RiPPLE

Water supply and sanitation (WSS) and Poverty

Micro-level linkages in Ethiopia

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Research-inspired Policy and Practice Learning in Ethiopia and the Nile region (RiPPLE) is a five-year research programme consortium funded by the UK's Department for International Development (DFID). It aims to advance evidence-based learning on water supply and sanitation (WSS) focusing specifically on issues of planning, financing, delivery and sustainability and the links between sector improvements and pro-poor economic growth.

RIPPLE Working Papers contain research questions, methods, preliminary analysis and discussion of research results (from case studies or desk research). They are intended to stimulate debate on policy implications of research findings as well as feed into Long-term Action Research.

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Acronyms

DAs	development agents
ETB	Ethiopian birr
GDP	gross domestic product
KAs	kebele associations
OLS	ordinary least squares
WSS	water supply and sanitation

Executive Summary

It is often argued that investments in water supply and sanitation (WSS) generate wide-ranging economic benefits. At the household level, improved access to WSS is expected to lead to significant improvements, not only in human health and welfare but also in levels of production and productivity. Because of these wide-ranging effects, investments in WSS are considered important instruments for poverty reduction but, while the expected benefits from investments in WSS are considerable, empirical evidence to support this remains quite limited. This study presents micro evidence, from a survey of 1500 households in Eastern Hararghe (Ethiopia), which enables a better understanding of the impacts of improved WSS access on health, timesaving and productive employment and poverty. Conclusions are drawn and policy implications discussed.

We find that access to improved water supply has a strong statistical association with increased volume of water consumed per household and a decrease in the average time spent fetching water. Both effects point to a significant timesaving of the household members responsible for fetching water. Household members with access to an improved source are more likely to participate in off/non-farm employment. Interestingly, households with access to improved water supply and productive water use (irrigation) have significantly lower overall and food poverty levels in terms of incidence, depth and severity. Our results also show that access to an improved water source significantly reduces the probability of illnesses, even more so if it is the source is located close by. We also find that improved water supply leads to a significant reduction in households' health expenditures. On the other hand, improved access also seemed to have a positive association with water-related illnesses, calling perhaps for mitigative measures to reduce incidence of water-related diseases.

This evidence clearly shows that improving access to water supply infrastructure alone is not sufficient to bring about desired public health benefits. Therefore, the pathways through which improved access to water supply has impacted poverty reduction in the study areas have to do with direct improved health benefits and through timesaving-induced increased participation of households in off/non-farm employment. Determinants of off/non-farm employment and poverty were also systematically analysed and factors identified; recommendations are made to enhance these poverty impacts of water supply improvements.

1 Introduction

At the macro level, investments in water can be an engine for accelerated economic growth, sustainable development, improved health and reduced poverty. Improved water resources management and water supply and sanitation (WSS) contribute significantly to increased production and productivity. Water resources are critical to production processes, and worker health is critical to increased production and productivity. A recent study indicates that poor countries with access to improved water and sanitation services have enjoyed annual average growth of 3.7% of gross domestic product (GDP); those without adequate investment saw their GDP grow at just 0.1% annually (SIWI, 2005). Investments in the water sector can also generate economic benefits that considerably outweigh costs and contribute to human development (ibid). Using welfare monitoring surveys from Ethiopia, Anderson and Hagos (2008) found evidence of significant relationship between improvement in households' source of drinking water and self-reported food situations. Hence, interventions to reduce poverty and bolster economic growth will be more effective if they explicitly include measures to improve people's health and livelihood systems as well as resilience of economies to rainfall variability. In this case, growth and poverty impacts need to be understood within the wider context of water resources management, including linkages to other sectors.

At the micro level, considerable savings in time and increased livelihood opportunities for the poor are gained through improved WSS (Slaymaker et al., 2007). There are also educational and health gains that augment economic growth and productivity. Access to a basic supply of safe water can significantly improve health, nutrition and productivity of individual labourers (Howard and Bartram, 2003). More time and better health reduce poverty because of improved labour productivity and opportunities for income generation. Women and girls particularly benefit, through increased take-up of income-generating opportunities and education. The opportunity costs of time spent accessing water (especially by women) may be considerable, in terms of not just income generation and school attendance etc., but also reproductive tasks such as caring for children or the elderly, all of which affect the overall health, welfare and productivity of the household (Magrath and Tesfu, 2006). Hence, access to WSS plays an important role in improving children's health (Slaymaker et al., 2007). It is important therefore to understand the trade-offs between expenditure of household resources (time, money) on accessing or managing water and other competing priorities (Joshi, 2004). The potential poverty impact of improved WSS access depends largely on the availability of other livelihood assets, e.g. land, labour, livestock, credit and local markets, which can be combined to generate increased income in cash or kind (Moriarty et al., 2004).

Literature relevant to understanding micro-level linkages is generally focused on two main areas: health impacts associated with access to improved domestic water supply and sanitation facilities; and improvements in agricultural productivity linked to access to water for irrigation. While there is an extensive literature on each, these debates have in general remained quite separate. However, a growing body of literature suggests that this dichotomous separation of thinking in relation to 'domestic' (social) and 'productive' (economic) uses is inadequate for understanding the complex relationship between water and livelihoods in developing countries. Understanding the 'grey area' in between is arguably the key to enhancing growth and poverty impacts of WSS services (Slaymaker et al., 2007). Furthermore, there is a need to better understand how WSS sector interventions can help poor households cope with livelihood shocks and stresses, achieve basic food security and enhance productivity (ibid).

The principal objectives of this study were as follows:

- To characterise existing WSS coverage and factors influencing access to improved services.
- To understand the effects of access to improved WSS on different aspects of poverty (not just health). In particular, we look at the incidence of water-related diseases, as compared with other types, between households with and without access to improved water supplies, and the effects in terms of productive days lost owing to illness, health expenditure and foregone household income. By doing so, we assess the extent to which access to WSS has directly affected water-related illnesses and indirectly affected productivity and household income. We also analyse the relationship between WSS access at household level and participation in off/non-farm employment opportunities. Furthermore, we assess whether improved access to WSS has led to a significant reduction in overall levels of poverty. This is measured by comparing differences in agricultural income and standards of living (higher expenditure) between households with access to improved source and households without.

2 Empirical evidence

While the expected benefits from investments in WSS on poverty are considerable, there is still only a small (although growing) body of empirical evidence on the issue. At the macro level, there is a positive relationship across countries between per capita income and access to water and sanitation (e.g. UNDP, 2006). However, although part of this relationship may reflect a causal effect of better access to water and sanitation on productivity and income, we found no studies that test this hypothesis directly. Some indirect evidence in support is provided by studies that find a positive relationship across countries between initial levels of health and subsequent rates of economic growth (e.g. Barro and Sala-i-Martin, 2005; Sachs and Warner, 1997).[1] For more direct evidence, however, we have to turn to more detailed studies at the country (or regional) level.

It is fairly well established that many people in developing countries, particularly women, spend a large amount of time collecting water: often up to six hours a day, according to one recent estimate (SIWI, 2005). There is also strong evidence that this limits the amount of time spent by women in productive employment. In rural Pakistan, for example, Ilahi and Grimard (2000) find a statistically significant negative relationship between time allocated by adult women to market-oriented wage employment and distance to the nearest water source, controlling for other influences. They conclude that '[poor] water infrastructure imposes a time constraint on rural women, which, in turn, tends to reduce their time allocation to income-generating activities' (p.61).

The quality of water sources may also be important for raising productive employment. Across villages in rural Tanzania, for example, Mduma and Wobst (2005) find a positive and statistically significant relationship between the proportion of households supplying labour to the labour market and the proportion that have access to safe water. The estimates control for various other influences on households' labour supply, including land availability, location, dependency ratios, education and availability of electricity.

There is also a fair amount of evidence from studies at the national (or regional) level that suggest that access to water and sanitation reduces child mortality. In Alemaya district in Ethiopia, for example, Spencer and Winkowska (1991) show that households located further from a river had much higher mortality rates than other households, controlling for household size and cash income level.[2]

More recently, estimates for Cameroon, Egypt, Peru, Vietnam and Uganda provided by Fuentes et al. (2006), Egypt by Abou-Ali (2003) and India by Guillot and Gupta (2004) all show a strong relationship between better access to WSS and lower infant mortality rates. However, although it is plausible that the positive effect of WSS access on child survival rates also has a beneficial economic impact, none of the above-mentioned studies test this link directly.

Finally, there have been several studies on demand for water at the household level, which have been used to explore the effect of access to water on household welfare. These include Basani et al. (2004) for Cambodia, Diakite et al. (2006) for Côte d'Ivoire and Nauges and Strand (2007) for urban

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[1] According to the latter study, for example, a rise in life expectancy at age one from 50 to 55 years would raise subsequent growth by 0.9% per year.

[2] The data refer to 1980; all surveyed households obtained their water from the river, but some were located nearer, and therefore had easier access, than others.

areas in El Salvador and Honduras. These studies are generally grounded in standard microeconomic theory, adapted to reflect the special features of water as a consumer commodity.

To summarise, there is a small but growing body of evidence on the economic impacts of access to water and sanitation, to which the current paper aims to contribute.[3]

[3] This study forms part of the RiPPLE research programme, which aims to promote improved understanding among policy makers and practitioners of key challenges faced in delivering effective WSS services in Ethiopia and the wider Nile Region (www.rippleethiopia.org).

3 Data and methodology

3.1 Data and sampling strategy

We used cross-sectional data from 1500 households from two woredas in Eastern Hararghe zone, Oromia regional national state.[4] The household survey was carried out in two selected focus woredas: Babile and Gorogutu (see Figure 3.1).

Stratified random sampling was used to select the kebele[5] associations (KAs), where stratification was carried out based mainly on agro-ecology, market access and access to WSS. The survey covered 12 and eight KAs from Gorogutu and Babile, respectively (see Annex 1 for a list of KAs). In addition, we considered presence of irrigation water, whether the given KA was a Productive Safety Net Programme (PSNP)[6] target KA and whether there were multiple use system (MUS) water points. The first three criteria were key in KA selection. Within each KA, 75 households (the same number in each KA) were chosen at random. Random sampling means that each household in the KA had an equal chance of being selected. Random sampling was done using a sampling frame – numbered list of households in the KA provided by the development agents (DAs) – and a random number table.

Figure 3.1: Location of study sites

Using a comprehensive questionnaire, administered by well-trained and supervised enumerators, data were collected on WSS (type of water system and other concomitant data together with sanitation facilities and changes in sanitation practices), household demographics, household assets, income from diverse sources, household expenditure, incidence of various illnesses and village-level factors

[4] The lower administrative structure of the government, or 'district'.

[5] The smallest administrative unit of Ethiopia, similar to a ward or a neighbourhood.

[6] The Ethiopian government has launched a national food security programme that targets food deficit communities.

such as access to markets, other services and infrastructure. The primary data gathered are used in this initial analysis.

3.2 Estimation approaches

Given the study objectives, a variety of approaches, varying from descriptive statistics to regression analysis, was used to describe the current situation and establish the links between WSS and different welfare outcomes. Establishing the link between access to WSS and health is relatively straightforward, but establishing a cause and effect relationship between access to WSS and poverty/food insecurity is more challenging. One could hypothesise a direct link, as water is an important input for increased agricultural productivity at the household level; it is also possible that there is an indirect link, i.e. impact of improved WSS on poverty through improved human health and timesaving leading to increased productivity and improved livelihood opportunities.

To model the probability of a household member being ill (water related or otherwise) as a function of various covariates we used a binary choice model of the form:

$$y_i = X_i^{'}\beta + \varepsilon_i \qquad (1)$$

where $y_i = 1$ if a member is reported sick and $y_i = 0$ if otherwise. The $X_i s$ are a vector of explanatory variables influencing the probability of illness. In these explanatory variables we included individual characteristics (age and sex of the individual); household-related variables (such as family size; number of children under five; number of seniors); level of wealth (as measured by average household income and asset holdings); access to improved water supplies; sanitation behaviour (e.g. ownership and use of pit latrines); and village-level factors representing access to health and other facilities. Similarly, we modelled the level of health expenditure incurred by a household to get treatment for its ill members using variants of censored regression models. The rationale is that the health expenditure variable is a censored variable requiring another estimation strategy than the usual ordinary least squares (Verbeek, 2000). The Tobit model is given as:

$$y_i = X_i^{'}\beta + \varepsilon_i \qquad (2)$$

where $y_i \leq 0$ or $y_i > 0$. The $X_i s$ are a vector of explanatory variables influencing the level of expenditure including patient characteristics (such as age, sex, etc.); type of illness;[7] household's ability to pay (measured by its asset endowments such as land and livestock holdings and average household income); and access to health services as measured by distance to health centre and the all-weather roads. The Tobit model imposes a structure that is often too restrictive: exactly the same variables affecting the probability of being ill determine the level of a positive expenditure for treatment and, moreover, with the same sign (Verbeek, 2000). This is not a realistic assumption. Hence, equation (2) is estimated using a truncated regression model by taking only the positive expenditures to relax this restriction and identify the determinants of positive expenditure.

When estimating poverty, following the money-metric approach to measurement of poverty, there is a choice between using income or consumption as the indicator of wellbeing. Most analysts argue

[7] Type of treatment was excluded from the list of explanatory variables as we found it to be highly correlated with type of illness and type of health facilities visited.

that, provided the information on consumption obtained from a household survey is detailed enough, consumption will be a better indicator of poverty measurement than income, for many reasons (Coudouel et al. 2002). Hence, in this paper we estimated poverty using consumption expenditure adjusted for differences in household size and composition. We used the Foster-Greer-Thorbecke (FGT) class of poverty measures to calculate poverty indices (Foster et al., 1984). These have some desirable properties (such as additive decomposability) and include some widely used poverty indices (such as headcount, poverty gap and poverty severity measures). Following Duclos et al. (2006), the FGT poverty measures are defined as

$$\mathrm{P}(z;\alpha)=\int_0^1\left(\frac{g(p;z)}{z}\right)^{\alpha}dp \qquad (3)$$

where z denotes the poverty line and α is a nonnegative parameter indicating the degree of sensitivity of the poverty measure to inequality among the poor. This is usually referred to as the poverty aversion parameter. Higher values of the parameter indicate greater sensitivity of the poverty measure to inequality among the poor. The relevant values of α are 0, 1 and 2.

At α =0 equation (3) measures poverty incidence or the headcount ratio. This is the share of the population whose income or consumption is below the official poverty line, that is, that cannot afford to buy a basic basket of goods, food or non-food or both, depending on which one is interested in.

At α =1 equation (3) measures depth of poverty (poverty gap). This provides information regarding how far off households are from the poverty line. This measure captures the mean aggregate income or consumption shortfall relative to the poverty line across the whole population. It is obtained by adding up all the shortfalls of the poor and dividing the total by the population. In other words, it estimates the total resources needed to bring all the poor to the level of the poverty line. Note also that the poverty gap can be used as a measure of the minimum amount of resources necessary to eradicate poverty, that is, the amount that one would have theoretically to transfer to the poor under perfect targeting (that is, each poor person getting exactly the amount he/she needs to be lifted out of poverty) to bring them all out of poverty (Coudouel et al., 2002).

At α =2 equation (3) measures poverty severity or squared poverty gap. This takes into account not only the distance separating the poor from the poverty line (the poverty gap), but also inequality among the poor. That is, a higher weight is placed on those households further from the poverty line.

We calculated these indices using STATA 9.0 and tested for difference between poverty profiles between households with access to water from an improved source and unimproved source groups, following approaches suggested by Kakwani (1993).

The steps we followed in estimating the poverty profiles are as follows. First, we chose household consumption expenditure as the welfare measure and this was adjusted for the size and composition of the household using adult equivalents. Second, the consumption poverty line was set at 1821.05 ETB (US$1 = ETB 9.2 in 2007), an inflation-adjusted poverty line of the baseline poverty line of ETB 1075 set in 1995/96 as a measure of welfare corresponding to some minimum acceptable standard of living in Ethiopia (MOFED, 2006). We also used an inflation-adjusted poverty line of 1096.03 as the absolute food poverty line, based on the corresponding 1995/96 food poverty line. These lines were chosen to enable meaningful comparison of poverty levels in the woredas (and with the rest of the country) and between various groups in the study sites. The poverty line acts as a threshold, with households falling below the poverty line considered poor and those above it considered non-poor. Third, after the poverty line had been identified, poverty indices such as headcount, poverty gap and poverty gap squared were estimated. Fourth, we constructed poverty profiles showing how poverty varies over population subgroups (example users of improved source vs. non-users, irrigation users and non-users) or by other characteristics (for example, location). The poverty profiling is particularly important, as what matters most to policymakers is not so much the precise location of the poverty line, but the implied poverty comparison across subgroups or across space and time.

An analysis of poverty will not be complete without explaining why people are poor or remain poor over time. Within a microeconomic context, the simplest way to analyse the correlates of poverty consists in using a regression analysis against household and demographic factors, specific individual/household head characteristics, asset holdings, village-level factors and access to market and basic services such as water supply, health and education. Let welfare indicator W_i be given as:

$$W_i = Y_i / Z \qquad (4)$$

where Z is the poverty line and Y_i is the consumption expenditure per adult equivalent. Denoting by X_i the vector of independent variables, the following regression

$$LogW_i = \beta' X_i + \varepsilon_i \qquad (5)$$

could be estimated by ordinary least squares (OLS). In this regression, the logarithm of consumption expenditure (divided by the poverty line) is used as the left-hand side variable. The right hand side variables in the regressions include: i) household characteristics: household head, including sex, level of education (read and write or not, arithmetic skills), age and number of dependents; ii) asset holding: livestock size (in Tropical Livestock Unit) and farm size, adult labour (by sex); iii) access to different services and markets: credit, non-farm employment, improved water supply and health. Access to market was proxied by distance to woreda (local) market and distance to seasonal and all-weather roads. Access to water supply was measured by whether the household reported improvements during the past five years (0/1); and iv) village-level characteristics, mainly kebele dummies to control for village-level covariates.

The β coefficients in equation (5) are the partial correlation coefficients that reflect the degree of association between the variables and levels of welfare and not necessarily their causal relationship. The parameter estimates could be interpreted as returns of poverty to a given characteristic (Coudouel et al., 2002; Wodon, 1999) while controlling for other covariates, the so-called *ceteris paribus* condition. We used survey regression techniques to account for the stratified sampling technique and, hence, adjusted the standard errors to both stratification and clustering effects (Deaton, 1997; Wooldrige, 2002), thereby dealing with the problem of heteroskedasticity. We also tested for other possible misspecifications (e.g. multicollinearity) using routine diagnostic measures. Furthermore, while poverty could be influenced by the state of health of members within the household, including such a variable to equation (5) will potentially cause endogeneity problems. To correct for this, we used an instrumental regression model on equation (5) by using the predicators of health expenditure to control for health effects in the poverty regression. The results of these analyses are reported in subsequent sections.

4 Results and discussion

4.1 Access to improved WSS

As far as current water supply is concerned, households in both woredas obtain water from protected and unprotected sources. The dominant protected water sources are community boreholes (86%) in Babile and public standpipes (63%) and community boreholes (29%) in Gorogutu. From the unprotected sources, unprotected community wells in Babile and other sources in Gorogutu are the dominant sources, contributing to 74% and 79%, respectively (see Table 4.1). The data highlight the fact that households in this area typically rely on multiple different water sources for different water uses (Adank et al., 2008).

Table 4.1: Protected and unprotected systems

	Babile		**Gorogutu**	
System	**Protected (n=1740)**	**Unprotected (n=1445)**	**Protected (n=2170)**	**Unprotected (n=7867)**
Household connection	0.00		0.03	
Public standpipe	0.10		0.63	
Community borehole	0.86		0.29	
Household boreholes	0.00		0.02	
Protected community well	0.03		0.03	
Unprotected community wells		0.74		0.04
Protected household well			0.00	
Unprotected household well		0.01		0.00
Stream		0.14		0.10
Community pond		0.04		0.05
Dam				0.00
Household pond		0.01		0.00
Others		0.06		0.79

Note: Number of respondents is greater than 1500 because households could indicate several sources.

When asked whether there were any changes in water supply during the past five years, 44% of respondents in Babile and 35% of respondents in Gorogutu indicated that there had been major changes. The most important introductions in Gorogutu, in order of their importance, include piped water system (43%), hand pump (22%) and spring development (17%). In Babile, on the other hand, hand pump development accounts for 87% of recent improvements (see Figures 4.1 and 4.2).

Figure 4.1: Most commonly introduced water systems in Babile (n=449)

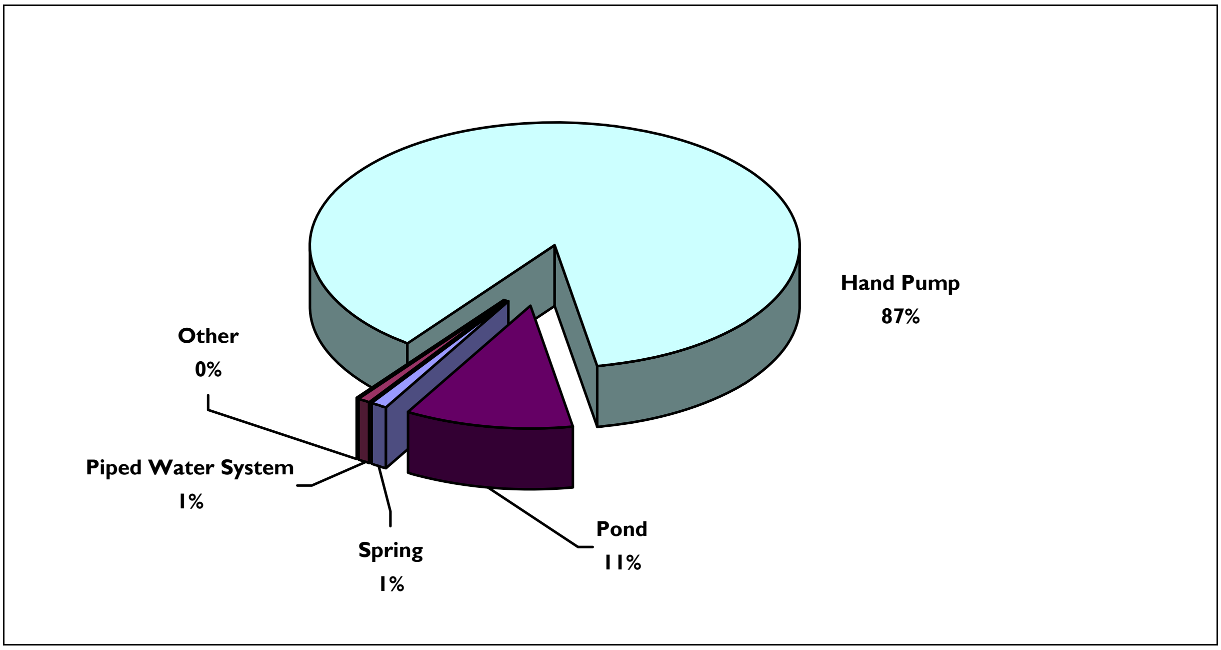
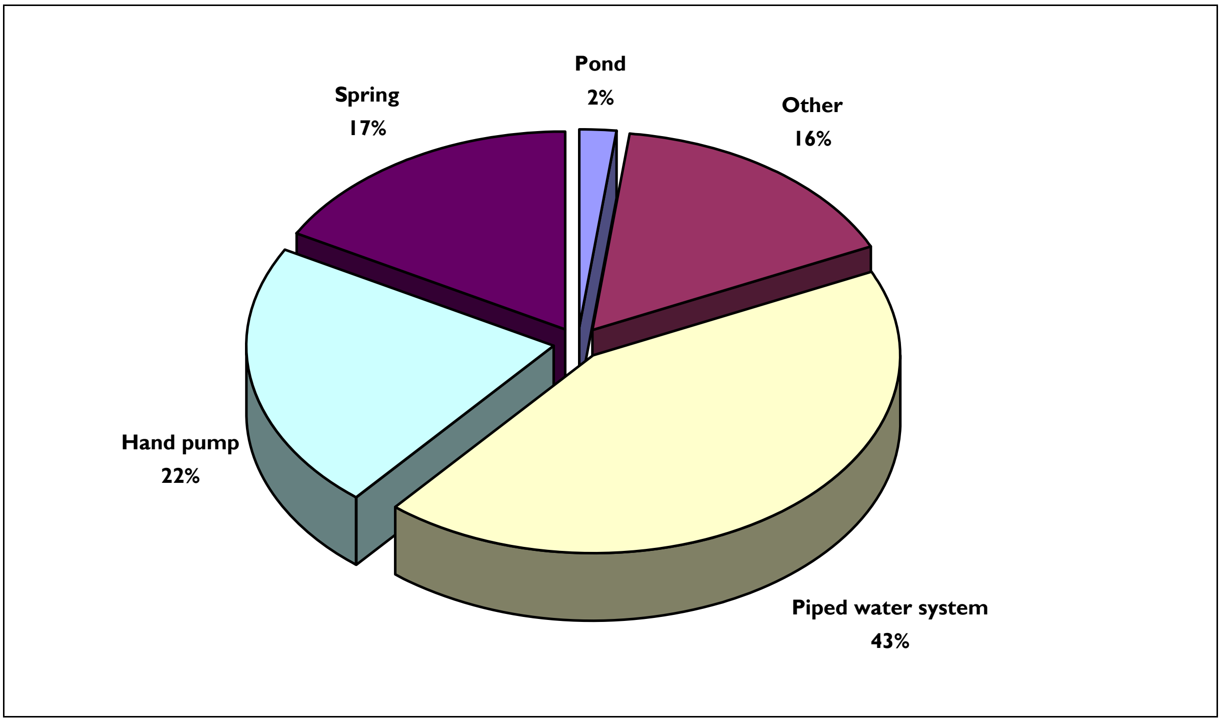


Figure 4.2: Most commonly introduced water systems in Gorogutu (n=1051)



In terms of access to protected sources,[8] proportionately more households in Babile have access to protected sources (49%), compared with 20% of households in Gorogutu. The average access to water from improved source in Eastern Hararghe zone was about 40% (WMS, 2005). Compared with 2004/05, there seems to have been an improvement to access to water from improved sources in Babile (see Annex 2 Table A2a), considering the zonal average for the time.

The introduced water systems were assessed as having important desirable characteristics. They were assessed as providing generally good quality water and reasonably reliable and relatively accessible (see Table 4.2). At the same time, it is important to note that continuous service is achieved in only 60% and 69% of systems in Babile and Gorogutu, respectively, reflecting the challenges of delivering effective services on a sustainable basis in this area.

Table 4.2: Characteristics of existing water supply system

	Responses	Babile (n=3200)	Gorogutu (n=9857)	Pearson chi2
Reliability	Only part of the year	8.31	10.01	86.7563***
	< 50 % of the year	5.85	11.35	
	> 50 of the time	25.84	10.09	
	Always available	59.99	68.55	
Quality	Smelly	13.43	3.91	55.2830 ***
	Unclear but not smelly	27.49	32.69	
	Clear	59.08	63.39	
Accessibility	Unrestricted	76.72	89.75	92.6309***
	Sometimes restricted	23.28	10.25	
Protected	Protected	48.77	20.40	243.1577***

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

Important changes were also witnessed from the introduction of new water supply systems. The most important changes include: increased supply of water, improved water quality, shorter distance (timesaving) and increased awareness in sanitation and hygiene.

Table 4.3: Perceived changes because of the new introductions in WSS (% of respondents)

Changes	**Babile (n=449)**	**Gorogutu (n=1051)**	**Pearson chi2**
Increased supply of water	29.40	22.65	**7.7219*** **
Improved water quality	36.30	27.12	**12.6732*** **
Shorter distance	15.81	9.71	**11.5028*** **
Shorter collection time	18.49	16.56	**0.8253**
Changes in water fee	0.22	1.24	**3.4998 ***
Increased awareness in hygiene and sanitation	14.70	11.04	**3.9577** **

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

[8] We categorised household connection, public standpipe, borehole, protected dug well and protected spring under protected water source; unprotected source includes unprotected wells, spring, rivers or ponds.

Notwithstanding this, water from unprotected sources still represents the major source of water in both woredas, more so in Gorogutu. In this case, the bulk of households in Babile, for instance, obtain water for domestic and non-domestic use from protected community boreholes and unprotected community wells; the majority of households in Gorogutu obtain water from protected public standpipe, stream, community pond and other unprotected springs. This clearly has important implications for WSS sector policy and programming approaches.

Table 4.4: Uses from different systems

System	Drinking and other household use		Non-household use	
	Babile (n=1608)	**Gorogutu (n=4199)**	**Babile (n=1577)**	**Gorogutu (n=5838)**
Household connection	0	21	1	39
Public standpipe	106	669	73	704
Community borehole	914	359	590	263
Household boreholes	3	25	5	17
Protected community well	22	30	26	41
Unprotected community wells	460	145	609	205
Protected household well	0	0		2
Unprotected household well	6	0	11	6
Stream	56	0	150	662
Community pond	11	123	46	400
Dam		13		26
Household pond	0	7	14	20
Others	30	2806	52	3453
Pearson chi2				**39.2968 *****

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

Table 4.4 shows patterns of water use from different systems in each woreda. It is interesting to note that a significant proportion of water drawn is for non-household use, particularly in Gorogutu. These non-domestic uses are rarely factored into scheme design and have important implications for sustainability. They also suggest that the benefits of improved access extend far beyond human health, which has traditionally been the main justification for WSS sector interventions.

We also explored factors determining the location of new water points in the two woredas. In doing so, we controlled for distance to the woreda; distance from all-weather roads; distance to nearest urban centre; population density; altitude; presence of irrigation; whether the kebele is food insecure (so targeted by the PSNP); and presence of nongovernmental organisations (NGOs) working in the kebele. The idea is to understand which specific communities are being targeted by the new investments in water supply provision and to identify the determinants of geographical targeting.

Our results show that investments in new water points were more likely in relatively well-connected kebeles, indicating that kebeles located far from all-weather roads are less likely to get water points. Availability of access roads is an important prerequisite for introduction of improved water supply. Moreover, communities located in the highlands are more likely to be targeted than communities in lowland areas, where water shortage is more severe. This may show a problem in targeting.

Communities with irrigation schemes were found to have a higher probability of having access to improved water supply; whether this has to do with high water potential or integrated interventions in water resources development is difficult to say. Furthermore, communities classified as food insecure are more likely to have received new water points than those that are not food insecure, indicating that the former are especially targeted in the provision of water supply. NGO interventions seem to have induced significant increases in water supply. However, population size was not a significant determinant of new introductions in water supply.

Table 4.5: Factors explaining introduction of new water points

Variables	**Coef.**	**S. error**	**M. effects**	**S. error**
Distance to all-weather road	-0.004	0.001***	-0.0010	0.0004***
Distance to nearest urban centre	-0.004	0.006	0.002	0.002
Population size	-0.00009	0.000	-0.00003	0.000
Mid-altitude (reference = low land)	0.066	0.092	0.025	0.035
Highland (reference = low land)	0.4517	0.164***	0.176	0.065***
Presence of irrigation	0.411	0.095***	0.1560	0.039
Food insecure KA	0.585	0.153***	0.2160	0.056***
World Bank project site (reference non-World Bank project)	0.135	0.1190	0.0510	0.042
MfM project (non-MfM project site)	0.393	0.214*	0.149	0.0790*
HCS project (non-HCS project site)	0.155	0.205	0.0580	0.075
CISP project (non-CISP project)	-0.635	0.149***	-0.209	0.041***
Gorogutu (reference Babile)	0.039	0.1850	0.015	0.068
Intercept	-0.801	0.204***	-	
	Number of obs = 1500 Wald chi2(12) = 114.19 Prob > chi2 = 0.0000 Log pseudo-likelihood = -937.37 Pseudo R2 = 0.0561		Number of obs = 1500 LR chi2(12) = 111.47 Prob > chi2 = 0.0000 Loglikelihood = -937.37 Pseudo R2 = 0.0561	

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

MfM = Menschen fur Menschen; HCS = Hararghe Catholic Secretariat; CISP = International Committee for the Development of People.

We examined access to sanitation by looking at changes in sanitation services (mainly latrine use) and waste management strategies. Accordingly, about 40% of households in Babile and 30% of households in Gorogutu, respectively, have their own latrines. Surprisingly, however, a high proportion of the households that own latrines in both woredas do not use them, instead defecating on open space around the bush, the farm or the homestead. Proportionately more households in Gorogutu use open space to defecate compared with Babile. This clearly has important implications for sanitation policy and programming and suggests that access to infrastructure alone is not sufficient to bring desired improvements in public health (Newborne and Smet, 2008).

Table 4.6: Access to sanitation

Changes	Babile (n=449)	Gorogutu (n=1051)	Pearson chi2
Latrine	39.87	29.50	15.3990***
Use latrine	37.19	26.26	18.0695***
Use bush	32.29	62.61	116.2121***
Use farm	50.78	39.68	15.8233***
Use homestead	15.37	13.42	0.9953
Other	0.67	0.48	0.2196

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

On the other hand, we found that there is proper waste management in both woredas. The majority of the households in both woredas reported that they used household waste as fertiliser and the rest is collected in dugouts.

Table 4.7: Waste management

Changes	Babile (n=449)	Gorogutu (n=1051)	Pearson chi2
Municipal container	1.78	0.0	18.8265***
Dugouts	46.99	17.22	144.4507 ***
Throw away	28.06	11.80	59.9168 ***
Use as fertiliser	81.74	83.16	0.4451
Burn	14.03	7.61	15.0318***
Use waste trucks	0.45	0.0	4.6878 **
Other	0.0	4.85	22.5547***

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

We also explored major health problems in the two woredas. Accordingly, the most important diseases, measured by the proportion of households that reported sick members, are presented in Table 4.8. Accordingly, the three most important diseases reported in Babile include diarrhoea (23%), malaria (19%) and respiratory problems (17%). Similarly, in Gorogutu, diarrhoea (25%), respiratory problems (18%) and common colds (11%) account for the three most important illnesses. For both woredas combined, diarrhoea (including its acute form) (49%), respiratory problems (38%) and malaria (27%) are the most important health problems. Hence, water-related and water-borne diseases account for the bulk of the illnesses in both woredas, more so in Babile.

Table 4.8: Health problems (% of households)

Changes	Babile (n=1946)	Gorogutu (n=1051)	Pearson chi2
Diarrhoea	11.41	16.76	28.1906***
Dysentery	11.72	9.06	
Trachoma	2.16	1.35	
Skin/rash problem	2.88	4.51	
Schistosomiasis	1.44	0.89	

Malaria	18.50	8.56	
Respiratory problem	16.96	18.11	
Common cold	9.76	11.31	
Fever	4.11	3.70	
Others	21.07	25.75	

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

These findings are important and, in light of the preceding analysis, suggest that isolated efforts to improve access to WSS infrastructure are not sufficient to reduce water-related and water-borne diseases.

4.2 Statistical association between improved water supplies and some welfare indicators

We explored the statistical association between access to improved water supplies and different welfare indicators, as indicated in Table 4.9 below. These could provide indicative insights as to how improved access to water supplies could influence household welfare before carrying out systematic analysis of these linkages while controlling for the effect of other covariates. Here, the interest is to establish these statistical associations without being concerned about cause and effect relationships.

Table 4.9: Summary of association between improved water supplies and some socioeconomic variables

Variable name	**Protected source (n=720)**	**Unprotected source (n=1234)**	**p-value***
	Mean	Mean	
Average distance to the nearest water source (minutes)	20.34	23.86	0.0006
Quantity of water fetched (litres)	55.82	48.71	0.0000
Illness (0 = not ill and 1 = being ill)	0.526	0.546	0.029
Participation in productive engagement	0.439	0.414	0.007
Miss job because of illness	0.389	0.366	0.010
Miss school because of illness	0.097	0.118	0.000
Per capita income	943.97	1827.54	0.2049
Per capita agriculture income	749.9	1681.12	0.1815
Per capita livestock income	128.89	152.66	0.0522
Per capita crop income	620.54	1527.48	0.1930
Per capita non-farm income	193.64	145.88	0.0158
Number of working days engagement	128.32	147.23	0.0143
Number of working days missed because of illness	68	80.91	0.1379
Income loss because of illness	389.93	494.51	0.3112
Number of school days missed because of illness	46.32143	58.54	0.2791

Medical expenditure	197.67	200.62	0.9062
Consumption expenditure per adult equivalent (annual)	2272.59	1262.102	0.0029
Face food shortage	270	726	0.000
Frequency of food shortage	2.31	2.348011	0.0102

Note: * Two-sided test of equality of means/proportions.

Accordingly, improvements in access to water supply were found to have a strong statistical association with increase in volume of water collected (seven litres per day per household) and decrease in average distance travelled (about three minutes per trip) to a water source. Both effects are expected to lead to significant timesaving of the household members responsible for fetching water. This is expected to increase household members' participation in productive engagement, most importantly in off/non-farm employment, where available. Not surprisingly, therefore, we find a strong statistical association between access to water from an improved source and participation in off/non-farm employment (although average number of days of engagement is higher in households without access to an improved source). Here, we did not consider who was taking part in off/non-farm employment. This may imply that, because of the timesaving attributed to improved water supply, households, particularly women, are more likely to participate in off/non-farm employment. Interestingly, we found a strong association between improved access and consumption expenditure and whether the household had faced food shortages or not during the past five years. The latter could be a good proxy indicator of food insecurity. In this case, households with access to improved water source have significantly higher consumption expenditure per adult equivalent than those without access. We also found a strong statistical association between access to improved source and incidence of food shortage. Households with access to improved water sources were found to be less likely to have faced food shortages and, if they did, food shortages were less frequent during the past five years compared with those without access. Income from livestock sales was not found to have significant association with access to an improved source.

Furthermore, we found a strong statistical association between improved access and illness (water related or otherwise) and missing jobs and schools because of illness. This could be suggestive (though not conclusive) of the possible pathways through which improved access to water supply could impact poverty. The pathways through which improved access may impact on household welfare seem to have to do with: i) the timesaving-induced increased participation in off/non-farm employment; ii) health benefits; and iii) livestock income. We explore this point further in the forthcoming sections.

4.3 Exploring linkages

The following section explores the linkages between improved access to water supply and different welfare indicators. The methodological approaches followed were presented in Section 3.2 of this report.

4.3.1 Improved water supply and health

We explored the determinants of illness[9] by controlling for individual and household characteristics; distance to water sources and type of water source (protected or unprotected); quality of water (whether the water points provide reliable and good quality water throughout the year, water treatment); sanitation behaviour (ownership and use of latrine); village-level covariates (using altitude, food insecurity status and woreda dummies); and wealth and asset variables. We ran three separate regressions for what we called water-related illnesses, non-water-related illnesses and all kinds of illness. In the last case we pooled the data for water- and non-water-related illnesses.[10] The results are reported in Table 4.10. This is followed by a presentation of the determinants of health expenditure. In explaining expenditure, we controlled for individual characteristics of patients; type of illness; wealth and asset variables (per capita income, land and livestock holding); and distance to all-weather roads and a health centre.

Our results show that the probability of being reported ill in any way decreased with access to an improved source, showing that households that have access to water from an improved source are less likely to fall ill. The probability of illness, on the other hand, increased with distance to the source. When we disaggregated illnesses into water related and non water related, the results were mixed. In this case, probability of water-related diseases increased with access to an improved source and decreased with distance to water source. On the other hand, the probability of a person having other illnesses decreased with access to water from a protected source and increased with distance. The possible explanation for this may have to do with the fact that the effect of distance to a water source on the incidence of water-borne diseases (e.g. malaria) is through its proximity while its effect on water-related diseases (e.g. diarrhoea) is through its quality. The distance variable is, hence, picking up the effect of distance on the incidence of water-borne diseases, particularly malaria. Having water from a protected source is found to have a significant negative effect on all illnesses and specifically on non-water-related illnesses, but a positive effect on water-related illnesses. The former result may have come as a result of better sanitation because of improved availability of water.

Table 4.10: Probability of illness (reported marginal effects from survey Probit regression)

Dependent variables (0/1)	**All kinds of illness**		**Water-related illness**		**Non-water-related illness**	
Variables	**Coef.**	**Std. err.**	**Coef.**	**Std. err.**	**Coef.**	**Std. err.**
Individual and household characteristics						
Age of patient	-0.0132	0.0004***	-0.003	0.0002***	-0.006	0.0003***
Sex of patient (female)	0.505	0.009***	0.079	0.009***	0.338	0.012***
Sex of household head (female)	-0.453	0.017***	0.022	0.015	0.249	0.012***
Education of household head (read and write)	.0145887	0.0113	0.017	0.007**	-0.013	0.010
Number of family members	-0.057	0.005***	-0.014	0.003***	-0.033	0.004***

[9] We broadly classified illnesses into water and non water related: in the latter category, we have diarrhoea, dysentery, malaria, eye and skin illnesses and schistosomiasis; respiratory illnesses and other illnesses are classified into the latter.

[10] We pooled the data together into these categories because we did not have adequate observations to do a separate meaningful analysis of the different type of illnesses.

under 5						
Number of seniors	0.323	0.023***	0.045	0.015***	0.208	0.020***
Access to safe water and sanitation						
Access to protected source (yes)	-0.050	0.014***	1.046	0.010***	-0.096	0.012***
Distance to water source (mins)	0.001	0.0003***	-0.0005	0.0001***	0.001	0.0002***
Water quality (unclear but not smelly)	0.025	0.023	-0.015	0.014	0.047	0.021**
Water quality (clear)	0.012	0.022	-0.088	0.015***	0.114	0.020***
Water availability: only available part of the year	0.099	0.024***	0.050	0.018***	0.028	0.023
Water availability: < 50 % of the time	-0.068	0.018***	-0.032	0.011***	-0.028	0.015*
Water availability: > 50 % of the time	-0.059	0.016***	-0.014	0.010	-0.047	0.014***
Water treatment: boiling	0.087	0.040**	-0.015	0.027	0.113	0.0414***
Water treatment: filtering	0.045	0.034	0.112	0.029***	-0.095	0.030***
Own pit latrine (yes)	0.034	0.011***	0.046	0.008***	-0.021	0.011**
Wealth and asset holding						
Average income	-0.0000	0.0000	-2.68e-06	2.66e-06	2.66e-07	3.26e-07
Average livestock holding	-0.024	0.008***	-0.002	0.005	-0.008	0.007
Average land holding	-0.051	0.004***	-0.002	0.003	-0.05	0.004***
Village-level covariates						
Altitude: mid-altitude (reference lowland)	0.093	0.012***	.0501489	0.009***	0.031	0.011***
Altitude: highland (reference lowland)	-0.041	0.019**	.1206236	0.016***	-0.163	0.0145***
Food insecure peasant's associayion (yes)	-0.002	0.012	-0.015	0.008**	0.0195	0.010*
Woreda dummy (Gorogutu)	-0.050	0.014***	-0.028	0.010***	-0.012	0.014
	Number of obs = 10753 LR chi2(23) = 3793.86 Prob > chi2 = 0.0000 Log likelihood = -5525.2609 Pseudo R2 = 0.2556		Number of obs = 10729 LR chi2(23) = 671.37 Prob > chi2 = 0.0000 Log likelihood = -4684.986 Pseudo R2 = 0.0669		Number of obs = 10753 LR chi2(23) = 2079.82 Prob > chi2 = 0.0000 Log likelihood = -5990.8393 Pseudo R2 = 0.1479	

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

Increased availability and quality of water seem to have significantly reduced incidence of illnesses, particularly water-related illnesses. Contrary to our expectation, latrine ownership seemed to significantly increase incidence of all kinds of illnesses.

More interestingly, households with better wealth endowments were found to be less likely to fall ill. Moreover, households in high altitude communities were less likely to fall ill compared with households in lowland communities. This might come from two sources: agro-ecological predisposition and differences in access to improved water supply, as indicated earlier. Finally, households in food insecure communities were also less likely to fall ill, perhaps because of the increased investment in improved water supply or the food safety net support households get.

Table 4.11: Determinants of health expenditure

Dependent variable: average household health expenditure				
	Tobit regression		**Truncated regression**	
Variables	**Coef.**	**Std. err.**	**Coef.**	**Std. err.**
Patient characteristics				
Age of patient	0.713	0.075***	0.437	0.037***
Sex of patient (female)	-6.503	2.716***	-3.849	0.839***
Type of illness				
Water related illness (1 = yes, 0 = otherwise)	328.17	8.141***	10.28	13.357
Other illness (1 = yes, 0 = otherwise)	359.89	8.00***	40.45	13.67***
Wealth and asset holding				
Average income	-0.00003	0.0001	-0.0001	0.0001
Average livestock holding	0.622	1.758	-1.08	0.650*
Average land holding	11.47	1.097***	3.57	0.302***
Access to services				
Distance to all weather roads	-0.027	0.0333	-0.0217	0.009
Distance to health centre	0.052	0.019***	0.020	0.005
Woreda dummy (Gorogutu)	-1.640	3.325	1.317	0.925
Intercept	-345.09	9.131***	86.73	14.95***
	Number of obs = 13631 LR chi2(10) = 8718.46 Prob > chi2 = 0.0000 Log likelihood = -41639.426 Pseudo R2 = 0.0948		Number of obs = 6669 Wald chi2(10) = 161.90 Log likelihood = -31924.977 Prob > chi2 = 0.0000	

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

With regard to amount of medical expenses spent by households, we found expenditures to increase with age of patient. Average health expenditure was also found to differ significantly by sex: there was significantly lower spending on female patients compared with male patients. Health expenditures were also found to be significantly higher for non-water-related illnesses, perhaps indicating that household often seek treatment for such types of illnesses compared with water-related illnesses. Households with bigger farm holdings were also found to spend more on health, indicating the importance of wealth. Not surprisingly, health expenditure increased with distance to health centre, perhaps indicating the higher transport cost incurred.

4.3.2 Improved water supply and participation in off/non-farm employment

As presented in Section 4.2, we found a strong association between improved access to water supply and participation in off/non-farm employment. Here, we systematically assess the determinants of participation in off/non-farm employment while controlling for a host of explanatory variables, including improved access to water supply.

As can be seen from Table 4.12 below, probability of participation in off/non-farm employment increased significantly with access to improved water supply. In fact, households that have access to water from improved sources are found to be 14% more likely to participate compared with those without. This could be attributed to timesaving from the increased availability of water and shorter distances, giving more labour time to the household. Given this result, we can conjecture that the most viable pathway through which improved access to water supply will have a poverty impact is increased participation of households in off/non-farm employment. An equally important result is that access to credit and skills of some sort (non-farm) were found to have very significant impact on participation. Other variables found to have a significant effect on participation in off/non-farm employment include household characteristics such as sex and age. Relatively older household heads and female-headed households were found to be less likely to take part in off/non-farm employment. While the first result is to be expected, the second may sound counterintuitive. However, what the result shows is that, compared with female-headed households, male-headed households are more likely to take part in such kinds of work, even controlling for the effect of improved access to water supply. On the other hand, we also found that, as the number of male adults in a given household increases, the probability of the household's participation in off/non-employment decreases. This may point to the high level of rural unemployment in the study sites and in Ethiopia in general.

Table 4.12: Determinants of participation in off/non-farm employment (survey Probit regression model)

Dependent variable: participation in non/off-farm employment (0/1)		
Variables	**Coef.**	**Std. err.**
Household characteristics		
Sex of household head (female)	-0.316	0.161**
Age of household head	-0.012	0.003***
Education of household head (read and write)	-0.164	0.276
Education of household head (arithmetic)	0.125	0.279
Any acquired skills (yes = 1)	0.541	0.121***
Number of male adults in household	-0.093	0.0514*
Number of female adults in household	0.032	0.072
Access to water supply and other services		
Access to protected source (yes)	0.352	0.104***
Distance to water source (mins)	-0.001	0.001
Access to formal credit market	0.0001	0.0001**
Distance to all-weather roads	-0.0003	0.001
Distance to woreda market	0.00002	0.0007
PA dummies		
Madisa Jalala (reference = Sheik Abdi)	0.132	0.243

Lafto Mada Talila (reference = Sheik Abdi)	0.127	0.244
Tola (reference = Sheik Abdi)	-0.766	0.249***
Abdulkadir (reference = Sheik Abdi)	0.170	0.240
Yaka Jalala (reference = Sheik Abdi)	0.145	0.284
Yaka Aman (reference = Sheik Abdi)	-0.319	0.259
Ramata Salama (reference = Sheik Abdi)	0.815	0.258***
Erar Mada Talila (reference = Sheik Abdi)	0.581	0.262**
Biftu Diramu (reference = Sheik Abdi)	0.296	0.253
Kobo Waltaha (reference = Sheik Abdi)	0.360	0.231
Bika (reference = Sheik Abdi)	-0.162	0.329
Ifa Daba (reference = Sheik Abdi)	0.427	0.240*
Warji Jalala (reference = Sheik Abdi)	0.198	0.253
Chafe Anani (reference = Sheik Abdi)	-0.452	0.254*
Bishan Babile (reference= Sheik Abdi)	-0.688	0.243***
Yaka Umama Tokuma (reference= Sheik Abdi)	0.431	0.295
Ifadina (reference= Sheik Abdi)	0.236	0.249
Abdi Buchi (reference= Sheik Abdi)	-0.480	0.258*
Gambela (reference= Sheik Abdi)	0.383	0.263
Intercept	0.169	0.270
	Number of obs = 1871 F(32, 1380) = 4.66 Prob > F = 0.0000	

Note: *, **, *** significant at 10%, 5% and 1%, respectively.

4.3.3 Poverty impact of improved water supply

As indicated earlier, we followed a two-pronged approach to assess the impact of improved access to water supply on poverty. First, we estimated poverty profiles of households using standard poverty measurement approaches. In doing so, we decomposed poverty profiles by households with access and those without access to improved water supply, and access to irrigation. Second, we ran determinants of poverty by controlling for all possible covariates of poverty and correcting for the endogeneity of health.

As can be seen from Table 4.13, households with access to improved water supply were found to have significantly lower overall poverty levels in terms of incidence, depth and severity. In fact, about 87% of the individuals in households without access were found to live below the absolute poverty line of ETB 1821, compared with about 67% in households with access. There is also significant difference in depth and severity of poverty of households with access to water supply compared with those that do not have access.

Table 4.13: Incidence, depth and severity of poverty of households with and without access (poverty line = ETB 1821.05)

Category	**Incidence ($\alpha = 0$)**		**Depth ($\alpha = 1$)**		**Severity ($\alpha = 2$)**	
	Value	**SE**	**Value**	**SE**	**Value**	**SE**
Access to improved water supply						

With (n=876)	0.67	0.017	0.509	0.016	0.437	0.015
Without (n=641)	0.87	0.009	0.717	0. 009	0.637	0. 010
z-statistic		-934.96***		-799.65***		-705.94***

This was also true in terms of food poverty. Using the food poverty line of ETB 1096, we found that about 79% of the population without access were found to live below the food poverty line, compared with about 55% of the population with access. There is also a significant difference in depth and severity of food poverty of households with access to water supply compared with those that do not have access. This could be taken as a good indicator of food security. From this, we can see that overall and food poverty are significantly lower in households with access as against those without. However, this also implies that the level of poverty in Eastern Hararghe is significantly higher than the overall level of about 39% in Ethiopia in 2004/05 (MoFED, 2006), calculated based on a poverty line of ETB 1075.

Table 4.14: Incidence, depth and severity of poverty of households with and without access (poverty line = ETB 1096.02)

Category	**Incidence ($\alpha = 0$)**		**Depth ($\alpha = 1$)**		**Severity ($\alpha = 2$)**	
	Value	**SE**	**Value**	**SE**	**Value**	**SE**
Access to improved water supply						
Users (n=876)	0.554	0.018	0.437	0.015	0.368	0.014
Non-users (n=641)	0.792	0.011	0.643	0.010	0.552	0.010
z-statistic		-759.06***		-712.60***		-635.58***

What these results show us is that poverty levels are significantly lower in households with access, but we do not know the main reason for this difference. One possible explanation could be that access to productive water is leading to significant reductions in poverty. We, hence, further explored whether levels of poverty were different between households that had access to irrigation and those that did not.

Table 4.15: Effect of access to productive water on incidence, depth and severity of poverty (poverty line = ETB 1821.05)

Category	**Incidence ($\alpha = 0$)**		**Depth ($\alpha = 1$)**		**Severity ($\alpha = 2$)**	
	Value	**SE**	**Value**	**SE**	**Value**	**SE**
With irrigation (n=557)	0.763	0.018	0.642	0.017	0.572	0.016
Without irrigation (n=943)	0.814	0.013	0.654	0.0126	0.577	0.0124
z-statistic		-647.68***		-567.62***		-520.19***

As can be seen from Table 4.15, households with access to irrigation were found to have significantly lower overall poverty levels in terms of incidence, depth and severity. The range in headcount ratio is 81 and 76. This was also true in terms of food poverty: households with access to irrigation show significantly lower food poverty levels compared with those without (see Table 4.16). However, the mere presence of irrigation is not the only factor that accounts for the difference in poverty levels, as can be seen from these results. One of the limitations of such poverty decompositions is that we do not control for the effects of other covariates. Hence, we estimated determinants of poverty using the approach described in Section 3.2. The results are reported in Table 4.17.

Table 4.16: Effect of access to irrigation on incidence, depth and severity of poverty (poverty line = ETB 1096.02)

Category	**Incidence ($\alpha = 0$)**		**Depth ($\alpha = 1$)**		**Severity ($\alpha = 2$)**	
	Value	**SE**	**Value**	**SE**	**Value**	**SE**
With irrigation (n=557)	0.705	0.019	0.579	0.017	0.495	0.015
Without irrigation (n=943)	0.713	0.015	0.582	0.013	0.497	0.012
z-statistic	-542.60***		-506.45***		-470.36***	

As can be seen from the results, access to an improved water source does not have a significant direct effect on wellbeing as defined earlier. However, a host of household- and village-level variables came out as significant in explaining household welfare. Most notably, asset ownership in the form of land and livestock was found to have a significant positive effect on household welfare. On the other hand, labour endowment, measured as the number of male and female adult members in the household, was found to have a negative effect on wellbeing. This result may imply that the marginal contribution of each additional labour unit to wellbeing in the communities is negative, which may reflect the poor functioning of the labour markets and rural unemployment. Participation in off/non-farm employment was found to have a significant positive effect on household welfare. This may reinforce our earlier hypothesis that the effect of improved water supply on poverty could be through making more time available for participation in off/non-farm employment. The amount of loans taken by households, for productive or non-productive purposes, has a negative effect on household wellbeing. This result shows that the marginal return in terms of poverty reduction from a given amount of loan taken is negative. This may point to suboptimal use of loans.

Among the household factors that turned out significant is the fact that female-headed households are found to have significantly lower wellbeing compared with male-headed households. As the number of dependents, measured as consumer–worker ratio, in a household increases, the wellbeing of the household will decrease. Other explanatory variables found significant in explaining wellbeing include distance to all-weather roads and distance to local markets. As expected, households that are located close to all-weather roads were found to be better-off compared with distant households. On the other hand, households located far from the market were found to be better-off, perhaps pointing out that what matters is the presence of roads and not merely distance. Our findings confirm that the potential poverty impact of improved access to WSS depends on the availability of other livelihood assets, which can be combined to generate increased income in cash or kind (Moriarty et al., 2004).

Table 4.17: Determinants of poverty (survey linear regression model)

Dependent variable: ln (welfare)				
	OLS		**IV regression**	
Variables	**Coef.**	**Std. err.**	**Coef.**	**Std. err.**
Household characteristics				

Sex of household head (female)	-0.224	0.106***	-0.469	0.273*
Age of household head	0.002	0.016	0.015	0.032
Age of household head squared	-0.0001	0.0002	-0.0001	0.0003
Education of household head (read and write)	0.131	0.195	-0.059	0.393
Education of household head (arithmetic)	-0.178	0.196	-0.081	0.403
Consumer–worker ratio	-0.204	0.036***	-0.156	0.085*
Skill of household head	0.096	0.088	0.284	0.322
Asset holding				
Livestock holding	0.0200	0.006***	0.025	0.012**
Land holding	0.014	0.004***	0.006	0.012
Adult labour (male)	-0.209	0.050***	-0.214	0.112**
Adult labour (female)	-0.208	0.055***	-0.060	0.136
Access to water supply and other services				
Change in WSS	-0.188	0.187	-0.188	0.187
Participate in non/off-farm work	0.126	0.059**	0.230	0.160
Amount of loan (in cash)	-0.0001	0.00002*	-0.0001	0.0001
Predicted health outcome	-	-	-0.004	0.002**
Village-level covariates				
Distance to all weather road	-0.007	0.001**	-0.006	0.002**
Distance to local woreda market	0.002	0.0005**	0.002	0.001**
Madisa Jalala (reference = Sheik Abdi)	1.199	0.212***	0.801	0.378**
Lafto Mada Talila (reference = Sheik Abdi)	1.646	0.232***	2.508	0.646***
Tola (reference = Sheik Abdi)	0.123	0.117	-0.183	0.304
Abdulkadir (reference = Sheik Abdi)	0.464	0.154***	0.508	0.354
Yaka Jalala (reference = Sheik Abdi)	0.241	0.156	0.424	0.583
Yaka Aman (reference = Sheik Abdi)	1.282	0.187**	0.893	0.443**
Ramata Salama (reference = Sheik Abdi)	0.149	0.105	-0.116	0.329
Erar Mada Talila (reference = Sheik Abdi)	0.353	0.168**	0.282	0.388
Biftu Diramu (reference = Sheik Abdi)	0.167	0.132	1.492	1.015
Kobo Waltaha (reference = Sheik Abdi)	-0.199	0.081**	-0.574	0.293**
Bika (reference = Sheik Abdi)	0.892	0.160	0.491	0.543
Ifa Daba (reference = Sheik Abdi)	0.100	0.142	0.572	0.432
Warji Jalala (reference = Sheik Abdi)	0.166	0.134	0.202	0.323
Chafe Anani (reference = Sheik Abdi)	3.046	0.145***	3.255	0.352***
Bishan Babile (reference = Sheik Abdi)	2.995	0.108	3.249	0.339***
Yaka Umama Tokuma (reference = Sheik Abdi)	2.765	0.155***	3.362	0.526***
Ifadina (reference = Sheik Abdi)	2.582	0.114***	2.636	0.337***
Abdi Buchi (reference = Sheik Abdi)	2.582	0.114***	4.069	0.679***
Gambela (reference = Sheik Abdi)	2.260	0.128***	2.659	0.4297***
Intercept	-1.965	0.304***	-1.774	0.801**
	Number of obs = 1407 F(36, 1351) = 112.71 Prob > F = 0.0000 R-squared = 0.6205		Number of obs= 1389 F(37, 1388) = 23.12 Prob > F = 0.0000	

The results from the instrumental variables (IV) regression model provide additional insight into the impact of improved water supply on poverty through improved health. The rationale for using the IV model was to control for the effect of water supply on poverty through improvements in health. As health is an endogenous variable, we needed to estimate it using instruments, so that we could use the predetermined health variable in the regression model. Health expenditure was taken as a good proxy for the problem of illness in a household. After having estimated health expenditure using instruments (see Table 4.17), we used the predicted value in the poverty regression. As can be seen from the results, the higher the health problem, the lower the wellbeing of the household. This captures the indirect effect of improved water supply on poverty reduction. The results from the IV regression model confirm more or less the result from the poverty regression, albeit less strongly in the latter.

To summarise, there is strong evidence on the impact of improved water supply on poverty. The mechanism through which this impact seems to work is: i) direct, through productive use of water in agriculture; and ii) indirect, through improved timesaving and increased participation in off/non-farm employment and through improved health by reducing health expenditure of households and increasing labour productivity. This study does not provide empirical evidence on the labour productivity gains of improved water supply and this need to be explored further.

5 Conclusions and implications for policy

While the expected benefits from investments in WSS on poverty are considerable, there is still limited empirical evidence in the current literature. The objectives of this study were to characterise WSS coverage and factors influencing access and to understand the effects of access to improved water supply on timesaving, health and poverty. By doing so, we assessed whether improved access to water supply had lead to a significant reduction in illnesses, with associated positive impacts on productivity and household income. We also examined the relationship between improved access and increased livelihood opportunities, i.e. through increased participation in off/non-farm employment opportunities. Furthermore, we assessed whether improved access to water supply has led to significant reductions in poverty. This is measured by comparing households' differences in agricultural income and consumption expenditure, between those with access to improved water supplies and those without.

Our findings indicated that there had been important changes in water supply during the past five years, whereby access to water from protected sources, such as public standpipes, hand pumps and protected springs, has increased. The newly introduced water systems were also appraised as reliable, providing good quality water and relatively accessible. The most important reported changes as a result of the introduction of new water supply systems include: increased supply of water, improved water quality, shorter distance (timesaving) and increased awareness in sanitation and hygiene. The overall trend is, therefore, quite positive.

However, detailed analysis of the distribution of services in the two focus woredas showed that investments in new water points were more likely in relatively well-connected kebeles. Kebeles located far from all-weather roads had a much lower likelihood of getting new water points during the past five years. This highlights the difficulties of targeting the unserved in remote rural areas and raises important questions for policymakers committed to making clean water accessible to all on an equitable basis (MoWR, 2006).

Notwithstanding the significant improvements in water supply, water from unprotected sources still provides the major source of water for about 60% or more of the households in both woredas, more so in Gorogutu. In this case, the bulk of households obtain water for domestic and non-domestic use from unprotected community wells, streams, community ponds and other sources. This may have implications for health and other community wellbeing. Not surprisingly, diarrhoea (including its acute form), respiratory problems and malaria are still the most important health problems, reported by 49%, 38% and 27% of households. Hence, water-based and water-borne diseases account for the bulk of the illnesses in both woredas, more so in Babile.

These results highlight the fact that people in rural areas typically rely on multiple water sources for different water uses. The factors underlying these patterns of water use behaviour and source preference are poorly understood and generally overlooked in mainstream sector policy and programming approaches, but they have important implications for sustainability. The evidence presented here challenges the traditional narrow sector focus on health benefits and points to a wide range of livelihood benefits that have hitherto remained 'invisible' in sector monitoring and evaluation.

Looking into linkages between improved access to water supply and health, our results show that access to an improved water source significantly reduces the probability of illness and even more so if it is the source is close. On the other hand, it also seems to have a positive association with water-related illnesses, calling perhaps for mitigative measures to reduce incidence of water-related diseases. This evidence clearly shows that improving access to water supply infrastructure alone is not sufficient to bring about desired public health benefits. Increased availability and perceived high quality of water are found to have significantly reduced incidence of illnesses. Because of the strong association between health and improved water supply, we also found that improved water supply leads to significant reductions in households' health expenditures.

The probability of participation in off/non-farm employment was found to have significantly increased with access to improved water supply. In fact, households that have access to water from improved source were found to be 14% more likely to participate compared with those without. This could be attributed to the timesaving benefits of increased availability of water at shorter distances, so that more labour time is available to households. This is an important new finding and suggests that lack of access to improved water supplies may act as a significant binding constraint to the participation of poor rural households in off/non-farm employment. This is a particular problem for labour-constrained households and has important implications for the effectiveness of labour-intensive work (food for work, etc.) designed to benefit vulnerable households, particularly women.

Regarding the impact of improved water supply on poverty, households with access to improved water supply were found to have significantly lower overall and food poverty levels in terms of incidence, depth and severity. Considering the effect of access to productive water on poverty, we also found that households with access to irrigation have significantly lower overall and food poverty. These findings provide strong empirical evidence of the contribution of water supply sector investment to poverty reduction.

But it is not only access to improved water supply or productive water that reduces poverty. A host of household- and village-level variables came out as significant in explaining differences in household welfare. Most notably, asset ownership in the form of land and livestock was found to have a significant positive effect on household welfare. Participation in off/non-farm employment was found also to have a significant effect. This reinforces our earlier hypothesis that the impact of improved water supply on poverty could be in timesaving benefits, by making more time available for participation in off/non-farm employment. Female-headed households were found to have significantly lower wellbeing compared with male-headed households. The results also show that the benefits of water supply sector investment are often unevenly distributed and suggest the need for greater attention to issues of equity in sector policy and programming. Furthermore, access to public infrastructure, such as all-weather roads, is found to have a significant impact on poverty reduction, as households that are located close to all-weather roads were found to be better-off compared with distant households.

In summary, our findings confirm that the potential poverty-reducing impact of improved access to water supply depends also on the availability of other livelihood assets. There is, hence, the need to build such community and household assets. Enhancing the asset base of households through credit programmes or others is an important entry point to enhance the impact of improved water supply on household poverty. Moreover, building of community assets such as roads could serve two purposes: enabling access to water supply and enhancing the impact of improved water supply on poverty. This could be another entry point for policy interventions to ensure poverty reduction and equitable development.

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Annex 1: List of kebeles included in the study

	Woreda	Name of PA	Agro-ecology	Distance to nearest urban (km)	Irrigation	PSNP	Population.	WS within 1.5km
1	Babile	Sheik Abdi	LL	2.5	1	0	4652	0
2	Gorogutu	Madisa Jalala	HL	4	0	0	4360	1
3	Gorogutu	Lafto Mada Talila	ML	3	0	1	8362	1
4	Babile	Tola	LL	2.5	0	0	3491	0
5	Babile	Abdulkadir	LL	5.5	0	1	2026	0
6	Gorogutu	Yaka Jalala	LL	18	0	0	3216	1
7	Gorogutu	Yaka Aman	LL	16	1	0	2031	1
8	Babile	Ramata Salama	LL	28	0	1	4448	0
9	Gorogutu	Erar Mada Talila	ML	20	1	1	5199	1
10	Gorogutu	Biftu Diramu	HL	17	0	0	3040	1
11	Gorogutu	Kobo Waltaha	ML	12	0	1	5456	1
12	Gorogutu	Bika	LL	21	0	1	3714	1
13	Gorogutu	Ifa Daba	LL	13.00	1	1	3894	1
14	Gorogutu	Warji Jalala	LL	16	1	0	6018	1
15	Gorogutu	Chafe Anani	LL	4	0	1	5357	1
16	Babile	Bishan Babile	ML	10	1	0	5284	0
17	Gorogutu	Yaka Umama Tokuma	ML	10	0	1	3437	1
18	Babile	Ifadina	LL	22	0	1	18324	0
19	Babile	Abdi Buchi	ML	15	1	0	2570	0
20	Babile	Gambela	ML	18	0	1	2780	0

Annex 2: Access to water supply

Table A2a: Access to water supply, 1999/2000

Zone	Tap in household	Tap in compound, private	Tap in compound, shared	Tap outside compound	Protected well/spring	Unprotected well/spring	River, lake, pond
West Wellega	0.23	1.58	0.99	17.89	14.04	22.4	42.87
East Wellega	0	1.81	1.08	18.97	14.57	21.81	41.76
Illubabor	0.22	1.27	1.21	19.32	13.7	22.34	41.94
Jimma	0.24	4.62	1.12	19.89	15.06	21.31	37.76
West Shewa	0.25	3.91	1.1	19.2	14.87	21.9	38.72
North Shewa	0.11	1.78	0.75	19.5	13.9	21.8	42.07
East Shewa	0.15	4.45	1.41	24.04	14.77	19.56	35.6
Arsi	0.05	2.16	1.24	20.39	14.6	22.04	39.5
West Hareghe	0.05	3.24	1	20.06	12.95	21.89	40.8
East Hareghe	0.12	1.25	0.62	17.18	14.9	22.24	43.66
Bale	0.11	1.14	0.76	19.2	14.59	21.75	42.46
Borena	0.14	2.12	1.41	19.63	19.15	19.11	41.43
South West Shewa	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Guji	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Adama Special Zone	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Jimma Special Zone	N.A	N.A	N.A	N.A	N.A	N.A	N.A

Source: Authors' calculations from the 1999/2000 and 2004/05 Welfare Monitoring Surveys.

Note: Pearson's chi2(66)=336.4 pr= 0.000.

Table A2b: Access to WS in 2004/05

Zone	Tap in household	Tap in compound, private	Tap in compound, shared	Tap outside compound	Protected well/ spring	Unprotected well/ spring	River, lake, pond
West Wellega	1.37	4.11	1.2	11.9	10.1	24.3	46.9
East Wellega	0.57	1.9	0.57	16.6	6.5	31.3	42.56
Illubabor	0.59	1.78	0.99	9.88	13.24	55.73	17.79
Jimma	0.49	0.98	0.65	6.18	22.3	57.7	11.7
West Shewa	0.38	4.33	4.33	10.36	11.68	32.2	36.7
North Shewa	0.2	2.76	2.76	14.6	13.21	45.2	21.3
East Shewa	2.33	16.5	13.76	32.59	6.03	6.56	22.22
Arsi	1.86	5.89	3.57	21.4	9.15	22.48	35.66
West Harerghe	0.19	3.36	3.18	23.74	4.86	45.79	18.88
East Harerghe	1.2	1.2	1.88	22.95	12.67	53.42	6.68
Bale	0	4.13	1.86	18.8	4.13	35.7	35.3
Borena	0.42	0.42	0.42	23.78	12.74	28.24	33.97
South West Shewa	1.19	5.15	2.38	11.49	8.12	32.87	38.8
Guji	1.08	1.29	3.02	9.27	11.85	46.55	26.94
Adama Special Zone	3.06	22.22	22.78	51.94	0	0	0
Jimma Special Zone	2.75	20.9	15.4	50.7	7.71	1.9	0.55

Note: Pearson's chi2 (90) =36000.0, pr= 0.000.

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