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SAFE WATER FROM FILTRATION PLANT: PUBLIC PERCEPTIONS AND ESTIMATION OF DEMAND

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ABSTARCT

This study aimed to estimate the demand of water filtration plant in a special context where water is available but of poor quality. The study found that household size, distance from filtration plant, full awareness and partial awareness are highly significant in estimating the demand for safe drinking water. It was also revealed that perceptions of the household head greatly affected their behavior towards the demand for safe drinking water. It was recommended that the community awareness should be focused related to safe or clean drinking water.

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Key Words: *Demand estimation, willingness to pay, awareness level, Perception, Safe drinking water, filtration plant.*

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INTRODUCTION

Water, when it is scarce is a serious problem, when unsafe and poor in quality is another important one. Especially it is a dilemma in a situation when it is freely available in abundance but unsatisfactory in quality or not safe for human consumption. "Clean water for a healthy World" is the slogan chosen by UN-Water committee members to stress that water quality is an absolute and imperative need for the world as a whole. The shaking fact is that water borne diseases kill 1.5 million children each year (Forlano, 2010).

Water problems are of various types in the world. Some people are facing shortage of drinking water while some areas have plenty of it in very poor quality. If water is of bad/unsafe quality, it demands for purification; a money spending activity. Poor populations of the developing countries are hardly getting food and they are not able to think of quality nor are they aware of the circular relation of quality and expenses. Quality needs more reward and the poverty issues are very closely related to the consumption of safe drinking water. However, awareness can help people to understand the positive effect of spending on safe drinking water.

Mostly, the research related to safe drinking water has been done in relation to its awareness and willingness to pay like Madajewics *et al.* (2007) who estimated well water users' response to information regarding arsenic level and Jalan and Somanthan (2008) work on household's response for cleaning fecal contamination in drinking water (which turned to be positive). There are instances where people were found insensitive to water related information (Johnson, 2003). This study addresses the issue of community's willingness to pay for the repair of damaged or non-functional filtration plant installed by an Non government organization (NGO) for the locality, and estimates the demand for safe drinking water in said circumstances. A careful analysis did separate how far either the unawareness or economic factors along in determining use of unsafe drinking water in the study area.

Water is a necessity which is related to our lives. Drinking water quality and quantity problem is researched intensively. For example, Altaf et al. (1993) studied the willingness to pay for piped water in two different areas of Punjab which resulted in water supply and policy problems in view of situations there. Haq et al. (2007) used contingent evaluation method and found that location, education of family members and source of water has significant effects on HH's WTP for improved water services. Willingness to pay estimates can be helpful in the provision of improved water systems and CV is an effective measure for it (Chowdhury, 1999). Risk perception is also a matter of concern for adapting safer water (Altaf et al., 1993; Crocker et al., 1991; Smith and Desvouges, 1986; Abraham et al., 2000). Private connections were termed as unaffordable by people (McPhail, 1994). The value of water as a resource depends as much on the quantity available as on its quality, therefore, both aspects should be considered simultaneously for adequate management (Xepapedes, 1992).

Altaf et al. (1993) conducted a study regarding willingness to pay for piped water in two areas of Punjab, one having relatively sweet groundwater and the other brackish ground water. Their conclusion showed water supply and policy problems in view of the situations there. According to them the ground water of the area is depleted so fast that caused the water tables to fall rapidly necessitating to rebore them for domestic purposes. But the government has not paid any attention to the matter and although the willingness of the people to pay was found to be high for piped water system, they cannot afford to invest in connecting to water system. They suggested that the water authority may devise financing schemes for the people to connect to the public water system.

Bello et al. (2006) estimated the peri-urban household demand for safe drinking water in the Kingdom of Lesotho near Republic of Africa. They used multi-staged method. Their main/ primary respondents were household heads. They employed Age, household size, education level in household (highest), distance of water source, female proportion in family / household, experience of water shortage and amenity demand for water as explanatory variables of the study. The results showed that household income, education level and gender variables insignificantly effecting demand for water.

Ahmad & Sattar (2007) used multinomial logit model in order to estimate the averting water contamination behavior. The variables like awareness level of households and their wealth were used in model so as to find the joint production of utility. The findings showed that measure of awareness for example different education levels of decision makers coupled with their exposure to mass media significantly affects their willingness to pay towards different water purification systems.

MATERIALS AND METHODS

The study used purposive and cluster sampling technique. The area selected as sample i.e. union council Sawal Dher, district Mardan, Khyber Pakhtunkhwa, Pakistan which was abundant in water, is very fertile and the supply of filtered water/safe drinking water was nominal there and the locality did benefit from a filtration plant which is non-functional now. Such characteristics fulfilled the requirements for the planned study.

Individual sample frame and sample size

Union council Sawal Dher consists of two villages, Sawal Dher and Chak Bilandi. The total population of union council was 41000 according to 1998 census, of which 35000 were the residents of Sawal Dher and 6000 were the population of Chak Bilandi including 17900 males and 23100 females. Male population growth was 80 to 90 per year and female were 120 to 130 per year respectively. With this growth rate male in 2011 were supposed to be 18835 and female 24475 and the total population was 43310. The main sample size was 130, selected from an individual sample frame of all household heads. The study addressed 130 heads of the households or head of families (since the person who is paying, the decision depends on his willingness to pay for safe drinking water). According to the formula given by Glenn D. Israel, the sample size with given error margin can be calculated as:

n = $\frac{N}{1+N(e)^2}$ and the error margin for a given sample size could be found as:

e = $\sqrt{N-n/nN}$

When we put values e = 43180 / 5630300

e = .0875

So on the basis of this formula the error margin for the present study is .0875 and we took decision on the basis of this significance level. Similarly the area was divided into six clusters. Each cluster contained one specific street where individual household heads were interviewed accidently (accidental sampling method). As we were interested to collect responses for the restoration of a filtration plant for which distance is a determining variable, we needed to access all such people who live near and at distance from that plant. The planned sampling method ensured a representative sample for the purpose.

Theoretical framework (microeconomic framework)

Microeconomic theory assumes that the consumers' choice is directed towards best bundles of goods which they can easily afford; those which do not cost them any more than "**m**" (the amount of money they have to spend). Suppose there are two goods with the prices p_1 and p_2 and total amount of money available for spending is **m**, then we can say that the budget constraint for these two goods would be:

$$P_1X_1 + P_2X_2 \leq m \tag{1}$$

And the expected budget line can be:

$$P_1X_1+P_2X_2 = m \tag{2}$$

Rearrangement gives us the formula:

$$X_2 = m/P_2 - (P_1/P_{2)}\, X_1 \tag{3}$$

Equation 3.3 states how many units of goods 2 the consumer needs to consume in order to just satisfy the budget constraint if she is consuming x_2 units of good-1. In matter of choice, the natural tendency of people is to choose the best things they can afford which clearly state the monetary resources available for it. This notion of making the best choice is represented by an abstract, mathematical way as following utility function.

$$U = f(x_1, x_2, ...x_n) \tag{4}$$

According to Courant and Porter (1998) household health production function entails their water sanitation activities and hence health can be taken as composite good (H) and Y as all other goods, we can develop the utility function of a consumer as following

$$U = U\,[Z, H\,(A, [\pi])] \tag{5}$$

Z denotes composite good (Marsahallian), measurement of the level of health is represented by H and H(A, [π])]) thus is the expression of production function of health. Similarly averting activities like boiling of water, use of water purification tablets and the use of filtered water is denoted by A while π (pi) indicates the perception of risk relate to health caused by water contaminations. We assumed that:

[U.sub.A] > 0 and [U/sub[π]] < 0 (Sub denotes subscript)

The expression show the behavior of household in which utility is taken by direct use of perceived safe water and care for health in an indirect manner. There are four choices for purifying water viz electronic personal filtration, ordinary filter, using chlorine tablets and the use of heat for boiling the water. There is a budget constraint for choosing A or Z i.e. Y = Z + [P.sub.1] [A.sub.1] + [P.sub.2] [A.sub.2] + [P.sub.3] [A.sub.3] + [P.sub.4] [A.sub.4] + C. Y here shows income P is the price of water alternatives (safe water) and the average cost of filtered water is denoted by C. composite good is considered to be equal to 1. Let's assume that consumer has chosen j, as water alternative, we can solve the conditional demand for water practice, a function of wealth (taken as proxy for income(permanent)), awareness both informal and formal with the addition of other related variables for example occupation, gender and the prevalence of water borne diseases within the family. Mathematically

[A.sub.j]= [A.sub.j] ([P.sub.j]Y,M,O) (6)

The set of variables related to awareness is denoted by M and the rest of (other) variables by O respectively.

Needs and desires are considered directly correlated to Utility. The argument is that desires can only be measured indirectly, as expressed in the outcome; in case of economics, the measurement is found in the price which a person is willing to pay for the fulfillment or satisfaction of his desire (Marshall 1920:78)

In the case under consideration for research, safe drinking water is considered as the need or desire of the person and the amount he is ready to pay for it can be obtained by using contingent valuation method. Compensating variation (a technique of contingent valuation method) method is the appropriate measure when the person must purchase the good, such as an improvement in environmental quality. It could be found by asking a person for his willingness to pay amount for better quality good. So WTP is defined as the amount that must be taken away from the person's income while keeping his utility constant: written as:

$$V(y\text{-}WTP, p, q1, \pi; Z) = V(y\text{-}WTP, p, q0, \pi_{;} Z) \quad (7)$$

Where V denotes the indirect utility function, y income, p the vector of price faced by the individual, and q_0 and q_1 are the alternative levels of the good or quality indexes (with $q_0 > q_1$ which shows that q_1 is better quality of water) Z is the Marshallian composite good denoting all other goods except safe drinking water and π the perceived health risk.

Econometric framework

Demand for safe drinking water is influenced by many factors. The traditional demand functions are not only the outcome of price and income but a lot of other variables are involved which capture a household preference pattern. These include the education (levels), demography, occupations and locations (Deaton, 1980). In case the data is cross sectional, the price differences are not the real differences but of differences in quality and space (location). Households does not allocate budget in a single stage but it may be considered as multi stage decision process in which the first (consider as upper stage) allocation is made for food items coupled with health and other categories. Lower to this stage, the food expenses are allotted to have clean water for drinking and other food objects. At the lowest stage, the expenditures on health are allocated to cure for waterborne diseases and other health items. As per the Engel's law, a household preference patter results into skewed income-consumption curves which means that with the increase in budget size, there is an increase in the budget allocation for luxuries and decrease in allocation for necessities. This implies that rich households are more likely to allocate a larger share of their budget to more expensive water purification devices as compared to poor households (Ahmad & Sattar, 2007). The documentary of True Vision Production showed that money is the main determinant of this demand in Bolivia and Tanzania and the ease of fetching safe drinking water was also affecting the effort for it (Palma, 2002). The situation varies from one geographical area to another. For instance a case study of district Peshawar empirically proved that the role of awareness besides the income constraint is the key determinants of demand for safe drinking water (Ahmad et al., 2010) and a paper by Bello et al. (2006) incorporated eleven variables, age, household size, family income, distance to water source, price of water, price of water substitute, female's proportion in family, peri-urban locations, gender, experiences of water shortage and amenity demanded for water. The initial survey and interviews with the locals of the sampled area showed that beside money and the role of awareness, there are some other variables which are affecting the demand for safe drinking water in the study area. The most important are included here. So the working model for this study was:

$$Qd_W = f\ (Y, P, Pr, D, H, Age, E, R) \qquad (8)$$

Hence the demand function for safe drinking water in a water abundant area was set as:

$$Qdw = \beta_0 + \beta_1 Y + \beta_2 P + \beta_3 Pr + \beta_4 D + \beta_5 H + \beta_6 A_+ \beta_7 L_+ \beta_8 R_1 + \beta_9 R_2 + e_i \quad (9)$$

Where:

Qd_W = Quantity demanded for safe drinking water per day by a household (liters)

Y= household head income in the study area per month

P = Own price. As here the process of fetching cost consumer whiles the filtration plant providing water freely. So this cost is taken as own price.

$P_{r=}$ Price of related goods / liter (substitute i.e. bottled water)

D = Distance to safe drinking water source in kilometers

H = number of individual in family of household

Age = age of household head in years

L = household head Literacy status

Where 1= literate and 0 = illiterate

R= awareness of the household head (aware or not)

Where R_1 =1 for the awareness of household head in case of full awareness

R_1 = 0 for other two categories

R_2 = 1 for partial awareness and R_2 = 0 for other two categories

Similarly when R_1 and R_2 are equal to zero we would get the values for no awareness

The estimated demand function for the model becomes:

$$Qdw = \beta_0 + \beta_1 Y + \beta_2 Pr + \beta_3 P + \beta_4 D + \beta_5 H + \beta_6 A_{+} \beta_7 L_{+} \beta_8 R_1 + \beta_9 R_2 \qquad (2.10)$$

We took income of the household for money provides the ability to pay for the restoration of the filtration plant and people are willing to pay when they are able to pay. The demand or willingness to pay according to economic theory is affected by price of the related good (complement or substitute) and hence the price of the bottled water is taken as the substitute for the filtrated water in the area. There were two other options viz electric filter and boiling as well but they were not practiced by the community there. He used Age of the household head and size of household in his model which is used here as well. While another variable i.e. literacy status of household head was added to find the effect of education on the decision maker for safe drinking water adaptation. Full awareness in the present case means that an individual is fully aware of water related problems, its causes and effects. He knows the diseases that could be caused by water impurity and thinks it important to be cared. A person may be termed as partially aware if he/she knows that water quality is not safe but is not aware of its effects.

Operationalization of opinion

The perceptive part of an individual is important for decision making and adaptability of a process. As the nature of response is nominal, we used the chi square test for checking the significance of the difference of opinions.

The formula for chi square is:

$x^2 = \Sigma[(O_k - E_k)^2/E_k]$

Where

O_k = Observed frequencies in the k_{th} cell.

E_k = Expected frequencies in the k_{th} cell.

Contingency valuation method (CVM)

Contingency valuation method is a method estimating the economic value of non-market environmental goods through survey questions and brings out individual's preferences regarding such goods (Carson, *et al.* (1993) this method was used to know about people willingness to pay in monetary terms for safe drinking water. The payment question in the planned study was open ended in order to obtain a representative measure purely based on true willingness to pay.

RESULTS AND DISCUSSION

Perceptions of community

We care for something if we perceive it important. "Perception is a process by which an individual organize and interpret their sensory impressions in order to give meaning to their environment" (Robins, 2008). People will care for safe drinking water if they perceive it important and necessary. There are factors which may be responsible for this perception. Nevertheless, the community in the study area who cared for the availability of safe drinking water was 52.3% of the total 130. The rest, i.e. 47.69% responded that they do not care about whether safe drinking water is available to them or not. These facts are shown as under. The statistics show that almost half of the community had no worry for safe drinking water.

It is human nature that they do not claim and demand for something until they perceive it their right. It is the first part of a person overt action for the attainment of the thing. Money may provide a mean to fulfill that effort after perceiving its importance. Other factors may also be involved in this process. But there are things which are considered as fundamental right. Water is considered one of them. Table 1 shows that all respondent households agree that it is their fundamental right to have safe drinking water.

Our actions are influenced by various things. In cases of monetary needs, various factors can play an important role. Our income may have several heads for it. According to economic theory, people spend on the basis of their preferences given to different bundles of commodities. We prefer things on the basis of our perception that it is importance for us. Table 1 shows that only 37.69% people were agree to spend for a personal water purification system if the filtration stay nonfunctional and the community or government is not ready to restore it. Most of them i.e. 62.30 percent were not ready for this activity.

Table 1. Frequency Distribution of Household by Perception for Safe Drinking Water and Chi square Statistics

Statement	Yes	No	Chi-square
I don't care whether safe drinking water is available to us or not	62(47.691)	68(52.307)	0.277
It is our fundamental right to drink safe water	130(100)	0	------
Are you willing to spend on personal water filtration system?	49(37.692)	1(62.307)	7.877*
I can't spend my income on piping system from plant.	125(96.153)	5(3.846)	110.769*
The filter is very far from my home	114(87.692)	16(12.307)	73.887*
It is government responsibility to provide free safe water.	127(97.692)	3(2.307)	118.277
I don't accept that the water I use is not safe.	95(73.706)	35(26.923)	27.692*

Note: The * shows that chi- square value is significant at 5 % significance level. (The values in parenthesis are percentages)

The test values for the care regarding the availability of safe drinking water is statistically insignificant at 5 % level of significance as shown in Table 1. It shows that care for safe drinking water as a perception of the community does not influence them for availing safe drinking water. Willingness to spend for personal filtration system and willingness to pay for piping system from plant to houses are both statistically significant as shown in Table 1. It is clear that it is the person who has to bring the change. If the community is not willing to benefit themselves, no other efforts can be beneficial. It is clear from the non-functionality of plant. Although the NGO installed filter, it is not working now.

Most of the people in the area do not accept that the water they are using is not safe. Table 1 shows it clearly that 73 % people are such who perceive that their water is safe and good for health. The chi square value is statistically significant and hence people acceptance about water quality does affect their use of good safer quality water.

The filter is perceived to be far from their houses by most (87.69%) of the household heads. The test value is statistically significant (Table 1). This affects their action/behavior to bring water from filtration plant.

Lastly people were asked about the pricing of water in terms of commoditization. They were in large agreed that government should provide safe drinking water free of cost. Almost all the respondents except 2.3% were having this view.

Table 2. Values of Estimated Parameters in Log Model

Original S.E.				Heteroscedasticity Corrected S.E.	
Variable	coefficient	S.E.	Significance (%)	S.E.	Significance (%)
Income (Rs/ month)	0.009	0.069	10.700	0.009	13.300
Price(bottled water)	0.637	0.632	68.400	0.637	68.400
Distance(km)	0.157	0.057	99.300	0.157	99.300
Household Size	0.151	0.014	99.999	0.151	99.999
Age(years)	-0.002	0.004	35.500	0.002	35.300
Full-awareness					
(Dummy)	0.284	0.117	98.300	0.285	98.700
Partial Awareness					
(Dummy)	0.164	0.097	90.600	0.164	94.400
Literacy(Dummy)	0.129	0.130	67.600	0.129	79.000
constant	-0.740	2.166	26.700	-0.740	25.600
Summary statistics					
F(8, 120)	16.570		99.999	14.880	99.999
R-squared	0.525			0.525	
Adj R-squared	0.500			0.500	

Table 1 show that the test statistics for this view point is statistically very significant. We can say that when a community thinks of an activity as the responsibility of government and they think basic necessities like water should be provided by government free of cost, then it greatly affects their personal quests for it.

Demand estimation for safe drinking water

Table 2 shows the statistics regarding the relationship between the dependent variable demand for safe drinking water and the explanatory variables. The table no.2 shows the details. The data fitted the specified model very well as 52.5% (R^2 = .525) variation in dependent variable is explained by the independent variables. Overall, the hypothesis that dependent variables collectively do not determine demand for safe drinking water is not accepted as the obtained F-value 14.880 is highly significant. It is evident from table 4.9 that distance, household size, dummy variables for full awareness, dummy variable for partial awareness are significant in their effect on dependent variable, demand for safe drinking water. So if distance is increased by 10%, there will be 1.57% increase in demand for dependent variable keeping other things constant. Similarly the fully aware household consumes 0.284 liters more than the base unaware and partially aware will use 0.164 liters more than the base unaware. Other variables like income, price of bottled water, age of household and literacy are not affecting demand for safe drinking water significantly as shown by their significance in Table 2.

Table 3 shows the values of estimated parameters in linear model in which the status of variables in terms of their effects remains the same. Distance, household size, full awareness and partial awareness as explanatory variable significantly affect the explained variable. The value of coefficient for distance shows that if there is a one unit change (increase) in distance, there will be 1.57 unit changes in demand for the safe drinking water, the relationship is positive. The more a household is away from the filtration plant the more is the facility inaccessible and the more is the call for it. If the household size is increased by one unit there will be 2.91 unit (almost three liters) increases in demand for the safe drinking water. The role of awareness is very effective. In case a person is fully aware, he /she will consume 6.2 liter more than the base unaware, while a partially aware will consume 3.21 more liters of safe drinking water than the base unaware. Other included variables of the model are income; having positive and insignificant relation, similar for price of bottled water; positive and insignificant, age negative and insignificant in effect. Although the effect of literacy is statistically insignificant, still a literate person will use 2.33 liter more than an illiterate one. The sign of constant term is negative showing that in absence of all independent variables, there may be no or negative demand for safe drinking water. The effect of constant term is however insignificant. We can say people will use unsafe water. The data collected was cross sectional in nature. There are very few chances of autocorrelation which is strongly supported by Durban Watson d value (Table 3).

CONCLUSION AND RECOMMENDATIONS

The main findings of the study confirmed the previous researches in similar regards. The study found that awareness has a significant effect on community's demand for safe drinking water. Both the levels i.e. partial and full awareness levels can have greater effects on the adaption of safe drinking water. Household size was found to have greater effects on demand for the safe drinking water. The study also found that people on the average are willing to pay for rehabilitation of supply source but most of the people cannot pay higher amounts and are in very low income groups. Distance between safe drinking water source and households' houses significantly affects community's demand for safe drinking water in large. It is concluded that the perception of community greatly affects the adaption of different means for safe drinking water. On the whole household size, distance,

Table 3. values of estimated parameters in linear model

Original S.E.				**Heteroscedasticity Corrected S.E.**	
Variable	coefficient	S.E.	Significance (%)	S.E.	Significance (%)
Income (Rs/month)	0.013597	0.065	16.400	0.072685	14.800
Price(bottled water)	0.219534	0.369	44.600	0.388308	42.700
Distance(km)	1.579649	0.611	98.900	0.565959	99.400
Household Size	2.912585	0.263	99.999	0.339496	99.999
Age(years)	-0.01996	0.068	22.800	0.075625	20.800
Full-awareness (Dummy)	6.201908	2.280	99.300	1.987204	99.800
Partial Awareness(Dummy)	3.219067	1.880	91.100	1.714585	93.700
Literacy(Dummy)	2.33294	2.492	64.900	2.221806	70.400
Constant	-15.3958	13.077	75.900	14.61115	70.600
Summary statistics for linear model					
F(8, 121)	16.460		99.999	15.490	99.999
R-squared	0.5212		------	0.5212	--------
DW-value(130,8)	1.712 at du =1.487 and dl =1.710				99.000

awareness level in case of full awareness and partial awareness were found statistically highly significant in their effect toward demand for safe drinking water. So these factors could be adapted as policy factors for any such projects which relates to the adaption of safe drinking water. On the basis of the results it could be recommended that the community should follow a collective effort to care for the filtration plant and the Government should provide them with the needed technical assistance. For better private use of public goods, the community should be made aware about the water facts of the area and the importance of the safe drinking water. As a policy guide, the government should focus on participatory approach for the projects of public interests and in future if there are any projects of water purifications, they must be coupled with infrastructure for piping. Water should be subsidized in poorer areas where such an important necessity of life cannot afforded by the masses and they are unable to attain it although they are willing to pay for it.

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