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The Value of Safe Water for Rural Households in Arsenic Affected Areas of Vietnam

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Using contingent valuation survey data for about 330 households in arsenic affected areas of the Red River Delta, Vietnam, this research estimates the value of arsenic-free water to the rural households. A particular focus is on households' willingness to pay (WTP) for piped water supply which can provide a sustainable solution to the arsenic problem in rural areas of Vietnam. The estimates suggest that households are willing to pay on average VND 160,430 per month for arsenic-free water i.e. tap water. It is about 3.5% of the average monthly household income. In line with economic theory and empirical results, willingness to pay is sensitive to household income, household size, gender, and age of respondents. This research highlights the importance of a consumer demand approach in water supply planning and is expected to help policy-makers and business firms to adopt more efficient strategies for ensuring safe water for the people in arsenic contaminated areas of emerging countries like Vietnam.

Key words: *Contingent valuation method, Willingness to pay, Arsenic contamination, Vietnam.*

Introduction

Arsenic in drinking water is a severe public health risk in Vietnam where UNICEF estimates there are approximately 10-15 million people using drinking water from tube wells (UNICEF, 2001; and Murcott, 2012). Recent studies have shown that arsenic contamination in groundwater at levels from mild to severe is concentrated in a number of provinces in the Red river delta (RRD) in northern Vietnam (Dang, 1992; Berg et al., 2001; UNICEF, 2001;

MoNRE, 2009; Jessen, 2009; and Murcott 2012). From 2001 to 2009, a number of large-scale surveys supported by UNICEF, the Ministry of Natural Resources and Environment (MoNRE) and international development partnerts were conducted in Vietnam (UNICEF, 2001; MoNRE, 2009; and Murcott, 2012). The findings revealed that the arsenic contamination of groundwater was high and widespread in Vietnam. The provinces most affected were Ha Nam, Nam Dinh, Ninh Binh and Ha Noi, which are situated along the Red river. Around 47% of the tested wells had arsenic concentrations above the drinking water guideline limit for arsenic of 10µg/l set by WHO. Nearly one million people are thought to be at risk of contracting illnesses and other health problems due to arsenic exposure in certain areas of the RRD including Ninh Binh province (Berg et al., 2007).

The presence of arsenic in drinking water is considered as one of the most significant environmental causes of cancer in the world (Smith et al., 2000). Long-term exposure to high levels of arsenic leads to public health problems including arsenic poisoning, cardiovascular disease, neuropathy issues, and gangrene (UN, 2001; and Kapaj et al., 2006). As a result of contaminated water supplies, Vietnam is currently facing long-term epidemic diseases related to arsenic exposure, the extent of which is still difficult to determine. In 2003, the Vietnam National Institute of Occupational and Environmental Health (NIOEH) first reported cases of arsenicosis (NIOEH 2003). Separately, Dang et al. (2006), Agusa et al. (2005), and MoST (2015) conducted studies on the health impacts of arsenic exposure in RRD and found a significant positive correlation between concentrations of arsenic in groundwater and in urine and hair of the local residents. All of these studies share the common conclusion that groundwater in the RRD is heavily contaminated by arsenic and that the health consequences are severe. They all also emphasize that the currently poor quality of drinking water in the RRD has to be improved urgently and immediate arsenic mitigation actions should be taken in order to yield optimal health gains (Charlet and Polya, 2006; Berg et al., 2007).

To find the solutions to the arsenic problems in drinking water, a variety of water supply options have emerged so far in Vietnam at household level such as rain and surface water harvesting, sand water filters, household commercial water filter etc. However, arsenic mitigation actions directed at providing alternative drinking water sources to those listed above are ongoing, but the results appear to be unclear as the monitoring and control of the water quality at household level is weak. Despite more than a decade of intensive research aiming at mitigation of the arsenic problem, the people in the RRD are still consuming arsenic-contaminated drinking water (Berg et al., 2001; and Nguyen et al., 2009). In this context, clean tap water from centralised water treatment plants is considered by the Government of Vietnam as the best and most sustainable solution to the arsenic problem, especially in the rural areas of Vietnam. The water quality will then be monitored and managed through the water safety plan. Moreover, the *'National Rural Clean Water Supply and Sanitation Strategy Up to the Year 2020'*, approved by the Prime Minister of Vietnam

under Decision No.104/2000/QD-TTg dated August 25th 2000 seeks to improve the health and living conditions of the rural population by setting targets of 60 liters of clean water per person per day by 2020.

However, like many developing countries, many plans of new central water treatment plants and distribution networks in Vietnam are engineering-centric, ignoring the nature of water users' needs and satisfaction (Pham and Tran, 2010). Criticisms of this approach focus on the failure of such programs to take account of demographic and financial realities (Whittington et al., 1993). Since the mid 1980's, a new vision based on a demand-oriented approach has emerged. This approach asserts that regulators and water providers need to understand user's socio-economic status, water use behaviour, ability, satisfaction and WTP for improved water quality; and the settings against which they operate in response to the new programs. Nugrahani et al. (2020) found that community acceptance and participation were among the factors that ensure to achieve optimal construction. In this regard, business organisations that understand behaviour of the concerned communities and implement green supply chain practices can increase their performance and also contribute to the society while filling their social obligations. Sazaba et al. (2018) concluded that strategic management practices were vital to enhance water supply chain. It was also highlighted that better supply chain implementation in terms of service quality and water quality was the key to customer satisfaction and the performance of the water supply firms.

Relatively little research has been done on economic valuation of arsenic-free water in developing countries. There are some works have been conducted to estimate economic value of improved water quality in Bangladesh and India (see, for example, World Bank, 2003; Ahmad et al., 2005; Ahmad et al., 2006; Akter et al., 2008; Abhijit, 2011; Khan et al., 2014; and Aziz et al., 2015). Using the contingent valuation method - CVM, these studies revealed a strong demand for tap water in arsenic contaminated areas of Bangladesh. The studies of the World Bank (2003), Ahmad et al. (2005) and Ahmad et al. (2006) found that rural households in an arsenic affected area of Bangladesh could spend about the value of BDT9 per month for arsenic-free water. The estimated amount is only 0.2% of their monthly household income. Akter (2008) estimated the WTP for safe water in rural areas of Bangladesh of US$9 per year, which was less than one percent of the annual household income. Similar finding was reported by Abhijit in 2011 in the study on economic analysis of arsenic in water in West Bengal. The average WTP to get arsenic-free water was Rs.26. Age, education, household size and household income were the key determinants of WTP for safe water in arsenic contaminated areas.

In the context of Vietnam, estimation of economic value of safe water in arsenic contaminated areas remains scarce. Previous studies were conducted on the economic aspect of arsenic contamination (Tran and Ross, 2009; Vo et al., 2017; and Pham et al., 2019) and

economic value of water and environmental improvement (Pham and Tran, 2010; and Dinh and Le, 2013). It was concluded that households in both RRD in the North and Mekong river delta in the South of Vietnam had relatively low level of awareness on arsenic contamination. Location, gender, occupation, income and education significantly influenced a respondent's knowledge of arsenic issue. Vo et al. (2017) found that sand filter and safe water treatment equipment are cost-effective solutions to the arsenic problem that should be promoted in the Mekong river delta. Pham et al. (2019) proposed a number of policy initiatives for provision of arsenic-free water in RRD including speeding up of the government's existing rural tap water program. For this, further research on public preference on water options and household WTP for safe water was highly recommended. Pham and Tran (2010) found that people in Hochiminh city were willing to pay approximately 3.5% to 4.5% of their monthly income for the improvement of water services. Separately, Dinh and Le (2013) investigated the consumers' WTP for environmental improvement in northern rural area of Vietnam. The study showed a WTP ranging between VND 100,000 to VND 157,000 per household per month. However, the issue of arsenic contamination was not mentioned in the study.

This research summaries the findings from a field survey with a sample of residents in Ninh Binh province of RRD, Vietnam. It aims to understand the behaviour of water users in an arsenic contaminated area and how they value the safe water. Using CVM approach, it addresses the central question: 'What is the value of safe water i.e. tap water to the local people in arsenic contaminated areas of RRD?'. The present study contributes to the still limited stock of empirical researches in environmental and water economics performed in Vietnam.

Theoretical Framework

Contingent Valuation Method (CVM)

Economic valuation of safe water to local people in arsenic-affected areas requires assessing the users' WTP. CVM is a widely used method in this kind of valuation. The theoretical model of this study is based on CVM approach constructed by Haneman (1984). The basic model for analysing WTP responses is the random utility model. In this approach, two water alternatives are presented to the respondents: (i) i = 1 is the state or condition that prevails when the new water supply action plan i.e. tap water is implemented, and (ii) i = 0 for the status quo or Business as Usual.

The utility that person *j* derives from choosing alternative water source *i* is written as V_{ij}, where M_j is the j^{th} household's income, z_j is the vector of household characteristics and attributes of the resources and ε_{ij} is an unobserved preferences.

$$V_{ij} = V_i(M_j, z_j, \varepsilon_{ij}) \quad \textbf{(1)}$$

According to Haab and Connell (2002), something has been changed from the status quo to the final state. In this case, the water quality indicator q could change from q_0 to q_1 so that utility for the status quo would be:

$$V_{0j} = V(q_0, M_j, z_j, \varepsilon_{0j}) \quad \textbf{(2)}$$

And utility in the final state would be:

$$V_{1j} = V(q_1, M_j, z_j, \varepsilon_{1j}) \quad \textbf{(3)}$$

Based on this model, respondent *j* will accept to pay a required amount of t_j monthly for arsenic-free water if and only if the utility with the safe water program exceeds utility of the status quo.

$$V_1(M_j - t_j, z_j, q_1, \varepsilon_{1j}) > V_0(M_j, z_j, q_0, \varepsilon_{0j}) \quad \textbf{(4)}$$

Thus if the income and other socio-economic characteristics of respondent are all kept at the same average, then the WTP for arsenic-free water is given by that value of t_j (monthly payment for safe water) which satisfies the following equation:

$$V_0(q_0, M_j, z_j, \varepsilon_{0j}) = V_1(q_1, M_j - t_j, z_j, \varepsilon_{1j}) \quad \textbf{(5)}$$

Design of Willingness to Pay Question

One of the most important tasks of CVM study is the design of WTP questions. There are at least four possible elicitation approaches to asking questions that lead directly to WTP or provide information to estimate preferences (Carson et al., 1999; Haab and Connell, 2002; and Dinh and Le, 2013).

- *Open-ended* approach which consists in asking the respondent what would be the maximum he/she would be willing to pay for the hypothetical good or service.
- *Bidding game* approach in which individuals are iteratively asked whether they would be willing to pay a certain amount. The amounts are raised or lowered depending on whether the respondent was or was not willing to pay the previously offered amount. The bidding stops when the iterations have converged to a point estimate of WTP.
- *Close-ended* approach which consists in presenting a specific value (payment) and asking the respondent whether he/she would be willing to pay this value (yes or no being the

choice of response). This method is also known as 'dichotomous choice approach'; and

- *Stochastic payment* approach which consists in presenting many values (possible payments) to the respondent and asking the respondent the likelihood that he/she would be willing to pay each of these payments.

The scientific panel of the National Oceanic and Atmospheric Administration of the United States (NOAA) has formerly rejected the open-ended approach since it was shown to produce unreliable results, and has endorsed the close-ended approach. Thus, among various possible elicitation techniques for placing the non-marketed value, the close-ended approach was chosen to obtain a household's WTP for free-arsenic safe water. According to Carson et al. (1999) the close-ended CVM question is incentive compatible when a survey is perceived by respondents as a potential source of influence on policy decision making. A shortened WTP question in this study is as below:

"The groundwater in your village is heavily contaminated by arsenic and the health consequences are severe. Suppose that the action plan on arsenic-free water i.e. clean tap water from centralized water treatment plant goes ahead in your village. The local citizens would obtain at least three kinds of benefits: (i) Improved public health because water quality would be ensured and free of arsenic and other pollutants; (ii) Reduced daily costs of living and (iii) Improved the relationship among the village members. Assuming that this tap water is the only arsenic-free water source for your village. Under this action plan, all households in this village, including yourself will have the possibility to be connected to the system as soon as the system is installed. To get the safe water, you have to contribute a monthly fee. Remember that there will be no option to get the safe water without paying the monthly fee which is essential to operate and maintain the water source. Would you vote in favour of the action plan?"

① Yes. Go to Question 2.4 ② No. Go to Question 2.3

If the respondent says Yes to the question, close-ended question was asked to elicit WTP for safe water. For this study, three bids were used in the WTP question. A pretest was held and then the bids were revised and finalized for use in the questionnaire. The final three bids of VND100,000, 150,000 and 200,000 were decided to value the safe water.

"If the monthly payment of the household was [choose VND 100,000 or 150,000 or 200,000], would you be willing to pay this amount to get access to safe water?"

① Yes ② No ③ I don't know

Finally, the maximum WTP for arsenic-free water was also asked of the respondents. The

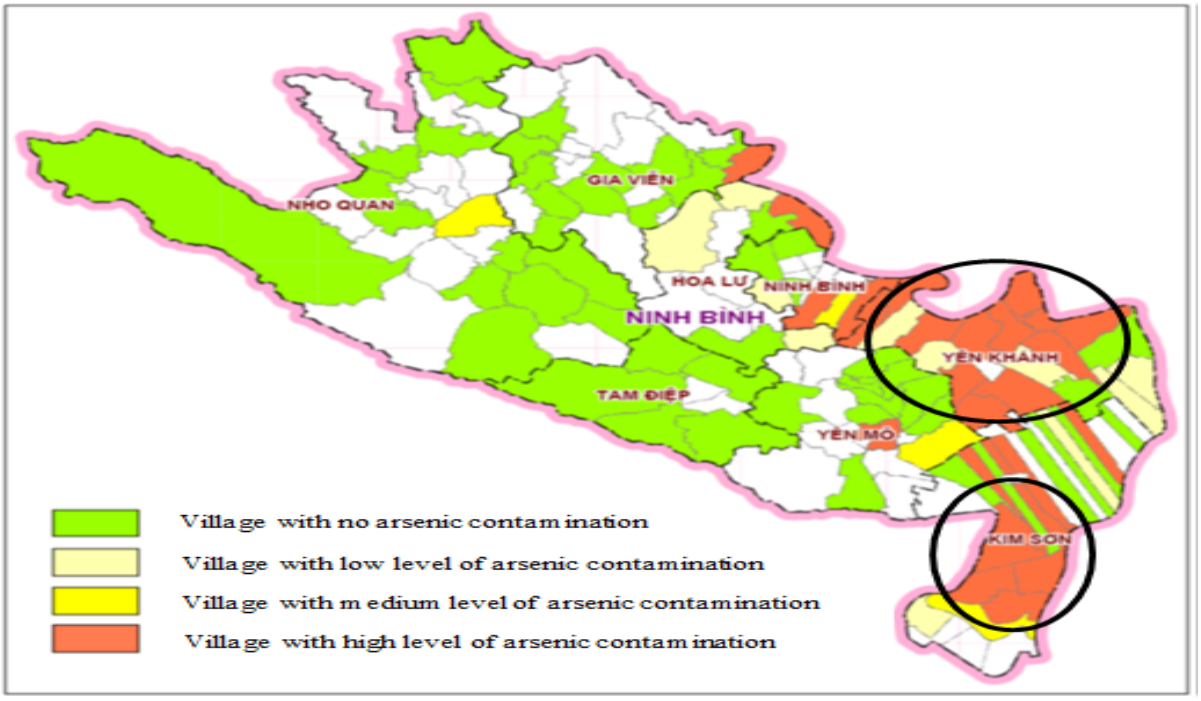
question was worded as follows:
"What would be the maximum monthly payment that your household would be willing to pay to implement the action plan in your village?_____ VND"

Research Design

Study Area

The study targeted two villages in Ninh Binh province, namely Khanh Thien (in Yen Khanh district) and Thuong Kiem (in Kim Son district). The study site has a total population of 11,902 residents and covers an area of 13.2km^2. These villages were selected based on two characteristics: (i) ground water is heavily contaminated by arsenic and (ii) tap water is still not available. Both villages have been identified as arsenic hotspots in Vietnam as shown in Figure 1 (MONRE, 2009). The UNICEF study (UNICEF, 2001; and Murcott, 2012) found that among the 38 villages surveyed in Ninh Binh, almost 16% had groundwater arsenic concentrations of more than 10µg/l. Currently, households in both villages are still consuming arsenic-contaminated drinking water and mainly depend on an unreliable source of water for daily use.

Figure 1. Ninh Binh arsenic risk map and study area



Source: MoNRE (2009)

Data Collection

The study used both secondary and primary data. The secondary sources of data on arsenic contamination, groundwater quality and health impact in Vietnam and RRD included officially and unofficially published information, reports on the studied topic, technical and scientific journals, other domestic and international publications and scientific data from previous technical and/or monitoring reports by relevant institutions. Related information and studies from developing countries affected by arsenic were also used as a source of reference. The primary data used in this study was collected through a survey of 329 households in July and August 2018 in RRD province of Ninh Binh. The head of the household, either male or female, was interviewed for the survey. The sample size was computed and the actual sampling procedure was undertaken. The sampling procedure used in Ninh Binh followed the guidelines developed by World Food Programme for Comprehensive Food Security and Vulnerability Analysis (WFP, 2006). A two-stage sampling technique was employed. In the first stage, the village was selected. In the second stage, the household respondents were randomly drawn. The number of householders surveyed per village is shown below:

Table 1: Distribution of sample households in study site

		Households		
	Village	**Number**	**Ratio (%)**	**Number of households in the survey**
1	Khanh Thien village	1,621	42.8%	115
2	Thuong Kiem village	2,168	57.2%	214
Total		**3,789**	**100**	**329**

Source: Ninh Binh DSO (2018) and authors' calculation

Key Characteristics of the Survey Instrument

The survey instrument was developed through focus group discussion and pre-testing of a survey questionnaire. Following best practice, a draft of the survey template was first discussed and reviewed in focus group discussion and pre-tested with approximately five households in each village to ensure that the questions and scenarios were understood by the respondents. The issues that were examined in the course of the pre-testing included: (i) whether there was any lack of clarity or misunderstanding of the questions presented to the respondents; (ii) whether the alternatives presented to the respondents were appropriate; (iii) whether there were a large number of unanswered questions; and (iv) whether the range of bids/payments presented to the respondents was appropriate. Once these two activities were completed, the survey was revised, finalised and made ready for implementation.

The final questionnaire collected information on the following aspects. The first part sought

qualitative information on people's awareness of arsenic problems and water use pattern. The second part of the survey aimed to determine whether the households are willing to change their habit of using safe water sources by shifting to tap water and to collect information about the households' WTP for tap water. To ensure that respondents understood clearly the nature of the action plan presented to them, a figure was used to facilitate comprehension. Before asking questions pertaining precisely to the WTP, respondents were given the opportunity to ask questions about the technical features of the action plan. The third part of the survey consisted of questions about the socio-economic features of the respondents.

Results and Discussion

Socio-Economic Characteristics of the Respondents

A total of 329 respondents were interviewed with men accounting for 31.6% of the sample. The average age of respondents was 52 years. Almost all respondents (86.9%) were married, 31.5% of respondents had completed primary school, 13.8% had completed high school, and 4.6% college/university. The occupation of the respondents was diversified: 58.1% were farmers; 4.6% were government officials or employees of state-owned enterprises; 2.4% were employees of private enterprise; and 24.9% were self-employed in various types of businesses. Non-working respondents (such as pensioners and housewives) comprised approximately 10% of the sample. An average household income was estimated to be approximately VND 4.57 mil. per month. It reached the highest level in Khanh Thien (VND 4.85 mil.). Approximately two third of the respondents have indicated their income to be sufficient to satisfy households basic needs such as food, clothes, power and water; 9.8% have savings while only 2.8% have difficulties in meeting the basic needs. This data on income is similar to the information provided by Ninh Binh DSO (2018). The socio-economic features of the samples indicate that the study area well represents the typical rural community of Vietnam's RRD. This similarity allows for a reliable extrapolation of the WTP results from the sample to the population of interest.

Table 2: Profile of the respondents

Description	Khanh Thien		Thuong Kiem		Average	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Age of respondents (year)	51.42	13.13	52.21	13.90	51.94	13.62
Household size (person)	3.74	1.55	3.71	1.56	3.72	1.55
No. of family member (18+ years) (person)	2.50	0.94	2.50	0.89	2.50	0.91
No. of family member have paid jobs (person)	2.00	0.73	1.84	0.79	1.90	0.77
Monthly respondent income (VND mil.)	2.75	1.44	2.50	1.48	2.59	1.47
Monthly household income (VND mil.)	4.85	2.53	4.42	2.27	4.57	2.37
Monthly household expenditures (VND mil.)	3.95	2.20	3.63	2.35	3.74	2.30

Household's Water Sources

97% of the households used rainwater for drinking. There was a strong belief among the rural people of Vietnam that rainwater is fresh, clean and the best in quality. Tube well water at 1% and other sources of water at 2% (including surface water and bottled water) were also used. Most households (74%) used tube well water for cooking and washing. Rainwater (6%) and other sources of water (20%) were also used.

Household's Concern and Awareness on Arsenic Contamination

Almost all the respondents in Ninh Binh are aware of arsenic contamination and consider using unsafe water as risky. 20.8% of respondents recognize arsenic as a threat to their family's health and 98.2% feel that it was extremely important to take action to ensure that their villages receive a safe water. However, only 68.4% of the respondents reported that they knew some of the symptoms of arsenicosis, but could not clearly describe them. 50.8% claimed that it would take years for arsenic poisoning to manifest itself and that the prolonged use of arsenic-contaminated water could lead to gangrene, cancer, and even death. 21.1% of the respondents felt that they could afford the cost of treatment if a family member was affected by arsenicosis. The survey results showed that none of the respondents had checked their drinking water during the last 12 months and 10% had taken measures to protect themselves from arsenic contamination. However, only 8.9% believed such interventions were effective to mitigate the level of arsenic in the water.

Estimation of Willingness to Pay

To run the model, the data was cleaned for missing information. The sample size was reduced to 299 usable observations. As described above, at first, the action plan for arsenic-free supply water was proposed and introduced to the respondents. Respondents were then firstly asked whether they would vote in favour of the action plan if the plan were to cost nothing to the household. It was found that 98% of respondents would vote for the action plan. The very high percentage of "Yes" response to this question (98%) indicates that respondents understood the nature of the issue and the nature of the action plan presented to them. 2% of the respondents indicated not wanting to connect to the safe water system even if this was to be free. Reasons stated for this answer included: no water supply yet, no trust in the project, pollution would be caused by road digging, and inconvenience would be caused by house renovation.

Using the close-ended elicitation procedure, respondents were asked if they would vote (Yes or No) in favour of the action plan with three bid levels of VND 100,000, 150,000 or 200,000. Each questionnaire contained only 1 bid and was randomly assigned to any given respondent. 104 respondents were presented with a bid of VND 100,0000, 92 with a bid of VND 150,000, and 103 with a bid of VND 200,000. The vote of the respondents by bid level is shown in Table 3. As expected, the higher the level of the bid presented to the respondents, the larger the percentage of them voting "No" for the action plan. Approximately 95% of the respondents said "Yes" when presented with a bid of VND 100,000; nearly 33% said "No" when presented with a bid of VND 150,000 and 63% said "Yes" to the highest bid of VND 200,000. The proportion of individuals to respond "Yes" to each offered bid in Khanh Thien village was higher than that in Thuong Kiem village.

Table 3: Votes for action plan

Parameters		**Bid level (VND)**			**Total**
		100,000	**150,000**	**200,000**	
Ninh Binh province		104	92	103	299
Voted "Yes" to offered bid	No of respondent	98	62	65	225
	Share (%)	94.2%	67.4%	63.1%	75.3%
Voted "No" to offered bid	No of respondent	6	30	38	74
	Share (%)	5.8%	32.6%	36.9%	24.7%
Khanh Thien village		40	32	37	109
Voted "Yes" to offered bid	No of respondent	40	26	28	94
	Share (%)	100%	81.3%	75.7%	86.2%
Voted "No" to offered bid	No of respondent	0	6	9	15
	Share (%)	0%	18.7%	24.3%	13.8%
Thuong Kiem village		64	60	66	190
Voted "Yes" to offered bid	No of respondent	58	36	37	131
	Share (%)	90.6%	60.0%	56.1%	68.9%
Voted "No" to offered bid	No of respondent	6	24	29	59
	Share (%)	9.4%	40.0%	43.9%	31.1%

The households' WTP for arsenic-free water has been estimated using utility model. The results are presented in Table 4. For the respondents who voted for the action plan with offered bid, the average WTP was VND 171,840 per household while for the respondents who did not vote for the plan with the offered bid, the average WTP was only VND 103,330 per household. Khanh Thien village has a higher mean WTP of VND 163,300 per household compared to VND 158,480 of Thuong Kiem village. Using the mean sample WTP per household, on average a household in study site would be willing to pay VND 160,430 per month for arsenic-free save water.

Table 4: Estimated WTP by respondents (VND)

No.	Respondents	n	Mean	Min	Max
1.	**Ninh Binh province**	299	160,430	50,000	385,000
	Voted "Yes" to offered bid	225	171,840	100,000	385,000
	Voted "No" to offered bid	74	103,330	50,000	170,000
2.	**Khanh Thien village**	109	163,300	70,000	350,000
	Voted "Yes" to offered bid	94	170,850	100,000	350,000
	Voted "No" to offered bid	15	116,000	70,000	170,000
3.	**Thuong Kiem village**	190	158.480	50,000	385,000
	Voted "Yes" to offered bid	131	172,560	100,000	385,000
	Voted "No" to offered bid	59	97,000	50,000	150,000

The estimated WTP is about 3.5% of the household's monthly income. This figure is higher than those obtained in the World Bank (2003), Ahmad et al. (2005), Ahmad et al. (2006), Akter et al. (2008), Dinh and Le (2013), Khan et al. (2014), Aziz et al. (2015) studies and is at the same level of Pham and Tran (2010), and Islam et al. (2019). The key message here is that people in arsenic affected areas of Vietnam may place relatively higher value on safe water compared to other places due to the seriousness of the issue. Clearly, this is an important issue that needs more attention in water supply policy design.

The Determinants Affecting the Willingness to Pay

In order to analyse the possible determinants of the WTP for safe water in studied area, a regression model similar to those used in previous studies on economic valuation was applied. In the model, the households' stated WTP is the dependent variable, while variables such as gender, age, level of education, household's size and household's income, marital status of respondent are the independent variables. The exogenous variables in the function are described in Table 5.

Table 5: Description of variables in the regression

Variables	Description	Value
WTP	WTP for free arsenic safe water	Continuous variable
Gender	Gender of respondent	Male = 1; Female = 2
Age	Age of respondent	Continuous variable
Marriage	Marital status	Married =1; Single=2
Education	Level of education of respondents	Primary school = 1; secondary = 2; high school = 3; college/university = 4
HH_size	No. of family member	Continuous variable
HH_income	Level of household income	Less than 1 mil = 1; from 1-2 mil = 2 …….. from 19-20 mil = 20

The summary output of regression analysis is presented in Table 6. As expected, income is statistically significant at the 1% level. The model also shows significant relationship between gender (at significant level of 1%); household's size and age of respondent (at significant level of 5%). The male respondents have expressed a higher WTP than female. It is obvious in Vietnam since a male plays an important role in the family especially in rural areas. Similarly, those respondents who have a bigger family have shown to have a higher WTP than others. It indicates that the more members in the family, the higher concern on health issues and the likelier the household will decide to pay more for safe water. The findings are found similar to those estimated in previous studies of the World Bank (2003), Nauges and Van den Berg (2006), Abhijit (2011) and Islam (2019). Age is found to negatively influence the WTP. Older residents have an average WTP much lower than the younger generation. However, the stated WTP amount displays insignificant relation against both marital status and education. The fact that education did not show any impact on WTP does not mean this factor is not important. In fact, we consider this factor as precondition for any intervention related with change in water use behaviour. Overall, findings strongly suggest that WTP for arsenic-free water is significantly affected by a household's demographic make-up.

Table 6: Summary output of regression analysis

Variables	Coefficients	Standard Error	t Stat	P-value
Intercept	228.415	31.491	7.253	.000*
Gender	-32.678	7.658	-4.267	.000*
Age	-.626	.281	-2.226	.027**
Marriage	-12.349	10.794	-1.144	.254
Education	-2.456	3.749	-.655	.513
HH_size	-4.843	2.289	-2.116	.035**
HH_income	12.846	1.412	9.100	.000*

Note: Number of observation = 299; $R^2 = 0.34$; Adj. $R^2 = 0.32$;
* significant at 1%; ** significant at 5%; and *** significant at 10%

Conclusion and Policy Implication

Arsenic contamination of groundwater is a severe public health risk in Vietnam. Located in the RRD in northern Vietnam, Ninh Binh province is one of the regions that suffer the most from arsenic contamination. Currently, local people mainly depend on unreliable sources of water.

This study applied the CVM to estimate the value of arsenic-free water to the rural households in Ninh Binh province with special focus on households' WTP for tap water supply which can provide a sustainable solution to the arsenic problem. The research clearly showed that local people in arsenic contaminated area of RRD expressed a strong preference for tap water and placed a relatively high value on arsenic-free water. The estimates suggested that households were willing to pay approximately VND 160,430 per month for arsenic-free water i.e. tap water. It is about 3.5% of the average household monthly income. In line with economic theory and empirical results, WTP is sensitive to household income, household size, and the gender and age of respondents. A key policy message from the study results is that for better water policy design, the policy makers and business organizations need to understand the water user's behaviour, their WTP and the settings against which they are operating in response to the new water supply programs. For this, more information on the households' demographic characteristics, households' water use patters, satisfaction, WTP and other factors affecting the households' WTP for the safe water need to be provided and considered in policy and decision making process. Without this, no policy can become successful.

The relatively high stated WTP for safe water in the studied area may imply that among the possible water supply options in arsenic affected areas, those which are more costly but more reliable may find wider acceptance among the local people. This indicates that attempting to facilitate the use of safe water/tap water, which normally is assumed as the most expensive water supply option is the right approach to deal with arsenic contamination in rural areas of

Vietnam. A proper financial and water pricing mechanism should be established to facilitate the process of providing safe water to all households in arsenic contaminated areas of Vietnam. However, the high stated WTP may also imply the seriousness of arsenic contamination for local residents in study area. There is a little evidence from the survey that local people have a deep knowledge on the issue. The lack of understanding and trust about water quality and in the reliability of arsenic mitigation options was clearly a significant obstacle in dealing with the arsenic issue in Vietnam. To motivate people to adopt protective behaviour by switching to a safe water source, information provision and building trust are important areas that need more effort and action.

Although the estimated WTP is reasonable the results of this study were derived from a relatively small sample size and cover only Ninh Binh province of RRD. There is necessity to examine the WTP in a broader aspects and to apply alternative valuation methods in future study. Though the research scope is limited to RRD, policy makers, researchers and local communities may find applicability for other locations as this study gives a better understanding of demand for safe water in the arsenic affected areas of Vietnam. This information can be used to readjust and reconsider the arsenic mitigation policy and management mechanism for more relevance in the future. It is also expected that academics and a wider civil society audience who are involved in water supply and sanitation programs will also benefit from the study.

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