INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR

ETHIOPIAN DEVELOPMENT RESEARCH INSTITUTE

ESSP II Working Paper 32

Access to Improved Water Source and Satisfaction with Services

Evidence from Rural Ethiopia

Degnet Abebaw, Fanaye Tadesse, and Tewodaj Mogues

Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program II, Ethiopia

Ethiopia Strategy Support Program II (ESSP II)

ESSP II Working Paper 32

December 2011

IFPRI-ADDIS ABABA
P.O. Box 5689
Addis Ababa, Ethiopia
Tel: +251-11-646-2921
Fax: +251-11-646-2318
E-mail: ifpri-addis@cgiar.org
http://essp.ifpri.info/

IFPRI HEADQUARTERS
International Food Policy Research Institute
2033 K Street, NW • Washington, DC 20006-1002
USA
Tel: +1-202-862-5600
Skype: IFPRIhomeoffice
Fax: +1-202-467-4439
E-mail: ifpri@cgiar.org
http://www.ifpri.org

THE ETHIOPIA STRATEGY SUPPORT PROGRAM II (ESSP II) WORKING PAPERS

ABOUT ESSP II

The Ethiopia Strategy Support Program II is an initiative to strengthen evidence-based policymaking in Ethiopia in the areas of rural and agricultural development. Facilitated by the International Food Policy Research Institute (IFPRI), ESSP II works closely with the government of Ethiopia, the Ethiopian Development Research Institute (EDRI), and other development partners to provide information relevant for the design and implementation of Ethiopia's agricultural and rural development strategies. For more information, see http://www.ifpri.org/book-757/ourwork/program/ethiopia-strategy-support-program or http://essp.ifpri.info/ or http://www.edri.org.et/.

ABOUT THESE WORKING PAPERS

The Ethiopia Strategy Support Program II (ESSP II) Working Papers contain preliminary material and research results from IFPRI and/or its partners in Ethiopia. The papers are not subject to a formal peer review. They are circulated in order to stimulate discussion and critical comment. The opinions are those of the authors and do not necessarily reflect those of their home institutions or supporting organizations.

This paper was previously published as IFPRI Discussion Paper 01044, *Access to Improved Water Source and Satisfaction with Services. Evidence from Rural Ethiopia.* by Degnet Abebaw, Fanaye Tadesse, and Tewodaj Mogues

---

About the Author(s)

Degnet Abebaw: Senior Research Fellow, Poverty and Human Resources Research Division, Ethiopian Economics Association/Ethiopian Economic Policy Research Institute

Fanaye Tadesse: Research Officer, Ethiopia Strategy Support Program II, International Food Policy Research Institute

Tewodaj Mogues: Research Fellow, Development Strategy and Governance Division, International Food Policy Research Institute

Access to Improved Water Source and Satisfaction with Services

Evidence from Rural Ethiopia

Degnet Abebaw, Fanaye Tadesse, and Tewodaj Mogues

Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program II, Ethiopia

Table of Contents

List of Tables

Abstract

In recent years access to safe and reliable water supplies has received increased government attention in Ethiopia. As a result, the national coverage rate for this service has gradually improved. Yet millions of people in rural areas still do not get drinking water from an improved water source. While expanding improved water source schemes is generally essential, it is equally important to ensure that the schemes have increased users' satisfaction with water quality and availability for everyday use. Using household survey data and employing univariate and bivariate probit models, this paper attempts to investigate the effect of access to an improved water source on users' satisfaction with both quality and availability of water. The study findings suggest that access to an improved water source significantly raised household satisfaction with both quality and availability of water. However, the effect of the improved water source on users' satisfaction was slightly lower for water availability than for water quality.

Keywords: drinking water, users' satisfaction, bivariate probit, Ethiopia

1. Introduction

Access to and use of safe drinking water can make an immense contribution to health, productivity, and social development. However, many people in developing countries continue to rely on unimproved water sources. According to the United Nations Development Program (UNDP 2006), nearly one-sixth of the world's population obtains drinking water from unimproved sources, and in many developing areas, progress in expanding clean water coverage is modest. In Sub-Saharan Africa, for instance, the proportion of the population that depends on unimproved sources has declined only slightly, from 52 percent in 1990 to 44 percent in 2004 (UNDP 2006). As part of the Millennium Development Goals, the international community has set a goal of reducing the proportion of people without sustainable access to safe drinking water by 50 percent by 2015 compared to its level in 1990 (UN 2010).

However, whereas expanding improved water infrastructure is necessary, that alone does not guarantee safety and adequacy of water to its users: Access is an intermediate output and has to be combined with favorable demand to generate desired outcomes among users (Larson, Minten, and Razafindralambo 2006). Recent evidence from empirical research (for example, Vasquez et al. 2009; Kleemeier 2000) also indicates that improved water supply schemes in many developing countries are not functioning properly. In Sub-Saharan Africa, for instance, it is estimated that 35 percent of all rural water systems are not functioning (Baumann 2005). Other authors (Vasquez et al. 2009; Deichmann and Lall 2007) also cited drinking water safety and reliability as key problems even when the basic water delivery systems are in place. Thus, "in addition to increasing access through implementation of improved water supplies, it is also necessary to ensure that both new and existing water systems are sustainable, so that access to safe water is sustained for all" (Harvey 2008, 117).

However, despite the importance of providing safe and reliable drinking water for poverty reduction and social development, relatively little is known regarding users' satisfaction with rural drinking water services in developing countries, particularly in Sub-Saharan Africa. Investigating users' evaluation of these services is increasingly seen as an important means for improving the performance of public services (Deichmann and Lall 2007). This paper attempts to shed light on this issue for rural households in Ethiopia. Our main purpose is to examine the sources of drinking water used by people in remote rural localities and to investigate whether access to an improved water supply has increased users' satisfaction with quality and availability. The paper uses survey data collected in 2009 from 1,117 rural households residing in eight districts.

The remainder of the paper is structured as follows. The next section presents background information on the drinking water situation in Ethiopia. Section 3 describes the empirical model and the data source used for this paper. Section 4 presents and discusses the results, followed by conclusions and policy implications in Section 5.

2. Background information: Drinking water supply in Ethiopia

Ethiopia has long been characterized by limited access to safe drinking water and sanitation services. In 1990, for instance, only 19 percent of the country's population had access to a safe drinking water supply (MoFED 2008). By 2007 this figure had reached 52 percent (*ibid.*). Table 2.1 gives an overview of Ethiopia's safe drinking water coverage for some selected years.

Table 2.1. Percentage of Ethiopia's population with access to safe drinking water, selected years

	1996	1998	2000	2004	2006	2007
Rural	10.0	14.0	17.0	25.0	41.2	46.4
Urban	72.0	84.0	92.0	92.0	78.8	82.0
Total	19.0	24.0	28.0	36.0	47.3	52.5

Source: MoFED 2007.

Even though coverage of safe drinking water supply has gradually increased at the national level, the rate is still very low. Inadequate quality of drinking water also remains a major cause of health problems and poor sanitation in rural areas of Ethiopia. The unavailability of safe drinking water in most rural locations is one of the main causes of diarrhea among children under the age of five (CSA 2006). The negative health impact of contaminated water is exacerbated because more than 90 percent of households consume this water untreated. Previous empirical studies elsewhere (see, for example, Jalan and Ravallion 2003; Esrey 1996) also show that access to improved water is an important contributor to improved child health and mortality reduction.

In Ethiopia, the problem of drinking water supply is further compounded by physical distance. A recent estimate reveals that about 52 percent of the population traveled half an hour or more to collect water every day (CSA 2006). This long travel distance to the nearest water source directly affects women and children, who are mainly responsible for fetching water. This has an implication on the productivity of women. The long hours spent in fetching water take a significant amount of time that could be employed in other income-generating activities. The human capital implication for young girls cannot be overlooked as well. Most girls in Ethiopia find it too difficult to attend and succeed in school because a significant amount of their time is used for domestic chores, including fetching water.

In recognition of the deep-rooted water problems in the country, especially in rural areas, the government has increased resource allocation to provide safe drinking water for its inhabitants. As a result, the proportion of government expenditure that went to water and sanitation infrastructure development grew from 2.8 percent to 4.5 percent between 2000/01 and 2004/05 (MoFED 2006) and access to improved water supply increased from about 19 percent to 52.5 percent between 1996 and 2007 (MoFED 2008). However, access still varies strongly across geographic regions in the country, and the problem is more pronounced in rural than in urban areas. Moreover, as in many other countries in Sub-Saharan Africa, the water facilities may not be operating properly due to various technical problems. According to a recent survey (WSP 2004 cited in UNDP 2006), 29 percent of hand pumps and 33 percent of mechanized boreholes were not functional, mainly due to lack of maintenance.

3. Framework and methodology

The measurement and analysis of satisfaction has received increased research focus in various disciplines, including economics, public administration, psychology, and marketing. As indicated in Deichmann and Lall (2007), satisfaction can be modeled as a function of (1) citizens' prior anticipation of the performance of a product or service, and (2) the actual performance, as perceived by them. In other words, "expectation serves as an anchor to the evaluation of performance" (Deichmann and Lall 2007, 652).

In applied research, measuring satisfaction with services is a difficult task. However, it is assumed to be potentially related to personal and economic characteristics such as age, gender, education, income, and wealth. Previous studies in economics indicate that women and older people have greater levels of satisfaction but that satisfaction levels strongly decline as the level of education increases (Clark and Oswald 1996).

Empirical studies of client satisfaction with public service delivery have received increased attention in recent years. For example, Van Ryzin's (2004) empirical work conforms with the model by Deichmann and Lall (2007), finding that citizen satisfaction with urban services is closely associated with the actual performance of the services versus citizens' initial expectations about these services. The latter study provides empirical evidence on the determinants of client satisfaction with public services using a microeconometric approach. These authors have found that wealthier households are more satisfied with the number of hours water is available than are poorer households. But they also have reported that satisfaction levels significantly decrease with household size and among male-headed households.

3.1. Empirical model

This section outlines the empirical model we use to explain households' satisfaction with drinking water supply services. In particular, we focus on water quality and availability from the major drinking water sources used by households. As such, the dependent variables represent the degree to which respondents are satisfied with the availability and quality of the water they obtain from the main source. As indicated in the next subsection, relevant data on these issues were provided by the main persons responsible for fetching water to the household by administering survey questionnaires to both spouses. When the husband and the wife express sharing responsibility for fetching water, we use the data from the wife's response since she will usually have more exposure to and knowledge about water availability and quality for domestic use.

In this paper, drinking water sources are classified into two categories: improved water source and unimproved water source. This classification is used to facilitate our empirical analysis of the extent to which obtaining access to water sources regarded as improved increases the intended users' satisfaction with water quality and availability. A household is considered to have access to an improved water source if it gets drinking water primarily from a private standpipe, a public standpipe, a protected spring, a dug well with a pump, rain water, a water vendor, or a tank truck. Sources such as rivers, lakes, ponds, and unprotected wells are regarded as unimproved water sources.

Suppose S denotes the observed satisfaction level reported by a household. S takes a value of one if the household is "very satisfied" or "satisfied" with the quality and availability of water, zero otherwise.[1] The observed response variable S is related to an unobserved latent variable S^* as follows:

$$S_i = 1 \text{ if } S_i^* = \alpha_{1i} X_i + \alpha_{2i} W_i + \varepsilon_{1i} > 0 \text{ and}$$
$$S_i = 0 \text{ if } S_i^* = \alpha_{1i} X_i + \alpha_{2i} W_i + \varepsilon_{1i} \leq 0, \qquad (1)$$

where X is a vector of socioeconomic variables, W is a dummy variable with a value of one if the major drinking water source is an improved source and zero otherwise, α_1 is a vector of parameters to be estimated, α_2 is the coefficient of interest, ε_1 is a disturbance term with $E[\varepsilon_{1i}] = 0$ and $\text{var}[\varepsilon_{1i}] = 1$, and i indexes households.

Equation (1) gives an unbiased parameter estimate of α_2 assuming that W is an exogenous variable. However, there is a concern regarding the validity of this assumption deriving from factors that may affect placement of facilities. Along this line, previous studies (Larson, Minten, and Razafindralambo 2006; Briand et al. 2009) show that the type of water source used by households in developing countries is related to their socioeconomic status, among other factors. From the supply side, service providers (such as government, nongovernmental organizations, and community-based organizations) may also use demand factors or local need to construct improved water schemes in rural areas. Factors that influence the choice and placement of improved sources lead to misleading conclusions if (1) these factors cannot be captured through appropriate location and other variables included as right-hand variables, and (2) there is some reason to think that non-captured (and thus omitted) variables are likely to be correlated with the dependent variable of satisfaction.

Simultaneity may also become another source of endogeneity. Households that, for whatever reason, have been and continue to be quite satisfied with their unimproved source are likely to stick to this source even if an improved water source a bit further away or requiring user fees becomes available. To the extent that these circumstances are true, simple comparisons of satisfaction rates of households fetching water from improved sources and of households getting water from unimproved sources would lead to biased results. Thus, to test and control for possible endogeneity of the water source choice variable in our satisfaction model, we construct a bivariate probit model.[2] Latent variables that define choice of water source and reported satisfaction with water quality and availability are as follows:

$$S_i^* = \alpha_{1i} X_i + \alpha_{2i} W_i + \varepsilon_{1i}$$
$$W_i^* = \beta_{1i} X_i + \beta_{2i} Z_i + \varepsilon_{2i}$$
$$E[\varepsilon_{1i}] = E[\varepsilon_{2i}] = 0, \text{var}[\varepsilon_{1i}] = \text{var}[\varepsilon_{2i}] = 1 \text{ with } \text{cov}[\varepsilon_{1i}\varepsilon_{2i}] = \rho, \qquad (2)$$

where $W = 1 \, if \, W^* \succ 0$ and $W = 0 \, if \, W^* \leq 0$, $S = 1 \, if \, S^* > 0$ and $S = 0 \, if \, S^* \leq 0$, X is a vector of exogenous variables, and Z is a vector of instrumental variables. ρ measures the correlation between unobserved or omitted factors in the source and the satisfaction equations. α_1, β_1, and β_2 are vectors of regression parameters to be estimated, and α_2 is the coefficient of interest. The variables S^*, X_i, and W_i are defined as before. A Wald test of

---

[1] Initially, respondents were asked to report their satisfaction levels on a four-point Likert scale (4 = very satisfied; 3 = satisfied; 2 = dissatisfied; 1 = very dissatisfied).

[2] A bivariate probit model is an appropriate model when a dependent variable and an endogenous explanatory variable are both binary (Wooldridge 2002).

ρ is employed to test the exogeneity of S and W (Wooldrige 2002). If ρ is not significantly different from zero, then equations (1) and (2) can be estimated using univariate probit models. However, when ε_1 and ε_2 are not independent, estimating equations (1) and (2) jointly in a bivariate probit framework will provide consistent estimates.

3.2. Sampling procedure and data

The empirical data for this paper were collected as part of a larger study of agricultural and rural public services by EEA (Ethiopian Economics Association) and IFPRI (International Food Policy Research Institute) in Ethiopia (EEA/IFPRI 2009). A multistage sampling procedure was used for the selection of observation units. First, eight districts were purposively chosen from seven administrative regions (two districts from Amhara and one each from Afar, Benishangul Gumuz, Gambella, Oromia, SNNPR (Southern Nations, Nationalities and People's Region), and Tigray). Second, we randomly selected 32 *kebeles*[3] (4 *kebeles* per district). Finally, we randomly drew 1,120 households from the 32 *kebeles*. The questionnaire included several modules, and all the questions were translated into the Amharic language. The questionnaire was administered separately to both spouses of the household. Data collection took place between January and March 2009. The survey collected data on various topics, including drinking water and agricultural services such as extension, credit, and cooperative services. It also included standard demographic and social variables and household asset information. Through *kebele*-level questionnaires, it collected information about community assets and infrastructure.

[3] A *kebele* is the smallest administrative unit in Ethiopia.

4. Results and discussion

4.1. Descriptive statistics

Table 4.1 shows descriptive summary characteristics of the sample households used in our empirical analysis. By construction, the sample households are almost equally divided among the eight survey districts. In terms of drinking water supply, about 29 percent of the households in our sample obtain drinking water from sources regarded as improved. Interestingly enough, we do not see any significant seasonal variation in terms of access to an improved water source in our study areas. However, perceived satisfaction with the quality and availability of water shows some degree of variation between dry and rainy seasons (see Table 4.3 for further details).

Table 4.1. Description of variables and summary statistics

Variable	Definition	Obs.	Mean	Std. dev.
Dependent variables				
Water source	1= improved; 0 = otherwise	1117	0.289	0.453
Water quality	1 = satisfied; 0 = otherwise	962	0.522	0.499
Water availability	1 = satisfied; 0 = otherwise	963	0.698	0.458
Independent variables				
Age	Age of head of household in years	1112	43.289	14.949
Sex	1 = male; 0 = female	1117	0.783	0.412
Education	education of household head, 1 = literate; 0 = otherwise	1112	0.388	0.487
Adult females	Proportion of adult (age > 15) females in the household	1117	0.617	0.486
Household size	Number of persons in the household	1117	5.681	2.517
Radio	1 = owns a radio; 0 = otherwise	1114	0.314	0.464
Ox	1 = household owns an ox; 0 = otherwise	1113	0.489	0.500
Pack animal	1 = household owns a pack animal; 0 = otherwise	1113	0.309	0.462
Light	1 = main source of light is non-biomass fuel; 0 = otherwise	1112	0.649	0.477
Roof	1 = roof of house is mainly made of iron sheet; 0 = otherwise	1112	0.177	0.382
Latrine	1 = household has an improved latrine; 0 = otherwise	1112	0.337	0.472

Source: Authors' computation based on EEA/IFPRI 2009.

The descriptive statistics in Table 4.1 indicate that 78 percent of the households in our sample are headed by males. Education of household head is fairly low. The fraction of the sample household heads who can read and write is just 39 percent. Overall, our sample households are characterized by limited access to sanitation and mass media information. The proportions of households who use improved latrines and own a radio stand at only 34 percent and 31.4 percent, respectively. Nearly one in three households in the sample possesses a pack animal. The descriptive results (not presented here) indicate that women and children are responsible for fetching water in more than 90 percent of the sample households.

Table 4.2 presents the types of water sources used among the sample households. As in other developing countries, households in our sample utilize more than one type of water source for drinking and other purposes. However, the descriptive results presented in Table 4.2 are based on the major source of drinking water used by the sample households. Sources of drinking water include private standpipe, public standpipe, dug well, protected and unprotected spring, rivers, lakes, ponds, and rain water. Despite the multiplicity of sources, each household was also asked to report the primary water source used by the family. For instance, surface water obtained from rivers, lakes, and ponds is the major source of drinking water for about 58 percent of the households in our sample. Access to improved water sources remains limited. The proportion of households who own a private standpipe or tap is just below 1 percent. Moreover, the proportion of households who get water from a public standpipe is only about 4 percent.

Table 4.2. Principal sources of drinking water (%)

	Wet season	**Dry season**
River, lake, or pond	57.98	58.14
Dug well with pump	24.07	23.75
Public standpipe	4.11	4.31
Unprotected spring	4.11	4.12
Protected spring	3.53	3.74
Water vendor	1.91	0.57
Rain water	1.91	0.10
Water truck	0.67	0.10
Private standpipe or tap	0.57	0.57
Other	0.19	0.57
Dug well without pump	0.00	4.02

Source: Authors' computation based on EEA/IFPRI 2009.

Respondents were asked to report their satisfaction with the availability and quality of water from their principal source of drinking water. Unfortunately, the survey did not include the collection of water samples to directly determine water availability and quality. Our analysis is thus dependent on respondents' own assessment of the adequacy and quality of the sources they use.

Table 4.3 presents a descriptive summary of the association between sources of drinking water and households' reported satisfaction. As expected, the descriptive results reveal strong association between the type of drinking water source the households use and their reported satisfaction. In general, households who obtain their drinking water from improved sources are more satisfied with both availability and quality of water. However, household satisfaction with the availability of water is lower than satisfaction with quality. As expected, households who obtain their drinking water from an improved source are more satisfied with both water quality and availability than those who fetch it from an unimproved source. The survey result also indicates that satisfaction rates are slightly lower in the dry season than in the wet season. These results imply households' perception of the need for improvement of drinking water services.

Table 4.3. Household satisfaction with drinking water supply by water source and season

Water services	Respondent is satisfied with the water service	Water source		Pearson chi2 value
		Unimproved	Improved	
Water quality	Wet season	41.99%	90.03%	202.83***
	Dry season	39.01%	90.28%	227.79***
Water availability	Wet season	77.48%	91.59%	29.05***
	Dry season	65.53%	83.02%	31.85***

Source: Authors' computation based on EEA/IFPRI 2009.
Note: *** = significant at 1%.

We also asked dissatisfied households to report their main reasons for dissatisfaction. Experiences of respondents with respect to water quality show considerable variation across the sample (see Table 4.4). The main causes of dissatisfaction include bad water color, presence of dirt substance, and bad smell. Many households also suffered illness from water-borne diseases. It is again of note that respondents' opinions regarding water quality problems are quite similar between wet and dry seasons.

Table 4.4. Reasons for dissatisfaction with water quality from the primary source (%)

	Wet season	Dry season
Dirt substance (visible pollution)	54.01	52.61
Bad color	23.54	17.12
Bad taste	7.78	8.35
Bad odor	7.34	10.02
Felt sick after drinking it	7.34	8.14
Other	0.00	3.76

Source: Authors' computation based on EEA/IFPRI 2009.

Respondents were also asked the main reasons for unavailability of water at their primary water sources. As indicated in Table 4.5, most respondents indicated inadequate water quantity in the source as the major problem, followed by broken facilities. Similar problems are reported by households for both wet and dry seasons.

Table 4.5. Reasons for non-availability of water at the primary source (%)

	Wet season	Dry season
Not enough water in source	81.4	87.4
Facility broken	16.2	10.4
Other	2.3	2.3

Source: Authors' computation based on EEA/IFPRI 2009.

4.2. Estimation results

Tables 4.6 to 4.8 present the estimation results of our empirical model. The Wald statistics indicate that the model specifications for our estimations have good explanatory power. Table 4.6 indicates univariate probit estimation results of factors influencing the access to an improved water source. As the results show a host of demographic, socioeconomic, and location characteristics have strong influence on household access to an improved source of drinking water in the study areas.

Table 4.6. Univariate probit estimation of household access to an improved source of drinking water

Variable	Coefficients	Standard error	Marginal effect
Intercept	-0.327	0.297	
Age	-0.002	0.004	-0.001
Gender	-0.208*	0.128	-0.066
Education	0.178*	0.109	0.055
Adult females	-0.197	0.279	-0.06
Under-five children	-0.008	0.117	-0.002
Household size	0.018	0.023	0.006
Radio	-0.026	0.111	-0.008
Ox	0.039	0.113	0.012
Pack animal	-0.126	0.121	-0.038
Light	0.304**	0.131	0.089
Roof	0.619***	0.142	0.211
Latrine	0.209*	0.121	0.066
No. of obs.	1102		
Observed probability	0.28		
Predicted probability (at x bar)	0.23		
Pseudo LL	-539.06		
Wald (chi2)	217.17***		

Source: Authors' computation based on EEA/IFPRI 2009.
Notes: District fixed effects were used in the regression.
*** significant at 1%, ** significant at 5%, * significant at 10%.

The variables relating to roofing and lighting of the household are significantly and positively associated with the dependent variable. Education of the head of household has a positive and close-to-significant relationship. In other words, households whose heads can read and write have a higher probability, by 5.5 percentage points, of getting drinking water from an improved source than do households with a nonliterate head. Contrary to our anticipation, female-headed households have a greater probability of using an improved source than do male-headed households. There may be several reasons for this result. First, women, along with children, are the main persons responsible for fetching water and other domestic chores, and as heads and decision makers, they may be more inclined to invest in the effort of fetching clean water. Second, as studies elsewhere indicate, women are more risk-averse than men and hence want to minimize water-borne illnesses by using improved sources of water available to them.

Households headed by older individuals have a lower probability of obtaining water from an improved source than those with younger heads, although this relationship is statistically weak. As expected, households who use an improved latrine are 6.7 percentage points more likely to also obtain drinking water from an improved source than their counterparts without an improved latrine.

Table 4.7 presents univariate (single-equation) probit and bivariate probit estimates for users' satisfaction with the quality of water. As noted earlier, the equations take into account a host of control variables apart from the water source variable. The parameter estimate for ρ has a statistically significant and positive coefficient, suggesting the rejection of the hypothesis that the error terms of the two equations are not related. In this regard, bivariate probit estimation is more appropriate than the single-equation probit model. The main implication here is that unobserved or omitted factors determining the probability of obtaining drinking water from an improved source also determine the likelihood of users' satisfaction with the quality of water obtained from the source.

Table 4.7. Estimation results of household satisfaction with water quality

Variable	Univariate			Bivariate		
	Coeff.	**Std. Error**	**Marg. eff.**	**Coeff.**	**Std. Error**	**Marg. eff.**
Intercept	-0.595*	0.304		-1.111***	0.257	
Age	0.0004	0.004	0.0002	-0.001	0.004	0.00002
Gender	0.085	0.142	0.034	0.165	0.123	-0.001
Education	-0.191	0.122	-0.075	-0.261**	0.111	-0.001
Under-five children	-0.034	0.124	-0.013	-0.051	0.113	-0.002
Household size	0.018	0.026	0.007	0.006	0.022	0.0003
Radio	0.196*	0.121	0.078	0.174	0.109	0.003
Ox	-0.072	0.121	-0.029	-0.073	0.111	-0.0002
Pack animal	0.016	0.134	0.006	0.073	0.119	-0.0006
Latrine	0.004	0.152	0.002	-0.094	0.125	0.0012
Roof	0.071	0.145	0.028	-0.154	0.143	0.0104
Water source	1.859***	0.146	0.598	2.864***	0.106	0.253
No. of obs.		951			951	
Pseudo LL		-442.75			-919.51	
Wald chi2 (df)		432.74*** (df=18)			860.8*** (df=36)	
$\rho\ (\varepsilon_{1i}, \varepsilon_{2i})$				-0.923		
Wald test of $\rho\ (\varepsilon_{1i}, \varepsilon_{2i}) = 0$ Chi2(1)				3.864**		
LR test of instrument variable for access to an improved water source ('lighting' variable) Chi2(1)					4.56**	

Source: Authors' computation based on EEA/IFPRI 2009.
Notes: District fixed effects were used in all regressions.
*** significant at 1%, ** significant at 5% ,* significant at 10%.

In Tables 4.7 and 4.8, the coefficient estimates of the water source equations are not reported for brevity's sake. However, these results were closely similar to the one presented in Table 4.6. To ensure identification we have included the variable 'lighting' in the water source equations but not in the satisfaction equations in both bivariate models. We found that access to non-biomass energy for lighting has a statistically significant effect on the likelihood of obtaining drinking water from an improved water source.[4] In particular, the 'lighting' variable has statistically significant coefficient of 0.281 (std. error = 0.132) and 0.341 (std error = 0.155) on the water source equations, respectively associated with the satisfaction-with-water quality and satisfaction-with-water availability equations. The likelihood ratio (LR) test on the null hypothesis of no correlation between the 'lighting' variable and the possibly endogenous variable 'whether a household obtains its drinking water from an improved source' is significant at less than 5%.

[4] In a separate probit model, not reported here, we also estimated the effect of the same variable on households' satisfaction of water supply services and found that its influence is not statistically significant.

Table 4.8. Estimation results of household satisfaction with water availability

Variable	Univariate			Bivariate		
	Coeff.	**Std. Error**	**Marg. eff.**	**Coeff.**	**Std. Error**	**Marg. eff.**
Intercept	0.695**	0.274		0.0664	0.846	
Age	-0.004	0.004	-0.001	-0.004	0.004	0.003
Gender	-0.198	0.131	-0.064	-0.197	0.174	-0.232
Education	-0.051	0.115	-0.017	0.056	0.158	0.211
Under-five children	-0.0004	0.115	-0.0001	-0.003	0.118	-0.018
Household size	-0.01	0.023	-0.003	-0.01	0.026	0.03
Radio	0.182	0.114	0.059	0.186*	0.115	0.009
Ox	-0.057	0.114	-0.019	-0.058	0.12	0.052
Pack animal	-0.142	0.127	-0.048	-0.144	0.154	-0.187
Latrine	-0.201	0.141	-0.068	-0.209	0.194	0.196
Roof	-0.032	0.139	-0.011	-0.04	0.291	0.557
Water source	0.812***	0.113	0.240	0.869	1.676	0.341
No. of obs.			951			951
Pseudo LL		-520.96			-998.78	
Wald chi2 (df)		112.08*** (df=18)			251.17*** (df=36)	
$\rho(\varepsilon_{1i}, \varepsilon_{2i})$				-0.038		
Wald test of $\rho(\varepsilon_{1i}, \varepsilon_{2i})$=0 Chi2(1)				0.0014		
LR test of instrument variable for access to an improved water source ('lighting' variable) Chi2(1)					4.83**	

Source: Authors' computation based on EEA/IFPRI 2009.
Notes: District fixed effects were used in all regressions. Wald test of rho = 0: chi2(1) = 1.461 Prob > chi2 = 0.227.
*** significant at 1%, ** significant at 5%, * significant at 10%.

In Table 4.7, the bivariate probit estimation result shows that having access to an improved water source significantly increases users' satisfaction with water quality. Put in other terms, a household that gets its drinking water from an improved source has a higher probability, by 60 percentage points, of being satisfied with water quality than one that gets its water from an unimproved source. In fact, Table 4.7 also gives evidence that apart from the type of water source, satisfaction is determined by households' socioeconomic and location characteristics. Keeping other factors constant, households with a literate head are significantly less satisfied with the quality of water they use for drinking than are households with a nonliterate head.

The parameter estimates of most of the control variables are largely consistent between the two estimation procedures. However, the effect of the endogenous variable, water source, on satisfaction is substantially lower when estimation is performed by bivariate probit. According to the bivariate probit estimate, obtaining drinking water from an improved water source increases household satisfaction by 25 percentage points. In the univariate probit model the large effect of the water source variable on household satisfaction can in large part be due to the strong positive relationship between the disturbances of the two equations.

In contrast to the satisfaction-with-quality equation, the bivariate probit model for water availability (see Table 4.8) does not yield a statistically significant correlation coefficient for ρ, even though the sign of the coefficient remains as expected. This means that a single-equation probit model can provide a consistent estimate of the effect of water source on users' satisfaction with availability of water. As expected, an improved water source has a significant and positive contribution to users' satisfaction with water availability. The magnitude of its effect on satisfaction with water availability is very similar to that on satisfaction with water quality (using the results from the bivariate probit estimation on water quality).

5. Conclusions

Increased access to clean water is an integral part of Ethiopia's economic development and poverty reduction policy. Recent official figures (MoFED 2008) indicate increased clean water coverage in the country. Despite the increased support provided to the sector, there are millions of people still depending on unsafe drinking water sources, especially in the rural areas of the country. Furthermore, coverage rates alone may understate the problem if poor satisfaction with the water quality and availability points to serious deficiencies in these aspects of water supply. In this regard, a recent survey (WSP 2004 cited in UNDP 2006) indicates that improved water infrastructure in rural Ethiopia is not functioning properly due to maintenance problems, suggesting that uncertainty regarding water availability remains a persistent challenge for the local population.

Thus, the main purpose of this paper has been to investigate whether or not improved water sources satisfy their users. The empirical data were collected from a random sample of 1,117 rural households residing in eight districts from seven regions of the country. We applied univariate probit and bivariate probit models to explain the effect of access to an improved water source on users' satisfaction with the quality and availability of water. Our regression analyses provide evidence that improved water sources have increased users' satisfaction with both quality and quantity of drinking water. However, in light of the substantial investments that water facilities entail, it is of interest that the results imply that having access to improved water entails an increase in satisfaction by only 25 percentage points. There are several possible reasons for this, including lack of awareness of the health benefits of clean water; deficiencies in water quantity coming from the facilities; long distances to travel to the facilities; and in-kind and monetary costs for facility construction and water use, which dampens households' enthusiasm for the facilities and affects satisfaction reporting, even if facilities do provide clean and (when reached) sufficient water. Future research should further investigate users' satisfaction with facilities intended to improve and increase provision of clean water in rural areas.

References

Baumann, E. 2005. Common RWSN context. Discussion Paper, St. Gallen, SKAT/RWSN.

Briand, A., C. Nauges, J. Strand, and M. Travers. 2009. "The impact of tap connection on water use: The case of household water consumption in Dakar, Senegal." *Environment and Development Economics* 15:107–126.

Clark, A. E., and A. J. Oswald. 1996. "Satisfaction and comparison income." *Journal of Public Economics* 61: 359–381.

CSA (Central Statistical Authority). 2006. Ethiopia Demographic and Health Survey. Addis Ababa, Ethiopia: CSA.

Deichmann, U., and S. V. Lall. 2007. "Citizen feedback and delivery of urban services." *World Development* 35 (4): 649–662.

Ethiopian Economics Association/International Food Policy Research Institute (EEA/IFPRI). 2009. Making Rural Service Provision Work for Women and the Poor: The Case of Agricultural and Water Supply Services in Ethiopia. Household Survey Dataset.

Esrey, S. A. 1996. "Water, waste and well-being: A multi-country study." *American Journal of Epidemiology* 43 (6): 608–623.

Harvey, P. 2008. "Poverty reduction strategies: Opportunities and threats for sustainable rural water services in Sub-Saharan Africa." *Progress in Development Studies* 8 (1): 115–128.

Jalan, J., and M. Ravallion. 2003. "Does piped water reduce diarrhea for children in rural India?" *Journal of Econometrics* 112:153–173.

Kleemeier, E. 2000. "The impact of participation on sustainability: An analysis of the Malawi rural piped scheme program." *World Development* 28 (5): 929–944.

Larson, B., B. Minten, and R. Razafindralambo. 2006. "Unraveling the linkages between the Millennium Development Goals for poverty, education, access to water and household water use in developing countries: Evidence from Madagascar." *Journal of Development Studies* 42 (1): 22–40.

MoFED (Ministry of Finance and Economic Development). 2006. *Plan for accelerated and sustained development to end poverty, 2005/06–2009/10.* Vol. 1. Addis Ababa, Ethiopia: MoFED.

________. 2007. *Building on Progress: A Plan for Accelerated and Sustained Development to End Poverty (PASDEP), Annual Progress Report 2006/2007*. Addis Ababa, Ethiopia: MoFED.

________. 2008. *Ethiopia: Progress towards achieving the Millennium Development Goals: Successes, challenges and prospects.* Addis Ababa, Ethiopia: MoFED.

UN (United Nations). 2010. United Nations Millennium Development Goals. Accessed at http://www.un.org/millenniumgoals/environ.shtml.

UNDP (United Nations Development Program). 2006. *Human development report 2006.* New York: UNDP.

________. 2009. *Human development report 2009.* New York: UNDP.

Van Ryzin, G. G. 2004. "Expectations, performance and citizen satisfaction with urban services." *Journal of Public Policy Analysis and Management* 23 (3): 433–448.

Vasquez, W. F., P. Mozumder, J. Hernandez-Arce, and R. Berrens. 2009. "Willingness to pay for safe drinking water: Evidence from Parral, Mexico." *Journal of Environmental Management* 90 (11): 3390-3400.

Wooldrige, J. 2002. *Econometric analysis of cross-section and panel data.* Cambridge, Mass., U.S.A.: MIT Press.

WSP (Water and Sanitation Program). 2004. *Ethiopia water supply sector resource flows assessment.* Sector Finance Working Paper 10. Nairobi: WSP.