their replies and then after they had responded they were given time to modify their answers. Heads of farm households were preferred, as it was felt that farmers had more knowledge of the in situ value of groundwater and why it might be subject to over-exploitation. In most cases, when the basic situation was introduced to the respondents, they would immediately and actively discuss the topic in terms of pumping depth, pollution of the groundwater and the effects it had on their crops. Some respondents even talked about land subsidence. Some also revealed their concerns regarding the future and/or offered possible solution.

Thus, it was felt that respondents have had enough information before they made their decision on the willingness to pay.

4 Analysis of Survey Results

The purpose in this section is to discuss the survey results collected in Fengqiu County. The survey results from in Yuci County in Shanxi are not presented in detail, but are used to test how representative are the results from Fengqiu County. These are discussed in the section

on "Expanding the Willingness to Pay from Fengqiu County to the rural area of North China Plain".

4.1 Response Rate and Respondents' Characteristics

As the survey was generally welcome by farmers, and as the in-person interview technique was employed, the response rate was very high. Of the total sample size there was a 99% response rate.

Like most surveys, the socio-economic characteristics of respondents were collected. It was found that:

- Over 50% of households has four to five members;
- Over 75% of the head of the household were found to be between 31–60 years old and that the ages of those were evenly spread within that range;
- In approximately 20% of cases the head of the household was found to be illiterate, while approximately 45% had graduated from elementary school, another 20% held a certificate of junior school;
- Approximately 40% of household had between 0.28 and 0.4 ha of cultivable land;
- Over 60% of households were found to have an annual farm income per ha of less than 5,000 Yuan, 40% of all household reported an annual total income of less than 4,000 Yuan and only 30% of households indicating incomes of between 4,000 and 10,000 Yuan.

These characteristics of respondents are in the main consistent with the statistical pattern of the county. Thus, it can be concluded that the sampling and the responses may not be biased (Fengqiu County' Agricultural Bureau 2004).

4.2 Analysis on the "Zero" Response

In the first stage of calculating the contingent valuation of in situ groundwater, it is necessary to eliminate the protest responses from the analysis. Protest responses need to be eliminated as they reveal the respondents' valuation of the solution, rather than the natural resource itself. The difficulty arises in separating the genuine zero responses from the protest zero responses (Jorgensen et al. 2001).

Table 2 Distribution of WTP in Fengqiu County

Response category	Number of respondents (%)
Willing to pay some money	58 (28%)
"I am not interested in or do care about conserving and restoring groundwater resources"	5 (2.4%)
"I can not afford to pay this amount"	101 (48.8)
" It is unfair to expect me to pay"	1 (0.5)
"The government program often does not get expected effect. I am opposed to paying for this government program"	18 (8.7%)
"I can not understand this project. I need more information before I give my answer"	4 (1.9%)
"Other reasons"	20 (9.7%)
Total	207 (100%)
Deleted as protester	49 (23.7%)

After a zero response a series of follow-up questions were asked to determine if those refusing to pay represented a valid representation of their value or if it reflect a protest against the suggested program to remedy the situation. As shown in Table 2, the check questions had five response categories and an "other reasons, please notify" category.

The second category (101 respondents, or 48.8%) represents valid reasons for indicating why they would not pay and these responses are such that it is not considered to be a protest response against the survey. The first, third and fourth categories (24 respondents or 11.6%) can be classified as protest, or scenario rejection, responses. The fifth categories (4 respondents or 1.9%) are difficult to classified, as their rejection depends on a select situation. As for the sixth category (20 responses or 9.7%), can be classified as other reasons (see Table 3). Over 50% thought that the groundwater was not over exploited, which can be classified as a potential protest response. The remaining respondents (10 or 4.7%) are also difficult to classify. Following Venkatachalam (2004) only the second category is considered to be a valid non-protest response, the others are considered to be a protest and can be deleted from total samples. This results in a total of 159 observations.

4.3 Estimating the Willingness to Pay

Data from CV surveys represent respondents evaluating a hypothetical market, rather than observations of actual economic transactions. The probability of Yes response verse the bid amount in the payment card is shown in Fig. 3. It can be seen that there exists no "range or centering bias" possibly caused by the payment card (Mitchell and Carson 1989). It would appear to follow the basic premise of consumer theory, i.e. falling demand with increases in price. The frequency analysis results show that the mean willingness to pay is 1.40 Yuan and both the median and the mode are zero.

A parametric model can be used to analyze the survey results to find how willingness to pay is affected by the social-economic characteristics of respondents. The multivariate linear regression model was considered as a suitable analytical tool for this purpose. Seven variables were included: age and education of the head of the household, household size, cultivable area, farm income, total income and irrigation cost of the household. It should be noted that in addition to gross farm income, households have another two possible income sources: livestock and off-farm employment. Consequently, the annual total income is another indicator that needs to be incorporated. Then, the irrigation cost per ha was hypothesized to be related to the respondents' willingness to pay for the in situ value of groundwater. Thus, the willingness to pay is thought to hold the following functional form:

$$WTP = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 \quad (1)$$

Table 3 Distribution of other reasons in Fengqiu County

Response category	Number of respondents (%)
"I do not think that the groundwater is over exploited"	11 (5.3%)
"If other people pay, I will pay"	2 (1%)
"If it is command, whatever I pay"	3 (1.4%)
"Not specified"	4 (1.9%)

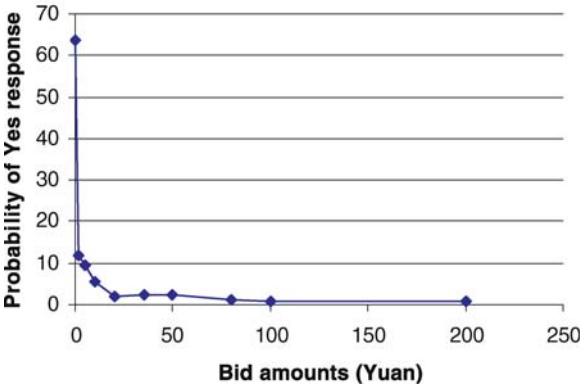

Fig. 3 Distribution of willingness-to-pay in Fengqiu County

Where, X_1 .... X_7, represent the seven variables, b_0,...b_7 are coefficients for X_1 .... X_7, respectively. The mean willingness to pay can be calculated by assessing the mean value of each independent variable.

Then, to estimate these coefficients (b_0,...b_7) is necessary to derive the means of willingness to pay. The logistic parameter model provides the relationship between the independent (X) variables and their coefficients (b) on the relative probability of answering yes to the contingent valuation question (Pr (Yes)) (Wang et al. 2003), in which the maximum likelihood regression techniques is adopted.

$$In(\Pr(Yes)/1 - \Pr(Yes)) = \sum b_i X_i \tag{2}$$

The results of the parameter estimate are summarized in Table 4. Only the results of the model with statistically significant independent variables (at the 95% confidence level or better) are presented. Except for the variable farm income per hectare of households, all other parameters were found to be statistically insignificant and were not included in the final model. The mean of the willingness to pay is estimated to be 1.26 Yuan per household per year, which is similar to the value (1.40 Yuan), obtained from a frequency analysis.

4.4 Expanding the Willingness to Pay from the Sample to the Population

Accurately expanding the sample to the population is dependent on the representative nature of the sample and the survey response rate. A conservative estimate of the willingness to pay can be calculated by assuming that the non-respondents and protests would have a zero value. This procedure provides a lower bound on the estimated willingness to pay. If the mean annual willingness to pay of households that responded with

Table 4 Parametric model of WTP in Fengqiu County

Variables	Value
Intercept (b_0)	0.201
Gross farm income per ha (b_1)	0.576
Sample size	208
Mean WTP (Yuan)	1.26
−2Log-likehood	200.457

Table 5 Distribution of WTP in Yuci County

Response category	Number of respondents (%)
Willing to pay some money	7 (35%)
"I am not interested in or do care about conserving and restoring groundwater resources"	1 (5%)
"I can not afford to pay this amount"	9 (45%)
"It is unfair to expect me to pay"	0
"The government program often does not get expected effect. I am opposed to paying for this government program"	2 (10%)
"I can not understand this project. I need more information before I give my answer"	0
"Other reasons"	1 (5%)
Total	20 (100%)
Deleted as protester	5 (20%)

a positive price in the survey is multiplied by the number of households in the county, then some idea of the social value of the in situ ground water can be calculated. The number of households in the county which would have a willingness to pay is 123,455. The aggregated willingness to pay would be 155,553.3 Yuan annually, for the in situ value of protecting and restoring groundwater subject to over-exploitation on the North China Plain.

4.5 Expanding the Willingness to Pay from Fengqiu County to the Rural Areas of the North China Plain

Fengqiu County was found to have similar natural and socio-economic conditions to the average rural areas of the North China Plain (see Table 1). The water shortage, overdraft of groundwater, land subsidence and pollution that occurs in Fengqiu County is similar to that in other places of the North China Plain. In addition, the distribution of the willingness to pay in Yuci County is similar with that in Fengqiu County (see Table 5). The mean willingness to pay was found to be 1.45 Yuan in Yuci County, while both the median and the mode are zero. So, Fengqiu County is representative of the rural area of North China Plain (Devousges et al. 1993).

As result of the similarities the willingness to pay can be extended from Fengqiu County, to the whole rural area of the North China Plain. Transfer of the unadjusted mean value or the value adjusted based on the real income differences between sites are often used as the benefit transfer method (Barton 2002). In addition, there is no obvious difference in the annual income between Fengqiu County and the average incomes rural area of North China Plain (see Table 1). Thus the simple unadjusted mean of willingness to pay estimated in Fengqiu County can be directly applied to the whole rural area of the North China Plain.

The total willingness to pay for the rural areas of the North China Plain is estimated to be 77.64 million Yuan per year. If this figure is divided by 5.5 billion m^3, the estimated annual over-exploitation of groundwater from the North China Plain, the in situ nonuse value of groundwater subject to over-exploitation can be calculated at 0.014 Yuan/m^3. In other words, 80% of total population on the North China Plain, i.e. those who live in the rural area and accounted for 70% of total groundwater use in this region, was found to be willing to pay 77.64 million Yuan annually, for over exploiting 5.5 billion m^3 of groundwater, or only 0.014 Yuan/m^3.

5 Discussion: The Rationality of the Contingent Valuation Results and Their Policy Implications

It must be asked whether the results obtained in this study are both reasonable and realistic. Despite following the guidelines specified by Whittington (1998), a high zero response was recorded and a very low mean willingness to pay was recorded.

Yung (2004) argues that the current disposable income and education level of respondents will have a strong influence on the magnitude of bids derived from a contingent valuation analysis. To illustrate this point Gatto and De Leo (2000) assessed the contingent valuation analysis undertaken on the Exxon Valdez disaster in 1989. In that study the population of the United States was used as a reference group to calculate the damage to the existence value of the affected species and ecosystems. Exxon was ultimately ordered to pay $US5 billion in compensation to the people of Alaska for their losses. This large figure could well have been due the high income of the reference group (i.e. the US population). If the same accident had occurred in Siberia where salaries are lower, the payout would have been correspondingly lower. In this study, the annual income per person is only 2,173 Yuan in the rural area on the North China Plain. If labor costs are considered, actual disposable income is even lower, if not equal to zero. This reflects the general situation of the whole country (Yang et al. 2003; Ministry of Agriculture 2000). So, it is hard to imagine that respondents with such a low-income level would have a high willingness to pay to the nonuse value of a good, even if they understand the importance these goods have. If one looks at the reasons specified by the respondents for why they would not pay for the restoration and protection of groundwater, the following was noted:

> *I know that protecting groundwater is very important as I have experienced that the groundwater level is decreased from 2 m to over 10 m. But, if I can not sustain enough food and income for my family, how I can afford some amount of money for the program?*
>
> *Not only will my current family but also my future generations live here. I have suffered groundwater problems with the failure of a well. I am certainly willing to make some contribution to this project, but this year my daughter had to give up her enrollment in the university, as I could not afford it. I really do not know what I could do for this project.*
>
> *Last year, my wheat died because the quality of the water was poor. This had never occurred before. Is anyone not willing to pay, when they have suffered a great loss? But in my case, I do have not enough money for next year's fertilizer and seeds*.

Such statements lead to the belief that, farmers' income level are considered to be the main factor limiting their willingness to pay.

The level of education of respondents may also contribution to the low willingness to pay value and high zero response. In this study, 85% of respondents had only received a "junior school or lower" level of education. This level is so low that comparable level can not be found in other contingent valuation studies, even those conducted in developing countries. Yet countering this point is the finding that farmers knew and appreciated the problems of groundwater degradation. However, in the eyes of farmers valuing groundwater may not be the same as valuing a remedy for the problems caused to it.

So, it is safe concluded that the low willingness to pay respondents had for the protection and restoration of groundwater that is subject to overexploitation in rural area of the North

China Plain is both probable and rational. Thus, it must be asked "is the existence of such a low willingness to pay significant to policy makers who need to make decisions on solving the problem of over exploitation of groundwater on North China Plain?" To address this issue it is necessary to have some idea on the costs of undertaking remedial work.

There are several methods policy makers could employ to protect and restore groundwater that is subject to over-exploitation. The first option is to divert water to the catchment in order to increase water supply, which in turn reduces the pressures on ground water. The Chinese Government construction of the South to North Water Transfer (also known as the Middle Line) Project is an example of a water diversion approach. The cost of the project would result in water being delivered to the North China Plain at an estimated 6 Yuan/m^3 (Li 2004a). This rate is approximately 430 times higher that the estimated willingness to pay reported earlier in the study. Within the plain, another water diversion project, one which diverts water from the Yellow River to Taiyuan, in Shanxi Province, has just been completed. The diversion cost was 7.8 Yuan /m^3 (Li 2004b), which exceeds the estimated willingness to pay found earlier by 560 times. A second approach is to recycle wastewater. There is no data available on the costs of recycling wastewater in China. However, the cost in Los Angeles has been estimated at 2.56 Yuan /m^3 (Liu 2003). At this cost, recycling would cost approximately 180 times more than the estimated willingness to pay reported earlier. A third approach is to legislate to protect areas of groundwater. While there is no data available on the cost of the practice, in Germany the cost has been estimated at 4.82 Yuan/m^3 (Pfaffenberger and Scheele 1992). Once again this cost is 340 times higher than the estimated willingness to pay of the respondents surveyed.

The great gap between the cost of protecting and restoring groundwater and the estimated willingness to pay places the policy-makers in a difficult situation. To start with the project to restore and protect of groundwater is almost impossible. However, using groundwater in the way it currently is on the North China Plain is unsustainable. So, it is safe concluded that the in situ non-use value obtained through a contingent valuation technique is of little use to policy makers. What is the point in putting so many resources into saving the in situ groundwater that its users value so insignificantly? Policy makers might do so if they believe that the estimate of the value of the groundwater is really higher than that determined in the analysis. What can be concluded from this analysis is that the contingent valuation method is not applicable to situations where people have very low incomes and education levels, such as those found in the rural areas of the North China Plain. Further research should be conducted on determining the point where income and possibly education levels are such that a contingent valuation could be of use to policy makers.

6 Conclusion and Suggestions

Valuation techniques are a useful tool if the values determined from them can inform decision-makers in some meaningful manner. One such technique, contingent valuation, does not work in this study where there are overwhelming low income and education levels amongst the respondents. Such a finding should not come as a surprise as many critics have identified the technical and conceptual problems associated with contingent valuation studies (see Mitchell and Carson 1989). By reducing complex environmental connections to a single value, without offering any real physical information about environmental impacts is bound to be problematic. In addition, the contingent valuation method is too

narrowly focused and does not take adequate account of uncertainty and irreversibility in decisions that have potentially far-reaching and long-lasting consequences. Finally, the method provides few opportunities for stakeholders to contribute to the decision-making process of something that is fairly complex and socially contentious, beyond expressing some individual's preferences through a set of monetary bids.

An alternative approach is to mathematically represent and model ecological processes to capture the stochastic interconnectivity of nonlinear interactions that have spatial and temporal aspects to them. These models provide a powerful tool for engaging stakeholders in learning about the structure of the problem and how to response to it. Integrating socio-economic and ecological models, as Carpenter and Gunderson (2001) have, may provide policy makers with the information they need to make a rationale decision. It certainly could not be as useless as contingent valuation has been in the case of trying to do something about the perilous situation facing producers on the North China Plain. Using an integrated approach allows for the calculation of the trade-off between economic profitability and its adverse impact on resources and the environment and would allow decision makers to impose their value judgment on the issues at hand (Stoorvogel et al. 2004). Using such an approach would allow policymakers to ascertain how different levels of groundwater over-exploitation affect farmers' income.

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