Influential factors and assessment of WTP for improving water environment in rural areas of Western China: a case study in Guangxi Zhuang Autonomous Region

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Abstract. This paper aims to study the personal willingness to pay (WTP) on improving water environment and the influential factors in four typical rural areas of Guangxi Zhuang Autonomous Region where confront non-point-source (NPS) pollution. For this, questionnaire was designed according to the Contingent Valuation Method (CVM) to investigate residents of different attitude at different ages, based on which the assessment of WTP for improving water environment. Meanwhile, Logistic Regression is employed to analyze the relationship between WTP and geographic information, socio-economic status and environmental attitude. The average pay fees is only 300 Yuan per household for household biogas system, it is far less than expected pay fees (RMB 1050-1550) by policy makers. Topography, income, age, farming scale and environmental attitude of respondents are remarkable correlated with the WTP. The influence of topography and environmental attitude is significant; income and farming scale are positively correlated with the WTP; while age is negatively related to the WTP. The assessment of WTP for improving water environment and its influential factors analysis are important for policy makers and managers involved in water environment improvement in rural China and other developing countries of the world.

1. Introduction

The development of rural areas mainly relies on local resources and environmental condition in China, which provide immediate and essential material to the development in agriculture and rural livelihoods [1]. However, the utilization and development of resources and environment also caused serious damages and pollution to environment. With the advancement of industrialization, urbanization and agricultural modernization, rural environment issues have become increasingly prominent, especially in the industrial and mining pollution, domestic wastewater and livestock sewage pollution [2]. As point source pollution, the industrial wastewater treatment rate has been greatly enhanced and the percentage of sewage treatment for Chinese cities has increased from 39% in 2003 to 89% in 2013[3]. But because of wide range, domestic wastewater and livestock sewage pollution as non-point source (NPS) pollution control has become a hotspot in the area of water pollution control. And NPS pollution has become increasingly prominent, making it an important factor affecting the water environment [4, 5]. In Chinese countries, NPS pollution control will be one of the most important issues in water environmental protection in the next several decades [6].

For the rural sustainable development, it is most important that controlling and managing rural NPS pollution, which calls for government to make various policy instruments or environmentally friendly programs. Meanwhile, in the literature there is a great deal of research about the personal willing to pay for improving water environment and its influential factors. In early research literature, the equation of willingness to pay (WTP) for environment improvement originated from indirect

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utility function, which was the theoretical foundation of the econometric model [7], and there were only the social and economic variables in measurement equation of WTP for improving environment [8]. However, WTP obtained by Contingent Valuation Method, in some sense is caused by non-economic factors [9]. Only using the social economic factors to explain the WTP is not complete, so more and more researchers introduced non-economic variables, such as environmental attitude, ethical principles, socioeconomic characteristics, policy instruments, personal hygiene behavior and so on, into the equation of WTP [10-15]. Among these factors, Hoyos, D. et al. [16] have showed that cultural identity is a key factor explaining the WTP to protect natural resources. Schaafsma, M. et al. [17] have demonstrated that distance decay is subject to significant directional effects which result in significantly different WTP estimates and the differences in total WTP up to 32%; And Breffle, W. S. et al. [18] have quantified the scale of income influencing WTP for join programs.

The purpose of this paper is to identify the critical factors affecting residents' WTP for improving environment in rural areas of Western China that confront NPS pollution, with particular emphasis on the role of geographic information, residents' socio-economic status and environmental attitude. Because rural areas of China are so wide that the range of rural water environment is extensive; furthermore, rural NPS pollution with intermittent is mainly affected by rainfall, and the strength of pollution is influenced by the type of soil, the type of land use and the terrain condition, which has significant geographic information [19]. Hence, some scholars, from the viewpoint of geographic information, studied rural NPS pollution and households' energy choices [20-22]. However, most of them focused on identifying critical pollutant or obtaining visual output. The assessment of rural residents' WTP for water environment improvement affected by integrated factors including the rural geographic information, residents' socio-economic status and environmental attitude is also less. Because household biogas systems have begun to be applied as a policy instrument in rural areas of Guangxi, this study would bring some innovative insights as it provides the means of analyzing residents' decision making process as regards their WTP of water environment. For residents' decisions to participate are essential to reaching policy objectives, understanding residents' attitudes towards household biogas systems and the range of factors that affect their decisions towards participation would be of significant interest to policy-makers.

This paper is structured as follows: the first section begins with a literature review on WTP estimation and impact factors of rural water environment. In the next section, the case study and the methods are then presented. The paper ends by setting out the results of this case study, which are discussed in final section.

2. Materials and Methods

2.1 Study area

The target area, Guangxi Zhuang Autonomous Region is situated between 104°26'—112°04' E longitude and 20°54'—26°24' N latitude. It is located in southwest of China with a total area of 236700 km^2 (Fig.1). Mountainous, plain, and hilly regions represent 60.5%, 27.2%, and 10.3% of land area, respectively. And drainage area accounts for the total area of Guangxi is 10.7%.

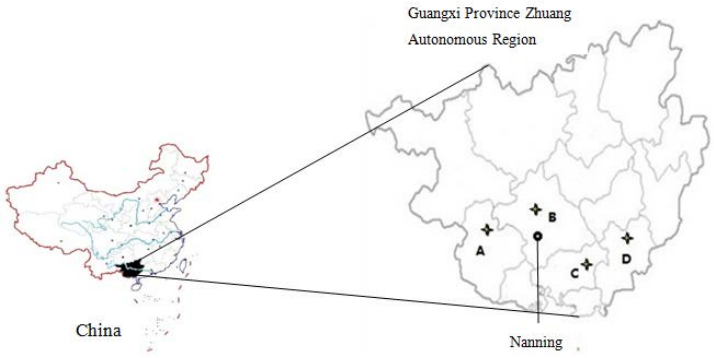

Fig.1 Four typical rural areas in Guangxi Zhuang Autonomous Region

(A——Daxin County; B——Wuming County; C——Pubei County; D——Beiliu City)

There are a great deal of technologies, methods and policy instruments to control and manage NPS pollution, such as anaerobic technology, environmentally friendly programs, and other government policies [23-25]. In this paper, we chose household biogas system as an example of a policy instrument improving water environment mainly because, it has been implemented in many villages around the province and became a critical means to control NPS pollution. So we assessed the personal WTP for improving water environment and its influential factors by using measures of attitude and motive strength to adopt household biogas technology.

Furthermore, Yang et al.[26] has showed that Guangxi Zhuang Autonomous Region is the national model province in biogas industry, for its rate of biogas users is the highest and biogas industry development level is ahead of other provinces. Therefore, four typical rural areas of Guangxi Zhuang Autonomous Region are chosen as the study areas (Fig.1). At present, Guangxi Zhuang Autonomous Region has formed four typical regional biogas industry development patterns: Mountain Development Pattern is represented by Daxin County in Congzuo City; Suburban Development Pattern is represented by Wuming County in Nanning City; Hilly Development Pattern is represented by Pubei County in QinZhou City; and Plain Development Pattern is represented by Beiliu City in Yulin City [27]. These four patterns also have wide application value in other provinces or areas. So studying residents' WTP of the four patterns and their influential factors can provide reference for other provinces or rural areas of other developing countries.

2.2 Survey design

Data are obtained through questionnaire surveys administered to the four typical rural areas (Daxin County, Wuming County, Pubei County, and Beiliu City) from July to August 2013. The survey instrument is designed based on the National Oceanic and Atmospheric Administration (NOAA) Panel recommendations including the use of personal surveys, the application of conservative measures, and the dichotomous choice WTP format[28].The questionnaire contained almost 14 items and consisted of three parts. The first part is designed to exhibit geographic information (geomorphic type, industrial enterprises, and the outflow of labor) of the typical rural areas. The second part is designed to evaluate the conditions of respondents and their families. The third part of the questionnaire contains 10 lever based on payment amount, which are designed to measure residents' WTP for improving rural water environment. Table.1 displays the framework of questionnaire.

Table.1 Framework of questionnaire

structure	content	questions
Part 1	Geographic information	geomorphic type, industrial enterprises, and the outflow of labor
Part 2	Individual endowment	Age, monthly income, cooking energy type
	Production pattern	Nonagricultural production, Migrant workers, Planting, Cultivation, Cultivated area, Farming scale
	Environmental attitude	The cognition of life sewage, the types information resources access
Part 3	WTP	whether willing to pay, how much to pay

For operability and objectivity of this investigation, we use multistage random sampling method. Specifically, the sampling process is divided into three stages and levels of the county, township and village, the use of sampling method is suitable in each stage, randomly selecting the representative of the population as the sample. This method of multistage sampling can select suitable sampling methods according to different characteristics of each sampling stage. Finally combining various sampling methods to make the sample with better representatives, we randomly selected two townships in each county, and two villages within each township. Finally, 15 households were selected for each sample village. Each householder or housewife is chosen to do the investigation. A total of 240 households in the 16 villages of the 4 counties are involved.

A core set of questions was directed to rural residents' WTP for household biogas system. Before posing the question, rural residents were asked whether they knew what a household biogas system. For the residents who asked for clarification on household biogas rules, we provided the following explanation: household biogas system is an ecological model for rural energy based on the principle of ecology, economics and system engineering. The model combines a biogas digester, pigsty, toilet and kitchen, which altogether make up the 3 parts of the system. This model makes full use of human and livestock feces, living and production waste, then generates electricity and produces the digested slurry with rich manure components similar to the fertilizer [29], as well as combines planting with animal breeding, and is presented as an integrated agricultural bioenergy system. Then the residents' socioeconomic characteristics (age, income, educational level, cooking fuels, etc.) and environmental attitude were asked.

2.3 Variables description

It is known that there is a close relation between economic factors and WTP estimates according to Contingent Valuation Method (CVM) [7-8]. However, for the WTP estimation in this paper, we base our assumptions on the attitude-behavior framework as used in most literature on this issue (e.g., Ojea E, 2007). This idea is summarized by Eq. (1):

$$P(WTP_i = 1) = \beta_i + \sum_{j=1}^{3} \beta_{ij}^{XA} \cdot XA_{ij} + \sum_{j=1}^{4} \beta_{ij}^{XB} \cdot XB_{ij} + \sum_{j=1}^{4} \beta_{ij}^{XC} \cdot XC_{ij} + \sum_{j=1}^{2} \beta_{ij}^{XD} \cdot XD_{ij} + \varepsilon_i \quad (1)$$

Table.2 Explanatory variables and the null hypothesis

Variable	Explanatory variable	Variable symbol	Description	Sign
Geographic information (XA_i)	Geomorphic Type	XA_{i1}	Plain=1; Mountain=2; Hills=3; Suburban =4	+/-
	Industrial Enterprises	XA_{i2}	Yes=1;No=0	+
	The outflow of labor / Floating Population	XA_{i3}	Proportion	-
Individual endow (XB_i)	Whether participate in household biogas system	XB_{i1}	Yes=1; No=0	+
	Age	XB_{i2}	Below 18 year =1; 19-45 year=2; 46-60 year =3; over 60 year=4	-
	Income	XB_{i3}	Below￥500=1;￥501-1000=2; ￥1001-2000=3; ￥2001-3000=4; over￥3000 =5	+
	Cooking fuels	XB_{i4}	Firewood=1; Coal=2; liquefied petroleum gas =3; Biogas=4; Electricity=5; Others=6	-
Production pattern (XC_i)	Go out for work	XC_{i1}	Yes=1; No=0	-
	Non-agricultural production	XC_{i2}	Yes=1; No=0	-
	Cultivated area	XC_{i3}	Area	+
	Farming scale	XC_{i4}	Number of slaughtered fattened hogs	+
Environmental attitude (XD_i)	The cognition of life sewage	XD_{i1}	Very low=1; low=2; commonly=3; high=4; Very high=5	+
	The access of information resources	XD_{i2}	Newspaper, Digital television, Broadcast, Internet and so on, the kinds of possess express by 1 to 5	+
WTP	payment account of household biogas system	WTP	1=Willingness to pay, then fill out a specific value; 0=Do not willingness to pay	

Here, $P(WTP_i = 1)$ represents the probability of WTP for "3 in 1" in i region, i =1, 2, 3, 4; β_i is constant term; XA_{ij}, XB_{ij}, XC_{ij}, XD_{ij} represent four factors of residents' WTP respectively, including geographic information, individual endow, production pattern, and environmental attitude. Their explanatory variables and the null hypothesis are defined in Table 2; β_{ij} represents the regression coefficient of the j factor for XA, XB, XC, XD factors in i region. ε_i is the residual term.

3. Results

The data of this paper were obtained by a questionnaire of four typical areas in Guangxi. Face-to-face survey method was used to obtain 240 valid questionnaires. There were 162 residents willing to pay a fee to household biogas system and the rate was 67.5%; there were 78 residents unwilling to pay, accounting for 32.5%. In Guangxi, the cost of a household biogas system with $8m^3$ is 3500-4000 Yuan, 2450 Yuan in it would be compensated by the central and local governments. Therefore, the residents only need pay 1050-1550 Yuan. [30]. In other words, the governments expect the residents to pay 1050-1550 Yuan. But, among the residents who would pay, the average pay fees was only 300 Yuan, it was far less than expected pay fees. In the four typical areas, the rates of residents who will to pay were 65.3% in Daxin County, 71.4% in Wuming County, 74.5% and 58.7% in Pubei County and Beiliu County respectively.

This paper applies SPSS.17 Software to analyze the 240 questionnaires. Table 3 displays the results obtained from the logistic formulated in Eq. (1).

Table.3 WTP regression results

	Variable	B	S.E.	Wals	df	Sig.	Exp(B)
Individual endow	whether have participated in household biogas system	2.833**	1.180	5.766	1	0.016	17.000
	Age	-2.370**	.949	6.238	1	0.013	.094
	Monthly income	1.158**	.512	5.107	1	0.024	3.184
	Cooking fuel	-0.084	.319	0.141	1	0.707	.921
Production pattern	Migrant workers	--	--	--	--	--	--
	Nonagricultural production	-2.197**	.978	5.052	1	0.025	9.000
	Cultivated area	1.190	.432	7.594	1	0.287	3.286
	Farming scale	4.071***	.493	.524	1	0.044	10.429
Environmental attitude	The cognition of life sewage	1.639**	.765	4.595	1	0.032	5.510
	Types information resources access	0.229	.248	1.101	1	0.265	1.257
	Constant	-82.466	52.476	.000	1	.000	.000

Note: (1) ***P<0.01, **P<0.05, *P<0.1; (2) For "migrant workers", due to the timing of questionnaire, the corresponding data could not be obtained, so it's not applicable in this table.

3.1 Influence of geographic information

Geographic information of the rural areas which this paper focuses on includes topography, the industrial structure, the number of township enterprises and permanent population as percentage of total population.

Topography characteristics in terms of micro decided the agricultural production way of residents, in terms of macro embodied the composition of the three major industries in the rural area. Fig.2 shows that the orange curve for rates of household biogas users in the four typical areas is consistent with the deep blue curve for the proportion of primary industry. However the relationship between the number of township enterprises, the proportion of the population of permanent residents and rates of household biogas users is not significant.

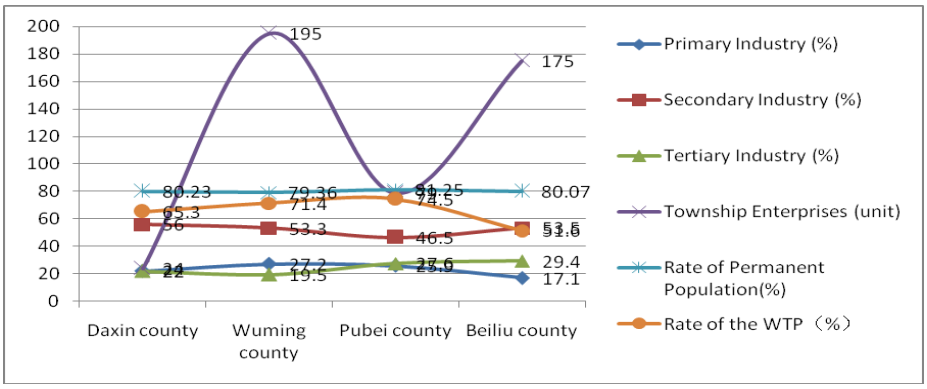

Fig.2 Rural areas characteristics and rates of the WTP

3.2 Results of personal endowment

As predicted in this paper, income of rural residents is positively related to the WTP probability, while age is negatively related to the WTP probability. This statement is further demonstrated by the Logistic Regression Model, the P of income is 0.024, and the P of age is 0.013, all of them are less than 0.05.

Boxall et al. [31] found that if alternative is ignored during the survey of WTP, then the participants' evaluation of WTP will be partial. However, the result of the survey about the types of cooking fuel does not match the above hypothesis: residents using un-green energy such as straw, coal are not willing to participate in household biogas system due to their being used to old cooking methods. They would rather do physical cook than spend money on construction, and are not willing to try new things and new technology. They generally have less education and poor economic conditions, so they are not interested in biogas energy promoted by the government, which resulted in the difficulty of biogas promotion and the difficulty of the implementation of the water environment management policy. Subsidies are given to the rural residents participating in household biogas system, but some residents are still reluctant to build biogas digester. The reason for this needs to be further studied.

3.3 Influence of production pattern

As assumed in Table 2, cultivated area and farming scale are positively related to WTP probability of household biogas system while the proportion of those engaged in nonagricultural production or workout is negatively related. However, the results indicate that the cultivated area is not significant with the WTP probability from the analysis of data ($P = 0.287>0.1$); Farming scale is positive and significant with the WTP probability ($P = 0.044<0.05$); Being engaged in non-agricultural production is negatively related to WTP probability ($P = 0.025<0.05$). Namely, respondents that breed heads there is greater exposure to the problems of water pollution due to the presence of sewage: therefore, greater sensitivity of respondents to them; in contrast, the respondents engaged in non-agricultural production are further away from the problem of the NPS water, therefore, less sensitive to it. In addition, the respondent employed in non-agricultural sectors being more heavily burdened by taxes than the employed in agriculture is also less willing to pay additional taxes.

The research was conducted during the summer vacation; outworkers were not at home at that time. The WTP probability of the outworkers could not be obtained through this research conclusion.

3.4 Influence of environmental attitude

Problems about life garbage and sewage pollution are designed to reflect environmental attitude of residents through questionnaire. The results show that the environmental attitude is positively correlated with the WTP probability of household biogas system ($P = 0.032 <0.05$). It proves that to strengthen publicity and education of rural environmental protection is a positive effect.

Normally, the number of information channel is seen as positively relative to the WTP probability of household biogas system: the environmental awareness of residents who have two or more channels of information should be significantly higher than the residents who lack information resources, and the WTP of the former also should be significantly higher than that of the latter. However, unexpectedly, the model shows that the number of information channels for residents is no significant relationship with the WTP probability of household biogas system. Through the analysis,

it is found that residents who have more channels of information, engaging in non-agricultural production, or have higher average family income, have no WTP for household biogas system, namely no desire for household biogas system. In this case, the government can adopt other appropriate means or policy instrument to improve water environment for this kind of residents' area.

4. Conclusion

This paper has highlighted the complexity of factors influencing Guangxi residents' decision-making environment about WTP for household biogas system, and analyzed the relationship between WTP and influential factors. We carried out this analysis using Logistic Regression.

Among the geographic information included in the model, topography has been to found to be the most significant factor of residents' WTP for household biogas system. The fact that the residents' WTP for improving water environment is different based mainly on different rural areas with different topography. This paper recommends designing and selecting corresponding patterns for water environment management while managing rural water environment according to the geographic information. The practice of Guangxi Zhuang Autonomous Region can be used for reference models which adopted Mountain Development Pattern, Suburban Development Pattern, Hilly Development Pattern and Plain Development Pattern respectively in different areas.

Some researchers have found that income level of rural residents is directly related to WTP [22]. This paper has indicated it again. Furthermore, as household biogas system have just commenced as a policy instrument to improve water environment in Guangxi, for stimulating residents to participate it, the government should give residents different subsidies according to their different income level.

A more important outcome of our study is based on its having taken place in areas facing NPS pollution and, moreover, on the fact that environmental attitude has significant effect on residents' propensity to WTP for household biogas system. Consequently, our paper highlights the fact that popularizing education of environmental protection for rural residents by various forms of propagandas as a preliminary stage in the process of promoting residents to participate.

Above all, the assessment of WTP for improving water environment and its influential factors analysis this paper study are important for policy makers and managers involved in water environment improvement in rural China and other developing countries of the world.

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