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Poverty impacts of improved access to water and sanitation in Ethiopia

F. Hagos, T. Slaymaker, J. Tucker, E. Ludi, E. Boelee & S. Awulachew [Ethiopia]

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. Investments in WSS are therefore considered important instruments for poverty reduction, but empirical evidence to support this remains quite limited. This study presents micro-evidence from a survey of 1500 households in Ethiopia on the economic impacts of improved access to WSS. We found that access to improved WSS has a strong statistical association with increased household water consumption and decreased average time spent to fetch water. Because of this time saving, household members with access to improved sources were also found to be more likely to participate in off-farm/non-farm employment. We also found strong evidence of positive impacts of improved access to WSS on health; although there are indications some type of illnesses may also have increased (e.g. water borne diseases). This evidence clearly shows that improving access to water supply infrastructure alone is not sufficient to bring about desired public health benefits. Interestingly, households with access to improved water supply and agricultural water were found to have significantly lower overall and food poverty levels in terms of incidence, depth and severity of poverty. Therefore, the pathways through which improved access to water supply has impacted poverty reduction in the study areas had to do with direct improved health benefits and through time-saving benefits induced increased participation of households in off/non-farm employment and irrigation. Determinants of off/non-farm employment and poverty were systematically analysed and factors identified and recommendations made to enhance these poverty impacts of water supply improvements.

Introduction

At the macro level, water sector investments can be an engine for accelerated economic growth, sustainable development, improved health and reduced poverty. Improved water resources management and water supply and sanitation contribute significantly to increased production and productivity, and recent studies indicate that poor countries with access to improved water and sanitation services have enjoyed annual average growth of 3.7% of GDP, while those without adequate investment saw their GDP grow at just 0.1% annually (SIWI, 2005). Furthermore, investments in the water sector can generate economic benefits that considerably outweigh costs and contribute to human development (Ibid.). 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.

At the micro level, improved WSS leads to considerable time savings and increased livelihood opportunities for the poor, as well as education and health gains (Slaymaker, et al., 2007, Howard & Bartram, 2003). More time and better health reduce poverty because of the greater opportunity for employment, and increased productivity of labour. The opportunity costs of time spent accessing water may be considerable not just in terms of income generation or school attendance, but also reproductive tasks such as caring for children and the elderly, all of which affect the overall health, welfare and productivity of the household (Magrath & Tesfu, 2006). However the potential poverty impact of improved WSS access seems to depend heavily on the availability of other livelihood assets e.g. land, labour, livestock, credit, and local markets (Moriarty, et al., 2004).

While the expected poverty impacts of investments in WSS on poverty are considerable, there is still limited empirical evidence in the current literature. At the macro level, a positive relationship is seen across countries between per capita income and access to WSS (e.g. UNDP 2006: 35-36). This may in part reflect a causal effect of better access to WSS on productivity and income. This theory has been largely untested, but indirect support is found in studies which find a positive relationship between initial levels of health, and subsequent rates of economic growth across countries (e.g. Sachs and Warner 1997; Barro and Sala-i-Martin 2005). For more direct evidence, we must turn to studies at the country or regional level.

There is strong evidence that collecting water limits the amount of time spent by women in productive employment (see for example Ilami and Grimard, 2000 on Pakistan). Improving the quality of water sources may also be important for raising productive employment. Across villages in rural Tanzania, 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. There is also evidence from a countries in Africa, Asia and Latin America that access to WSS reduces child mortality (Fuentes *et al*, 2006; Guillot and Gupta, 2004; Abou-Ali, 2003). Finally, several studies on demand for water at the household level have explored the effect of access to water on household welfare. These studies are generally grounded in standard microeconomic theory, adapted to reflect the special features of water as a consumer commodity.

Objectives of the study

The objectives of this study were to characterise existing WSS coverage and factors influencing access to improved services; and to understand the effects of improved WSS access on different aspects of poverty. This study goes beyond assessing the impacts WSS on health to examine: the incidence of water-related diseases among households with and without access to improved WSS; the relationship between household WSS access and participation in off/non-farm employment opportunities; and whether improved access to WS and access to irrigation has led to a significant reduction in overall levels of poverty.

Data and methodology

Data and sampling strategy

The household survey was conducted during October- December 2007 on 1500 households in 2 woredas (districts) in Eastern Hararghe zone, Oromia Regional National State, Ethiopia[2]. Stratified random sampling by agro-ecology, distance to market and presence of improved WSS was used to select 20 kebeles (villages) from these woredas. 75 households were randomly selected for surveying in each kebele. Detailed data was collected on WSS facilities and access, household demographics, household assets, income from diverse sources, consumption expenditure, incidence of different illnesses and village-level factors such as access to market and other services. This study is part of a comprehensive study by the project, the WSS-poverty nexus is just one aspect of the study whose results are reported here.

Estimation approaches

A variety of approaches from descriptive statistics to regression analysis were used to describe the current situation and establish the links between WS and different welfare outcomes. To model the probability of a household member being ill as a function of various covariates we used a binary choice model, where the dependent variable is whether a household member is reported sick or not and the explanatory variables included individual characteristics (age and sex of the individual), household related variables (such as family size, number of children under five, number of seniors), access to improved water supplies, sanitation behavior (e.g. ownership and use of pit latrines), and village level factors representing access to health and other services. Similarly, we modeled the level of health expenditure incurred by a household, 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 vector of explanatory variables influencing the level of expenditure include patient characteristics (such as age, sex,

etc.), type of illness1, household's ability to pay (measured by its asset endowments such as average land and livestock holdings and average household income), and access to health services as measured by distance to health centre and all weather roads. To overcome the structural restriction imposed by the Tobit model (see Verbeek, 2000), we also estimated a truncated regression model by taking only the positive expenditures and identified the determinants of positive expenditure.

To estimate poverty, in this paper we used expenditure adjusted for differences in household characteristics. We used the Foster-Greer-Thorbecke (FGT) class of poverty measures to calculate poverty indices as these indices are said to have some desirable properties (such as additive decomposability), and include some widely used poverty indices such as head-count poverty gap and severity measures (Foster et al., 1984); Duclos et al., 2006). We calculated these indices using STATA 9.0 and tested for differences in the poverty profiles of households with and without access to an improved water source, as proposed by Kwakani (1993). The consumption poverty line was set at ETB 1821.05 (Ethiopian birr) (US$1=ETB9.2), an inflation-adjusted poverty line based on the official poverty line of ETB 1075 set in 1995/96 by the Ethiopian government (MOFED, 2006). An inflation-adjusted poverty line of 1096.03 was also used as an absolute food poverty line, based on the corresponding 1995/96 official food poverty line.

An analysis of poverty would not be complete without explaining why people are poor or remain poor over time. In microeconomics, the simplest way to analyse the correlates of poverty is by a regression analysis against various factors (see Coudouel et al., 2002; Wodon, 1999). 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: (a) household characteristics household head, including sex, level of education (read and write or not, arithmetic skills), age and number of dependents; (b); asset holding: livestock size (in Tropical Livestock Unit) and farm size, adult labour (by sex); (c) 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, distance to all weather roads. Access to WS was measured by whether the household reported improvement in WS during the last five years (0/1); and (d) village level characteristics mainly kebelle dummies to control for village level covariates.

The estimated coefficients of the poverty regression are 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. 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) and thereby dealt 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 in the poverty equation risked causing an endogeneity problem. To correct for this we used an instrumental regression model, using the predicators of health expenditure to control for health effects.

Results and discussions

Access to improved WSS

The data show that households in both woredas obtain water from protected and unprotected sources, and typically rely on multiple water sources for different uses (see Table 1). It is interesting to note that a significant proportion of water drawn is for non-household use. 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, the main traditional justification for WSS interventions.

44 % of the respondents in Babile and 35% in Gorogutu indicated that they had experienced major changes in water supply over the last 5 years. The new systems were widely perceived as having resulted in increased supply of water, improved water quality, shorter distances and increased awareness of sanitation and hygiene, and were considered to provide good quality water on a reasonably reliable and accessible basis. At the same time, we note that continuous service is achieved in only 60-69% of systems, reflecting the challenges of delivering effective services on a sustainable basis in this area, and that use of unprotected

[1] 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.

sources still predominates in both woredas. We also found that investments in new water points were more likely in relatively well-connected kebeles, while kebeles far from roads were less likely to get water points. Moreover, communities located in highlands were more likely to be targeted that communities in lowland altitudes, where water shortage is more severe. This may show a problem in targeting.

Table 1. No of users from different types of sources (By use type)

System	Drinking and other household uses		Non-household uses	
	Babile (n= 1,608)	Gorogutu (n= 4,199)	Babile (n= 1,577)	Gorogutu (n= 5,838)
Household connection	0	21	1	39
Public stand pipe	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.

We examined access to sanitation by looking at changes in sanitation services and waste management strategies. About 40% of households in Babile and 30% in Gorogutu have their own latrines but considerable proportions do not use them and continue to defecate outdoors. This 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.

We also explored the major health problems in the two woredas. Diarrhoea (including its acute form, dysentery) accounted for 49% of health problems and malaria for 27%; together with respiratory diseases water-related illnesses make up the bulk of illnesses reported. These findings are important and suggest that isolated efforts to improve access to WSS infrastructure are not sufficient to reduce water-related diseases.

Statistical association between improved water supply and welfare indicators

We explored the statistical association between access to improved water supply and different welfare indicators (see Table 2). This gives indicative insights into how improved access to water supply could influence household welfare, before systematic analysis is done to establish cause -effect relationships.

Improvements in access to water supply were found to have a strong statistical association with increase in volume of water collected (7 litres per day) per household and decrease in average distance travelled to a water source. Both are expected to lead to significant time savings (about 3 minutes per trip), which are expected to increase household members' participation in productive engagement. Indeed, we find a strong association between improved access to water and participation in off/non-farm, although the average number of days engagement is higher in households without access to improved source.

Interestingly, we found that households with access to improved water sources have significantly higher consumption expenditure per adult equivalent than those without access, and are less likely to have faced food shortages, and likely to have experienced them less frequently, during the last five years. Furthermore, income from livestock sales was found to have a significant association with improved access although agricultural income was not significantly associated with access to water from protected source. We also found significant association between improved access and illness and missing jobs/school because of illness. The pathways through which improved access may impact on household welfare thus seem to relate

a combination of direct health benefits, time-saving induced increased participation in off/non-farm employment and livestock income than to crop productivity.

Table 2. Association between improved water supply and some socio-economic variables

Variable name	Protected source (n = 720)	Unprotected source (n= 1,234)	p-value*
	Mean	Mean	
Average distance (in minutes single trip)	20.34	23.86	0.0006***
Quantity of water fetched (in litres per day)	55.82	48.71	0.0000***
Illness (0/1)	0.526	0.546	0.029**
Participation in productive engagement	0.44	0.41	0.007***
Miss job because of illness (last year)	0.389	0.366	0.010***
Miss school because of illness (last year)	0.097	0.118	0.000***
Per capita income (in ETB)	943.97	1827.54	0.2049
Per capita crop income (in ETB)	749.9	1681.12	0.1815
Per capita livestock income (in ETB)	128.89	152.66	0.0522**
Per capita agricultural income (in ETB)	620.54	1527.48	0.1930
Per capita non-farm income (in ETB)	193.64	145.88	0.0158**
Number of working days engagement in a year	128.32	147.23	0.0143**
Number of working days missed because of illness in a year	68	80.91	0.1379
Income loss due to illness (in ETB)	389.93	494.51	0.3112
Number of school days missed because of illness in a year	46.32143	58.54	0.2791
Medical expenditure (in ETB)	197.67	200.62	0.9062
Annual consumption expenditure per adult equivalent (in ETB)	2272.59	1262.102	0.0029***
Faced food shortage (no of households)	270	726	0.000***
Frequency of food shortage	2.31	2.348011	0.0102***

* Two-sided test of equality of means/proportions, ETB= Ethiopian Birr.

Exploring linkages

Improved water supply and health

We ran three separate regressions for what we called water related illnesses, non-water related illnesses and all kinds of illness, in the latter case we pooled the data for water and non-water related illnesses. We found that the probability of being reported ill in any kind of illness decreased with access to improved source showing that households that have access to water from an improved source were 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 ones, the results are mixed. In this case, probability of falling ill in water related diseases increased with access to improved source and decreases with distance to water source. On the other hand, the probability of a person falling ill in non-water related illnesses decreased with access to water from a protected source and increases with distance. The possible explanation 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 because of its quality. The distance variable is perhaps picking up the effect of distance on the incidence of water borne diseases, particularly malaria.

Improved water access and participation in off/non-farm employment

We systematically assessed the determinants of participation in off/non-farm employment, controlling for a host of explanatory variables including improved access to water supply. We found a strong association between improved access to water supply and participation in off/non-farm employment, after controlling for other covariates. This could be attributed to the time saving associated with increased availability of water and shorter fetching distances leading to increased availability of labour at household level[3] and

reinforces the conjecture that one of the most important pathways through which improved access to water supply will impact on poverty is through increased participation of households in off/non-farm employment.

Having access to credit, and skills of some sort (non-farm), are also found to have a very significant effect on participation. Household characteristics also play a role. Households with older or female heads were less likely to take part in off/non-farm employment. On the other hand, we also found that as the number of male adults in given household increases, the probability of the household's participation in off/non-farm employment decreases. This may point to the high level of rural unemployment in the study sites and in Ethiopia in general. These results clearly show that improved access to water supply can enable increased participation in off/non-farm employment. The fact that we see such strong effects even in an area with high rates of unemployment suggests that access to water may be a significant binding constraint to seeking and participating in off/non-farm employment in rural areas.

Poverty impact of access to improved water supply

As discussed above, we used a two-pronged approach to assess the impact of improved water access on poverty: estimating the poverty profiles of households using standard poverty measurement approaches and identifying determinants of 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. Accordingly, 87% of the population without access were found to live below the absolute poverty line of ETB 1821 compared with about 67% of the population with access (see Table 3). Using the food poverty line of ETB 1096 we found that about 79% of the population without access live below the food poverty line compared with 55% of the population with access (see Table 4).

Table 3. Incidence, depth and severity of poverty of households with and without access (poverty line = ETB1821.05)

Category	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	Value	SE	Value	SE	Value	SE
With access (n=876)	0.67	0.017	0.509	0.016	0.437	0.015
Without access (n=641)	0.87	0.009	0.717	0.009	0.637	0.010
z-statistic	-934.96***		-799.65***		-705.94***	

Table 4. Incidence, depth and severity of food poverty of households with and without access (poverty line = ETB1096.02)

Category	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	Value	SE	Value	SE	Value	SE
With access (n=876)	0.554	0.018	0.437	0.015	0.554	0.018
Without access (n=641)	0.792	0.011	0.643	0.010	0.792	0.011
z-statistic	-759.06***		-712.60***		-635.58***	

We further explored levels of poverty between households which have access to irrigation and those without, as productive irrigation is a potential route by which water could contribute to poverty reduction. Irrigation in the region is primarily small-scale, where households operate a small holding averaging about 0.2 of hectare and grow cereals and vegetables. Households with access to irrigation were indeed found to have significantly lower overall poverty and food poverty levels in terms of incidence, depth and severity.

We next estimated determinants of poverty. Our regression results showed that access to an improved water source does not have a significant direct effect on household wellbeing. However, a host of household and village level variables were found to be significant in explaining household welfare. Most notably, asset ownership in the form of land and livestock were found to have a significant positive effect on household welfare. However, 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 may imply that the marginal contribution of each additional unit of labour to wellbeing in the communities is negative, reflecting the poor functioning of the labour market and high rural unemployment. Participation in off/non-farm employment was found to

have a significant effect on household welfare. This reinforces our earlier hypothesis that an important effect of access to improved water supply on poverty could be through time savings allowing greater participation in off/non-farm employment. The amount of loan taken by the household has a negative effect on household wellbeing. This shows that the marginal return in terms of poverty reduction from a given amount of loan taken was negative, which may point to sub-optimal use of loans.

Some household factors are also significant. Female-headed households are found to have significantly lower wellbeing than male-headed, and as the number of dependants (consumer-worker ratio) increases the wellbeing of the household decreases. Other explanatory variables which are significant in determining wellbeing include distance to all-weather road and to local woreda market. As expected, households that are located close to all-weather roads were found to be better-off than those further away. However, households located far from the woreda market were found to be better-off than those nearer, suggesting that distance is less important than the presence of good roads. Our findings thus provide empirical evidence to support earlier studies which have concluded that the potential poverty impact of improved WSS access depends on the availability of other livelihood assets e.g. land, labour, livestock, credit, local markets which can be combined to generate increased income (SecureWater, 2003, Moriarty et al., 2004).

The results of the Instrumental Variables Regression model provide additional insight on the impact of improved water supply on poverty through improved health. This was used to control for the effect of water supply on poverty through improvements in health, using health expenditure as a proxy for household health status. Households with greater health expenditures, hence poor health status, are found to have lower wellbeing. This captures the indirect effect of water supply on poverty through health.

To summarize there is strong evidence on the impact of improved water supply on poverty. The mechanism through which this impact seems to work is (1) direct through productive use of water in agriculture and (2) indirectly through improved time saving and increased participation in off/non-farm employment and through improved health by reducing health expenditure of households and probably, increased 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.

Conclusions and policy implications

While the expected benefits from investments in water supply and sanitation (WSS) on poverty are considerable, there is still limited empirical evidence in the current literature. Our findings indicated that there were important changes in water supply during the last five years where access to water from protected sources such as public stand pipe, hand pump and protected springs has increased. The new introduced water systems were also appraised as reliable, providing good quality water, and relatively accessible. The most important changes witnessed as a result of the introduction of new water supply systems include: increased supply of water, improved water quality, shorter distance (time saving) 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 weredas showed that investments in new water points were more likely in relatively well connected Kebeles. Kebeles which are located far from all weather roads had a much lower likelihood of getting new water points during the last five years. This highlights the difficulties of targeting the unserved in remote rural areas and raises important questions for policy makers committed to making clean water accessible to all on an equitable basis.

Notwithstanding the significant improvements in water supply, water from unprotected sources still provides the major source of water for about 60 percent or more of the households in both weredas, more so in Gorogutu. In this case, the bulk of households obtain water for domestic and non-domestic use from unprotected community wells, stream, community pond and unprotected springs. This may have implications on 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 percent of the 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 are generally overlooked in mainstream sector policy and programming approaches but 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 which 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 improved water source significantly reduced the probability of illnesses and even more so if it is the source is close. On the other hand, it 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. Increased availability and perceived high quality of water are found to have significantly reduced incidence of illnesses.

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 14% more likely to participate compared to those without access. This could be attributed to the time saving benefits of increased availability of water in shorter distance so that more labour time is available to the household. 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 works (food for work etc) designed to benefit vulnerable households.

Regarding, the impact of improved water supply (both domestic and productive) 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 of poverty. These findings provide strong empirical evidence of the contribution of water supply sector investment to poverty reduction.

But is not only access to improved water supply or productive water that reduces poverty. A host of household and village level variables came out significant in explaining household welfare. Most notably, asset ownership in the form of land and livestock were found to have significant positive effect on household welfare. Participation in off/non-farm employment was found also to have a significant effect on household welfare. This reinforces our earlier hypothesis that the effect of improved water supply on poverty could be time saving benefits by making more time available for participation in off/non-farm employment. Female-headed households were found to have significantly lower wellbeing compared to 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 are found to have a significant impact on poverty reduction as households that are located close to all weather roads were found to better-off compared to households far off. In summary, our findings confirm that the potential poverty impact of improved water supply access also depends on the availability of other livelihood assets. There is, hence, the need to devise mechanisms to build such community and household assets. Enhancing the asset base of households through credit program or otherwise 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 also be another entry point for policy interventions to ensure poverty reduction and equitable development.

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Note/s

[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 cent per year.
[2] 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] Based on the assumption that improved sources are indeed closer and/or more productive resulting in a reduction in the amount of time spent collecting water to satisfy household needs.

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Contact details

Dr Fitsum Hagos
International Water Management Institute (IWMI)
Subregional Office for the Nile Basin and East Africa
PO Box 5689, Addis Ababa, Ethiopia
Tel: + 251-11- 6172191
Fax: + 251-11-6172001
Email: f.hagos@cgiar.org
www.iwmi.org , www.rippleethiopia.org

Tom Slaymaker
Overseas Development Institute (ODI)
111 Westminster Bridge Road, London SE1 7JD, UK
Tel: +44-20-7922-0300
Fax: +44-20-7922-0399
Email: t.slaymaker@odi.org.uk
www.odi.org.uk , www.rippleethiopia.org