Domestic Water Use and Values in Swaziland: A Contingent Valuation Analysis

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Abstract

The paper reports on the use of the contingent valuation method to study the determinants of Swazi households' willingness to pay (WTP) for an improvement in their water quantity and quality. A sample of 374 households was surveyed and a Tobit model was applied to explain household preferences for quality and quantity of domestic water supply and derive estimates of WTP for such a service. The results confirm that household income had a positive and statistically significant impact on WTP for both quality and quantity. Distance to the water source is positively associated with WTP regardless of the location (rural or urban) and of the household head's age, education, and gender. Current water consumption was also statistically significant for WTP for improved quantity, but with a negative sign, implying that the more a household consumes water, the less that household is WTP to have improved water quantity. Conversely, the same household would be WTP for improved water quality. Rural households showed a much higher WTP for improved water provision services than urban households. There is therefore scope to improve water service levels in Swaziland even at a higher water price. More precisely, the estimates of WTP obtained in this study indicate the possibility of introducing a demand-driven program to expand the coverage of rural tap water schemes.

1. Introduction

Water is increasingly becoming a scarce resource in Swaziland (World Bank, 1993). Despite the fact that Swaziland is a country traversed by five major rivers with mean annual rainfall ranges between 550 and 625 mm in the lowveld, and between 850 and 1400 mm in the highveld, water is one of the major constraints to development (Government of Swaziland, 2003a). A high proportion of the population (47%), residing in rural and peri-urban areas,

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does not have access to safe and clean water (Government of Swaziland, 2003b).

National health statistics in the country show that some infant mortality is related to water borne diseases, which is a reflection of the poor quality of water. This has been evident by the 2003 outbreak of typhoid in rural areas, which resulted in the deaths of six people, four of whom were children (World Health Organization, 2002). In addition, Swaziland's available fresh water resources are already almost fully utilized and under stress (Seetal and Quibell, 2003). As the population increases, both within Swaziland and in the surrounding regions, better management of water resources is required in order to ensure its continued availability.

The total number of households in Swaziland in 2001 was estimated at 233 843, of which 79 205 (34%) live in rural areas and 154 638 (66%) live in urban areas (Statistics Swaziland, 2002). With regards to domestic water supplies in the urban areas, 89% of the population is provided with treated water and 60% of the population has access to water-borne sewage systems or septic tanks. In the rural areas, in spite of substantial investments, coverage levels remain low largely because of poor maintenance of existing water systems (Government of Swaziland, 2003a). Thus, real water coverage in these areas is approximately 30%. The majority of river gauging stations are not functional and water equipment is outdated (World Health Organization, 2002). As a consequence, regular monitoring of the levels of pollution is also poor.

Public or private investments for improved water-related services, particularly in rural areas, are therefore essential if better livelihood conditions for local residents are envisaged. To implement these investments, decision-makers need information about the possibility of adopting an impartial, cost-recovery strategy resulting from the application of water tariffs to domestic users.

The main objectives of the study on which this paper is based were to determine how much Swazi households are willing to pay (WTP) for an improvement in their water quality and quantity as well as establishing the possible factors affecting their WTP. Specifically, the study is designed to:

1. Quantify the WTP for improved water quality and quantity by the Swazi households in both rural and urban areas;
2. Investigate the determinants of their WTP.

This is in order to determine, in monetary terms, the value of improved quality and quantity of domestic water in the country and to provide an understanding of the factors that affect this monetary value. This exercise is essential to produce quantitative economic information on domestic water uses and value that policy-makers may find useful in implementing the National Water Act (Government of Swaziland, 2004).

The rest of the paper is organised as follows: Section 2 develops the methodology and illustrates the data. Section 3 presents the results and their discussion while section 4 concludes.

2. Theoretical framework, modeling and sampling procedure

This section presents the model, methods and procedures used to conduct the study on which this article is based.

The Contingent Valuation Method (CVM) was selected for its appropriateness when dealing with estimation of non-use values. The CVM can be used to elicit consumers' WTP for almost any environmental good or service, including more abundant and cleaner water (Mitchell and Carson, 1989). Whittington *et al.* (1993) have carried out contingent valuation studies of households' WTP for improved sanitation services. Banda *et al.* (2004) applied a CVM to analyse determinants of quality and quantity values of water for domestic uses in the Steelpoort sub-basin of South Africa. A Tobit model was applied to household survey data, to explain household preferences for quality and quantity of domestic water supply and to derive estimates of WTP for such a service. The Tobit model takes the following functional form (Tobin, 1958):

$$\hat{y}_i = x_i^{'}\beta + \varepsilon_i \qquad (1)$$

where:

$$y_i = \hat{y}_i \quad if \quad \hat{y}_i \succ 0 \qquad (2)$$

or:

$$y_i = 0 \quad \text{if} \quad \hat{y}_i \leq 0 \qquad (3)$$

The variable y_i is the observed contingent valuation bid by individual *i*, $\hat{y}_i$ is a latent measure, x_i are the independent variables, β is a vector of parameters and ε_i is the error term distributed as independent normal with zero mean and constant variance (σ^2). The explanatory variables in the regression model are a set of variables dealing with demographic characteristics, socio-economic characteristics, a set of dummy variables concerned with whether the household is practicing avoidance measures against water-borne diseases and on the presence of small children in the household. This method elicits the probability and not the actual value of WTP, which is subsequently calculated through descriptive statistics. Following Greene (1997), the WTP probability is computed as:

$$P(Y=1)=\frac{e^{Zi}}{1+e^{Zi}} \tag{4}$$

where:

$$E(Y/X)=0[1-F(\beta' X)]+1[F(\beta' X)] \tag{5}$$

and $F(\bullet)$ is the cumulative density function. Irrespective of the distribution used, the marginal effect is obtained as follows (Greene, 1997):

$$\frac{\partial E(Y/X)}{\partial X}=\left[\frac{dF(\beta' X)}{d(\beta' X)}\right]\beta=f(\beta' X)\beta \tag{6}$$

The response for WTP is a binary variable that takes the value 1 if the response to the question is 'Yes' and 0 if the response is 'No'. Let the binary variable be WTP and the underlying latent variable be WTP*. Then the general formulation of the empirical Tobit model is given as:

$$WTP_i^*=\beta' X_i+\varepsilon_i \tag{7}$$

where X_i is a vector of explanatory factors in the regression for the individual *i*, *β* is a vector of fitted coefficients and WTP^*_i is the stated WTP for individual *i*. Since WTP* is not observed, it is the underlying latent variable that is related to the observed WTP as follows:

$$WTP_i=1 \quad \text{if} \quad WTP_i^*>0 \tag{8}$$

and:

$$WTP_i=0 \quad \text{if} \quad WTP_i^*\leq 0 \tag{9}$$

An econometric analysis was used to test the relationship between WTP and socio-economic factors. Questions were asked in an ordered, categorical form and then were transformed into binary variables. The respondents were asked if they were WTP for a better quantity and improvement in the quality of water.

Constructing realistic and meaningful scenarios, in accordance with the needs of the study, minimised hypothetical/scenario mis-specification bias. Information was provided about the symptoms of contamination, the health risks and the cost of treatment, both in the short-term and following prolonged use of contaminated water. Information was also provided about the different types of treatment technologies that could be used in Swaziland. This was all done verbally during the course of the interviews.

WTP can be functionally expressed as follows:

WTP = f (WATCON, HHINC, HHSZ, EDN, WATSOC, PAB, SML, CLT, LOC, AGE, GENDER)

or, in a linear regression form:

$$WTP = \beta 0 + \beta 1\ WATCON + \beta 2\ HHINC + \beta 3\ HHSZ + \beta 4\ EDN + \beta 5\ WATSOC + \beta 6\ PAB + \beta 7\ SML + \beta 8\ CLT + \beta 9\ LOC + \beta 10\ AGE + \beta 11\ GENDER + \varepsilon$$

where:
WTP is the probability that households will be WTP for quantity or quality;
WATCON is water consumption expressed in m^3/month/household;
HHINC is household's monthly income expressed in Emalangeni (E)[1];
HHSZ is household size expressed in number of individuals;
EDN is the household head's level of education expressed in number of years spent in education;
WATSOC is the water source for the household (1 for in-dwelling, 2 for collective taps and 3 for river water);
PAB is a dummy variable indicating that the household is practicing avoidance measures against water-borne diseases[2] (1 = 'Yes', and 0 = 'No');
SML is a dummy variable indicating the presence of small children in the household (1 = households with children; 0 = households without children);
CLT is the time in hours/month spent collecting water within the household;
LOC is a dummy variable indicating household's location (1=urban; 0=rural);
AGE is the age of household head (in years);
GENDER a dummy variable indicating the sex of household's head (1=female; 0=male);
and ε is the error term representing the unpredicted or unexplained variation in the dependent variable and is assumed to be regularly distributed.

The target population of this study was defined as households that use water for domestic purposes in Swaziland. The study was conducted in the eleven main centres of the country[3]. The centers included one city, three towns and seven small towns. The first four centres are urban and the remaining seven are rural (Department of Urban and Rural Development, 2002). Data on population and number of households was obtained from Statistics Swaziland (2002).

Since the study defined two types of households in Swaziland, the stratified and random sampling method was selected, with urban and rural households being the two strata. A sample of 374 households was surveyed categorised into rural and urban based on the geographic and socio-economic characteristics of the residential centres[4]. This method was chosen to identify issues that may be relevant in explaining the differences in water use between rural and urban households. These issues included the percentage of formal dwellings in the area, services delivered to the community, distance travelled to the source of water and level of literacy.

3. Results

The study interviewed mainly the heads of the households (87% of the sample). Any household member available who was old enough to answer the questions satisfactorily composed the remaining 13%. The results of the observed average household characteristics are shown in Table 1.

Table 1: Mean characteristics of the interviewed household.

Variable	Rural	Urban
Age of household's head (years)	52.3	49.8
Level of education of household's head*	1	3
Family size	9	6
Average household income (E/month)	2 352	15 846

*(Level of education 5= Degree, 4= Diploma, 3= O'level, 2= Primary, 1= None).

Respondents residing in urban areas are younger than those living in rural areas, have higher educational levels and higher income. Households in rural areas are larger than those residing in urban areas.

3.1 Water use

The different types of water users in Swaziland may be delineated according to the source of water used (Table 2). Most people in rural areas rely on river and collective tap water, whilst private tap is mainly found in urban areas.

Table 2: Source of water for the interviewed households

	Rural		Urban	
Source of water	Frequency	Percent	Frequency	Percent
Private tap water	10	8	229	93
Collective tap water	49	39	18	7.2
River water	68	53	-	-
Total	127	100	247	100

The per capita consumption of water was significantly different between the two surveyed areas (urban and rural) for all water sources (Table 3). There is a clear correlation between the household's income and source of water. The higher the income, the higher is the probability to have private tap water.

Table 3: Per capita income and per capita water consumption by source (per month)

	Rural		Urban	
Source of water	**Per capita income (E)**	**Per capita water consumption (m³)**	**Per capita income (E)**	**Per capita water consumption (m³)**
Private tap water	1470.7	3.9	4951.9	5.4
Collective tap water	100	2.3	123.9	1.3
River water	94	2.9	-	-
Average	261	2.7	2641	5.1

3.2 Willingness to pay

When estimating the odds of WTP for quantity, households in the rural areas appeared more likely to be WTP than those in the urban area (Table 4). Only 6% were WTP for an increased quantity of water in the urban areas and these households were exclusively among the few receiving their water from the collective tap. In the rural areas, 58% of the interviewed households were WTP for an improved availability of water. In both areas, households were WTP for a better quality of water. The figure was nevertheless again much higher in the rural areas (67%) than in the urban areas (20%). It is noteworthy that in both areas, there was a higher WTP for improved water quality than for increased water quantity.

Table 4: WTP (yes or no) for improved water quantity and quality

	Rural	Urban
WTP for improved quantity	**Percent**	**Percent**
No	42.0	93.9
Yes	58.0	6.06
WTP for improved quality		
No	33.3	80.1
Yes	66.7	19.9

For the households that were WTP, the study inquired about the amount of money they declared to be WTP for improved water quantity and quality. As Figure 1 shows, there is a clear correlation between WTP (for improved quantity in the figure) and income. The correlation coefficient between WTP for quantity and income was 0.23. This was lower than the correlation coefficient between WTP for quality and income (0.51).

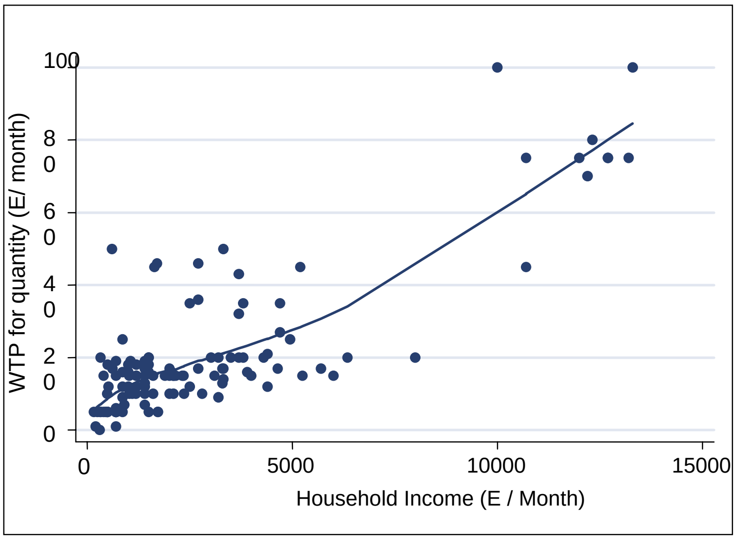

Figure 1: Correlation between WTP for quantity and income of households (E/ month)

Many households seem to associate the availability of private tap water with the direct and indirect benefits that they may receive from it. For instance, good quality water supply (as tap water is considered to be by most domestic users) would indirectly benefit served households in the case of outbreak of diseases such as cholera. Avoidance of medical costs could result in a consistent benefit, not mentioning the working hours gained in the case of disease avoidance (McConnell and Ducci, 1998). These aspects, among others, might therefore induce respondents to realize the economic importance of water and thus contribute to their WTP for a good quality and quantity of water.

Table 5 provides a synthesis of the amounts households would be WTP in Emalangeni/household/month. It is interesting to note that rural households are WTP a higher amount of money for an improved water quantity despite their much lower income. On the other side, urban households are more concerned with (and WTP more for) an improved water quality.

Table 5: WTP in Emalangeni/household/month for improved quantity and quality of water

	Rural		Urban	
	Mean	**St. Dev.**	**Mean**	**St. Dev.**
WTP for quantity	7.13	10.34	6.82	17.72
WTP for quality	6.44	7.93	16.40	27.73

3.3 Contingent valuation approach

Two regression analyses were conducted adopting the model illustrated in the section above, where the probability that the household would be WTP for higher water quantity was the dependent variable for the first regression, and the probability that the household would be WTP for an improved water quality was the dependent variable for the second regression. Probability of WTP was then related to a set of explanatory variables, including variables on demographic characteristics, socio-economic characteristics and water use/sources of the surveyed households. In estimating the determinants of WTP for improved water quantity and quality, some of the variables were not statistically significant, hence the decision to drop them from either the quantity or the quality regression model was taken. The statistically significant variables for both WTP regression models were: income, water consumption, source of water, age and gender of the head of the household. Variables excluded from one model but included in the other were: collection time and practice of taking avoidance measures against water-borne diseases (dummy). Results of the regression illustrating the probability of WTP for improved water quantity are summarised in Table 6.

Table 6: Tobit results of WTP for improved water quantity

Tobit estimates		Number of obs = 332		
		LR chi2 (4) = 89.74		
		Prob > chi2 = 0.0000		
Log likelihood = -562.25188		Pseudo R2 = 0.0739		
WTP quantity	Coefficient	Std. Err.	t	P>| t |
HHINC	0.0023869	0.0006784	3.52	0.000***
WATCON	-3.12434	0.918313	-3.40	0.001***
CLT	0.5708033	0.0789491	7.23	0.000***
WATSOC	-18.21501	5.284404	-3.45	0.001***
AGE	0.2747466	2.275221	0.12	0.029**
GENDER	1.759339	1.230838	1.43	0.061*
Constant	-18.97918	7.339519	-2.59	0.010
Standard error	31.83606	2.577452	(Ancillary parameter)	
Obs. summary: 234 left-censored observations at WTP quantity <=0 98 uncensored observations				

One, two or three asterisks (*) means statistical significance at the 10%, 5% and 1% test levels respectively.

The variable Household Income (HHINC) had a positive and statistically significant, impact on WTP for quantity[5]. Households with higher income are therefore more willing to pay for improved water services. HHINC was perfectly collinear with the variable education level of the household's head, and thus the latter was dropped from the regression model.

Water Consumption (WATCON), was also statistically significant, but with a negative sign when regressed on WTP for quantity. This result is quite intuitive too. The negative sign means that the more a household consumes water, the less that household is WTP to have an improved water availability in terms of quantity. Households consuming little water are those living in rural areas, characterised by large sizes and lower income. They are more likely to be WTP for improved water availability than their urban counterparts, who already have more reliable and better water sources.

Collection Time (CLT), was also statistically significant at all levels with a positive sign, as expected from the literature (Marrett, 2002). This suggests a negative relationship between availability of water and the distance or time taken to collect the water. Households walking long distances to collect water on a daily basis (from collective taps but particularly from the river) are more likely to be WTP for a nearby source.

The variable Source of Water (WATSOC), was statistically significant with a negative coefficient for WTP for quantity. Households that have a regular supply of private tap water were less willing to pay for improvements in the quantity. These households are more likely to choose to maintain the status quo. Conversely, the worse the opinion of the household about the water availability is (e.g river water users), the more a household would be WTP for its improvement. These results are consistent with the findings by Kolstad (2002).

AGE and GENDER of respondents both had a statistically significant and positive effect on the household's WTP. Older heads of households have higher WTP for quantity than their younger counterparts, while male household heads have lower WTP than female household heads. This result could be explained by the fact that older women are usually involved in collecting water. They are the ones who are most likely to perceive the strain of walking long distances when collecting water.

Results of the model for WTP for improved water quality are summarised in Table 7.

Table 7: Tobit results of WTP for improved water quality

Log likelihood = -585.16578		Number of obs = 226		
		LR chi2(5) = 89.47		
		Prob > chi2 = 0.0000		
Tobit estimates		Pseudo R2 = 0.0710		
WTP quality	Coefficient	Std. Err.	t	P>| t |
LOC	-77.37195	11.69755	-6.61	0.000***
PAB	38.68821	6.638338	5.83	0.000***
AGE	0.1444255	0.0818122	1.77	0.078*
GENDER	0.7601581	1.320938	0.58	0.066*
HHINC	0.005284	0.000762	6.93	0.000***
WATCON	0.5685311	0.1794684	3.17	0.002**
Constant	15.47005	7.381161	2.10	0.037
Standard error	34.65609	2.607959	(Ancillary parameter)	
Obs. summary: 120 left-censored observations at WTP quality <=0 106 uncensored observations				

One, two or three asterisks (*) means statistical significance at the 10%, 5% and 1% test levels respectively.

The Location of the Household (LOC) is an important variable explaining household's WTP for improved water quality. The regression coefficient was statistically significant. This implies that the rural respondents are more likely to be WTP for water quality improvement than urban households. This result is consistent with the previous findings and is a consequence of the serious water quality problems due to poor provision services in the rural areas.

The vector of variables for Presence of Small Children in the Household was dropped from the model because of a multicollinearity problem. This variable was perfectly collinear with the variable Household Practicing Avoidance Measures. However households with small children seem highly concerned with health risks posed by using contaminated water. As a consequence, the regression coefficient for Practicing Avoidance Measures (PAB), was statistically significant at all three test levels and positive.

Current Water Consumption (WATCON), was statistically significant and positive when regressed on WTP for quality. This is an interesting result especially when compared to the earlier finding that the WATCON coefficient for improved water quantity was negative. The interpretation is that the more a household consumes water, the more that household is WTP for a better quality; in fact while its needs for quantity are satisfied, household's concerns shift towards quality aspects.

Source of water (WATSOC) was statistically significant and negative. This means that as the users' appreciation of the water quality increases (e.g for indwelling tap users), their WTP declines.

Variables HHINC, AGE and GENDER have the same signs and significance as in the model illustrated in Table 6.

4. Conclusions

This paper uses the contingent valuation method to analyse the determinants of Swazi households' willingness to pay for an improvement in their available water quantity and quality. The study was conducted on a sample of 374 households, of which 127 (34%) were from the rural area and 247 (66%) were from the urban area. A Tobit model was applied to the data generated by the survey to explain the determinants of households' WTP for improved quality and quantity of domestic water supply.

Location of the households (urban/rural) was the most statistically significant criterion to explain both the probability to be WTP, and the amount of money a household is prepared to pay for improved water services. Rural respondents were more likely to be WTP for water quantity improvement and, surprisingly, their bids were quantitatively higher than those coming from urban households, showing a real struggle for a better, closer and more reliable source of water in rural areas. Rural households are also more likely to be WTP for water quality improvements. Urban households are ready to propose higher bids to improve their quality of water, due to their higher income.

Regressions' results also show that, regardless of household location, income has a positive and statistically significant impact on WTP for both quality and quantity. Similarly, distance to the water source is positively associated with WTP for water quantity and quality. Current water consumption is also statistically significant, but with a negative sign when regressed on WTP for improved water quantity. On the other hand, the more a household consumes water, the more that household is WTP for a better quality; in fact, while its needs for quantity are satisfied, households' concerns shift towards quality aspects. The current source of water is also a statistically significant determinant for households' WTP for both improved quantity and quality. In this case, households with in-dwelling tap water are less WTP than households fetching water at collective taps or from the river.

Overall, results confirm that water service levels are important to Swazi households, which are willing to pay for incremental changes in service levels. There is, therefore, scope to improve water service provision in Swaziland even at a higher water price. This was acknowledged for some time in the context of other services, such as electricity provided in the country, but evidence in the water sector is still lacking. More precisely, the estimates of WTP obtained in this study indicate the possibility of introducing a demand-driven program to expand the coverage of rural tap water schemes.

Acknowledgments

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Notes:

1. *1 Lilangeni is equivalent to approximately 15 US cents.*
2. *These included boiling water, filtering and chlorification.*
3. *Mbabane, Manzini, Nhlangano, Piggs Peak, Siteki, Big Bend, Mhlume, Hlatikulu, Lavumisa, Mhlume and Lobamba.*
4. *From a mother population of 233 843 households, a uniform sampling fraction equal to 0.0016 was chosen, leading to a total of 374 households, of which, accordingly to the weight of the two strata, 127 (34%) were from the rural area and 247 (66%) were from the urban area.*
5. *The same impact was observed for the variable HHINC on WTP for quality.*

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